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Cruise Report

R/V Natsushima – Hyperdolphin
NT06-22 Cruise in Sagami Bay

December 8th (Yokosuka) – December 15th (JAMSTEC),

2006

C O N T E N T S

4-4. *In situ* marking experiment for estimation of shell growth rate of *Calyptogena* clams

Yohei Tada, Katsunori Fujikura, Hiroshi Kitazato

4-5. Marking experiment for estimation of *Calyptogena* clams, feeding ecology of snail *Phymorhynchus buccinoides*, and taxonomical study of shrimp *Alvinocaris longirostris*

Katsunori Fujikura

4-6. Seismometer Installation to Seafloor benchmark

Eiichiro Araki, Sho Kaneko

Appendix

1. List of Samples (Appendix_1_Samplelist.xls in the folder)
2. List of Videotapes
3. Photographs of payload for each dive
4. Shipboard log

1. Introduction

1-1. General Introduction

Marginal seas that are developing along continental slope are characterized by high accumulations of both organic and inorganic materials. The high rate of sedimentation at continental margin is thought to be sustained by both vertical input from sea surface primary production and lateral transfer from coastal to land area. These material transportation patterns are more typically appeared at an arc-trench system where active material transportation is taken place both from water column and from land areas. High input of nutrients both from land areas and coastal upwelling keeps ocean surface in a eutrophic condition. Sagami Bay is a typical marginal sea where active depositional processes have taken place (Kitazato, ed., 2003).

Material budgets at sediment-water interface should give constraint finally for biogeochemical cycles at oceans. Benthic activities occurred at sea floor, in particular to redox boundary zone, play a key role for understanding material cycle at deep-sea floor. Thus, monitoring of benthic activities is required for getting basic data of material cycles at sediment-water interface. However, very rough first order estimation of material budgets has been gotten at continental margins up to now, in particular to those at arc-trench systems with active tectonic forcing. We should measure quantitatively *in situ* material fluxes at sediment-water interface on the sea floor. Detailed distribution patterns of biogeochemical components at sediment-water interface with sediment core analyses, planer optode imaging, microelectrode measurements, benthic chamber measurements and *in situ* feeding experiments with C-13 labeled food materials should be positive approaches for elucidating benthic processes at deep-sea floor.

Cold seepages are typically distributed in active continental margins. Seepage is located as outgoing fluxes of both hydrocarbon and major biogeochemical components from sediments to sea water at continental margin with active tectonic forcing. In Sagami Bay, *Calyptogena* colonies flourish at seepage sites. Activities of *Calyptogena* colonies give us important signal for understanding outgoing fluxes from sediment to seawater. Growth rates of *Calyptogena* may provide a good key for understanding vital condition of clams. Clear growth rings are recognized in *Calyptogena* shell. However, it is still unknown what is the actual meaning of rings. Marking experiment with both strontium sulfide and calcein is direct methods for estimating what kinds of environmental factors should relate to growth ring formation.

In situ measurements of earthquake are important for better understanding

regional seismological activities. In particular, borehole measurements are suitable for micro-earthquakes. In situ borehole measurements are carried out at the bench mark where piston core hole is sticked in the sea floor.

Multidisciplinary researches mentioned above plan to be done during and after dive cruise NT06-22. I hope that we can draw clear images of continental margin processes through our collaborative studies. This dive cruise is partly supported by the Grant-in-Aid from Japan Society of the Promotion of Science, Fundamental Research A to H.K.

Cruise Coordinator for the cruise NT06-22

Hiroshi Kitazato
(Institute for Research on Earth Evolution,
Japan Agency for Marine-Earth Science and Technology, Japan)

1-2. Area of Investigation

Sagami Bay is a deep-sea that situates in the central part of the Japanese Islands facing to the Pacific Ocean. A north-south extended deep trough lies at the central part of the bay where the water depth reaches at more than 2000 m. Sagami Bay is surrounded with land areas. Only the southern part opens to the Pacific.

Most diving campaigns were performed at a deep-sea permanent station (St. OBB II; 35˚00.7'N, 139˚22.5'E, depth 1450m) in the central part of Sagami Bay, Japan, which borders the Pacific Ocean. The station is located on a flat bottom of the Sagami Trough. The station is located on a flat bottom region of the Sagami Trough. Three water masses are recognized in the central part of Sagami Bay (Iwata, 1987). The upper a few hundreds of meters are occupied by relatively saline waters of the Kuroshio current (>34.6‰); the Subarctic Intermediate Water (= Intermediate Oyashio Water; 34.1‰) resides below this water to a depth of about 1000m, beneath which occurs the Pacific Deep Water. The North Pacific Deep Water overlies the station SB. The bottom water is characterized by temperatures of 2.3+- 0.1˚C, salinities of 34.5+-0.2‰, and dissolved oxygen concentration of 1.1+-0.2 ml/L. Bottom temperatures in the central part of Sagami Bay do not change throughout the year (Miya and Nemoto, 1991; Momma et al., 199?). Both salinity and dissolved oxygen concentration may also be invariant throughout a year.

Cold seepage site at southeast off Hatsushima Island is another diving site. This seepage intimately connected with fault activity of Sagami Bay West fault, one of active submarine fault system for bordering western end of the Sagami Bay. *Calyptogena* colonies are distributed at the site. Microbial mat occasionally develop at specific area where outgoing flow may exist. Deep-sea Permanent Observatory that has established by JAMSTEC has been located at the site since 1993. Bottom water environments has monotired at the station.

1-3. General Purpose

For aims to elucidate both ecological and biogeochemical processes at sediment-water interface on the active continental margins, we try to conduct several different *in situ* measurements on the sea floor with profiling lander, *in situ* incubation with benthic chamber, *in situ* feeding experiments and faunal analyses of meiobenthos at the central part of Sagami Bay where decadal long observations of depositional processes have been carrying out at a permanent deep-sea station, OBB II. In addition to central Sagami Bay measurements, we also challenge to carry out long-term measurements of oxygen penetration depth with planer optode system assembled on a lander supporting electricity through underwater cable network attach to deep-sea permanent station off Hatsushima Island, western Sagami Bay. We have also made marking experiments with Sr sulfide and calcein at cold seepage site at Hatsushima deep-sea station for understanding growth rates of *Calyptogena*.

Earthquake activities are measured at bench mark hole with bore hole measurement devices close to Hatsushima cold seepage site.

2. Participants on board

2-1. Scientists

Name		**Occupation**	**E-mail**	**Bording**
	Professional Affiliation	**Institution**	**Tel**	**Term**
	Address		**Fax**	
Hiroshi Kitazato		Program Director		12/8-12/10
	JAMSTEC	IFREE 4		
Eiichiro Araki		Researcher		12/8-12/15
	JAMSTEC	DONET		
Katsunori Fujikura		Sub Leader		12/8-12/15
	JAMSTEC	XBR		
Kazumasa Oguri		Researcher		12/8-12/15
	JAMSTEC	IFREE 4		
Hidetaka Nomaki		PD Researcher		12/8-12/15
	JAMSTEC	IFREE 4		
Sho Kaneko		Researcher		12/8-12/15
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Youhei Tada		Ph.D Student		12/8-12/15
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Glud Ronnie		Associate Professor		12/8-12/15
	University of Copenhagen	Marine Biological Laboratory		
Staahl Henrik		Postdoc		12/8-12/15
	University of Copenhagen	Marine Biological Laboratory		

Hirotaka Nakamura				12/8-12/15
	JAMSTEC	MEDID		
Maki Ito		Marine Technician		12/8-12/15
	NME, LTD.	Marine Science Dept.		

2-2. Crew members

R/V Natsushima Crews

Captain:	Eikou UKEKURA	Chief Engineer:	Eiji SAKAGUCHI
Chief Officer:	Rikita YOSHIDA	1st Engineer:	Koji HUNAE
2nd Officer:	Hiroyuki KATO	2nd Engineer:	Saburo KALAEMURA
3rd Officer:	Yuki HURUKAWA	3rd Engineer:	Daisuke GIBU
Boat Swain:	Yoshikane ODA	No.1 Oiler:	Seiichi MASTUDA
Able Seamen:	Kiyoshi KANEDA	Oiler:	Ryouji MARUTA
Able Seamen:	Shuji TAKUNO	Oiler:	Yoshinori KAWAI
Able Seamen:	Tadahiko TOGUCHI	Oiler:	Tastuomi CHINO
Able Seamen:	Shuichi YAMAMOTO	Oiler:	Souta MISAGO
Able Seamen:	Takashi SOEJIMA		
Sailor:	Toshiki OKUYAMA		
Chief Electronic Operator:	Masamoto TAKAHASHI	Chief Steward:	Kaoru TAKASHIMA
2nd Electronic Operator:	Yuhey TAKEUCHI	Steward:	Hidetoshi KAMATA
		Steward:	Hidetoshi NAKAHARA
		Steward:	Koji KIRITA
		Steward:	Futoshi HATAKEYAMA

ROV Hyper-Dolphin Operation Team

Operation Manager:	Kazuhiro CHIBA
1st Submersible Staff:	Mitsuhiro UEKI
2nd Submersible Staff:	Tomoe KONDO
3rd Submersible Staff:	Katsushi CHIBA
3rd Submersible Staff:	Atsushi TAKENOUCHI
3rd Submersible Staff:	Teppei KIDO
3rd Submersible Staff:	Yuudai SAKAKIBARA

3. Dive results

Following files exist in separated folders

3-1. Dive Results

Dive log, Dive report, Dive summary, Topography, Event list, Track chart

3-2. CTD META data

4. Individual Scientific Report

(Introduction, Method, Results and future studies)

4-1. Monitoring of two dimensional O_2 profiles at sediment-water interface

Kazumasa Oguri and Hiroshi Kitazato

4-1-1. Introduction

Oxygen is a key element to understand interactions between carbon cycles and benthic activities at sediment-water interface (SWI). To know oxygen distributions and their changes at SWI, planar optode techniques have been applied to get two dimensional O2 distributions (eg, Glud et al., 1996). The principle of O2 optodes are based on a energy transfer between luminescent dye and oxygen molecules (Kautsky, 1939). To measure two dimensional O2 distributions, luminescence from a “sensor foil” coated by luminophore is measured by a multi-gateable CCD camera. Recently, this method is applied for the measurements in situ (Wenzhöfer and Glud, 2004; Glud et al., 2005). However, in the previous studies, measuring time has restricted at most one day due to higher power consumption in electronics. To solve the problem, we designed our planar optode system to get power from permanent deep-sea station via undersea cable. The aim of our experiment in this cruises are: (1) to connect the planar optode system with the Hatsushima observatory supported by an operation of ROV “Hyperdolphin”, (2) to monitor power consumption at Hatsushima land station and Yokohama Institute for Earth Sciences, JAMSTEC, and (3) to obtain time-series O2 distribution images using with the system and detect short time O2 fluctuations by biological activities or some other effects caused by physical-chemical changes in bottom environment.

4-1-2. Methods

4-1-2.1 Planar O2 optode system

Our planar O2 optode system has developed based on the system by Glud et al. (2005). Fig. 1 shows a schematic diagram of the optode system. This system is ready for

O2-pH measurement using a combined sensor foil. However, we used it in “O2 mode” in this experiment because the new sensor foil is under development. As detailed description is made in the figure, we describe the brief outline of the system in the text. In the main cylinder, DC/DC converters, a computer for data storage and controlling the camera and timer boards are installed (Fig. 1a). When power is supplied from the observatory via undersea cable, the timers start up automatically and begin to supply the power to each module at programmed times. Periskop cylinder is supported by an elevator unit. Multi-gateable CCD camera, trigger board and LED illuminators are installed in a periskop cylinder (Fig. 1b). The periskop cylinder was hold in an elevator. In front of the periskop, platinum ocataetyilporphyrin (PtOEP) based transparent sensor foil was attached. At the measurements, bottom half part of the periskop is sunk into sediment. To detect correct position, optical sensor is attempted for identifying the SWI.

These two cylinders are connected with a power and a hybrid cables for data transfer and signal to allow trigger into the camera.

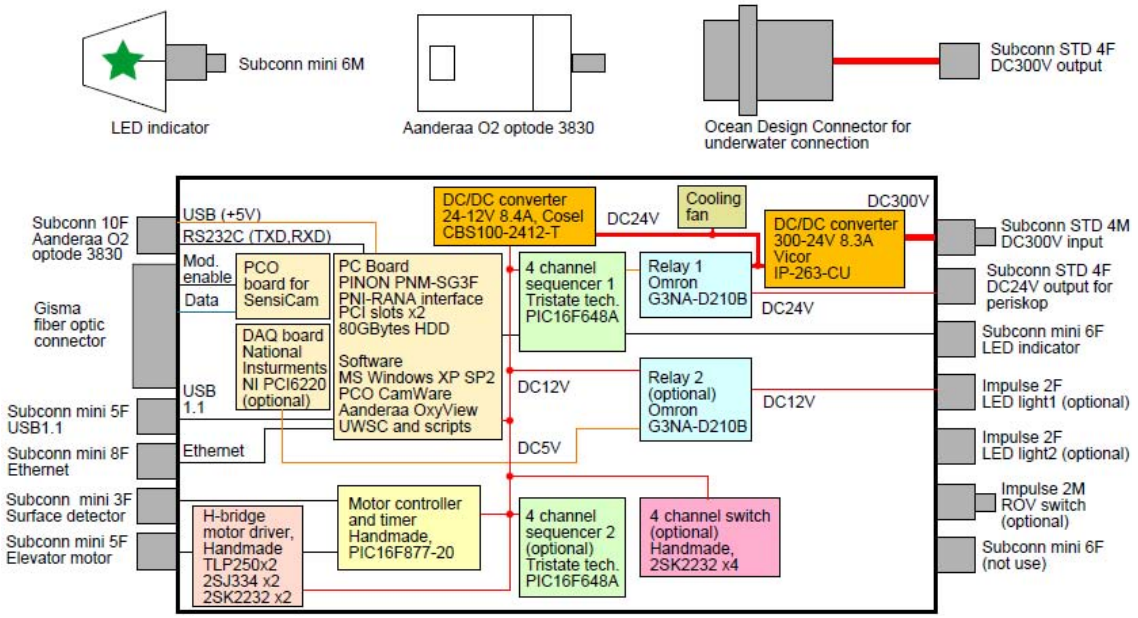


Fig. 1a, Schematic diagram of the internal connection of main cylinder. The cylinder was made from Titanium material. LED indicator was constructed to fix LEDs and a connector into hard epoxy resin. Aanderaa O2 optode (Tengberg et al., 2006) was used for getting reference O2 concentrations at bottom water. To connect with the extension cable, receptacle for undersea connection was attached in the lander.

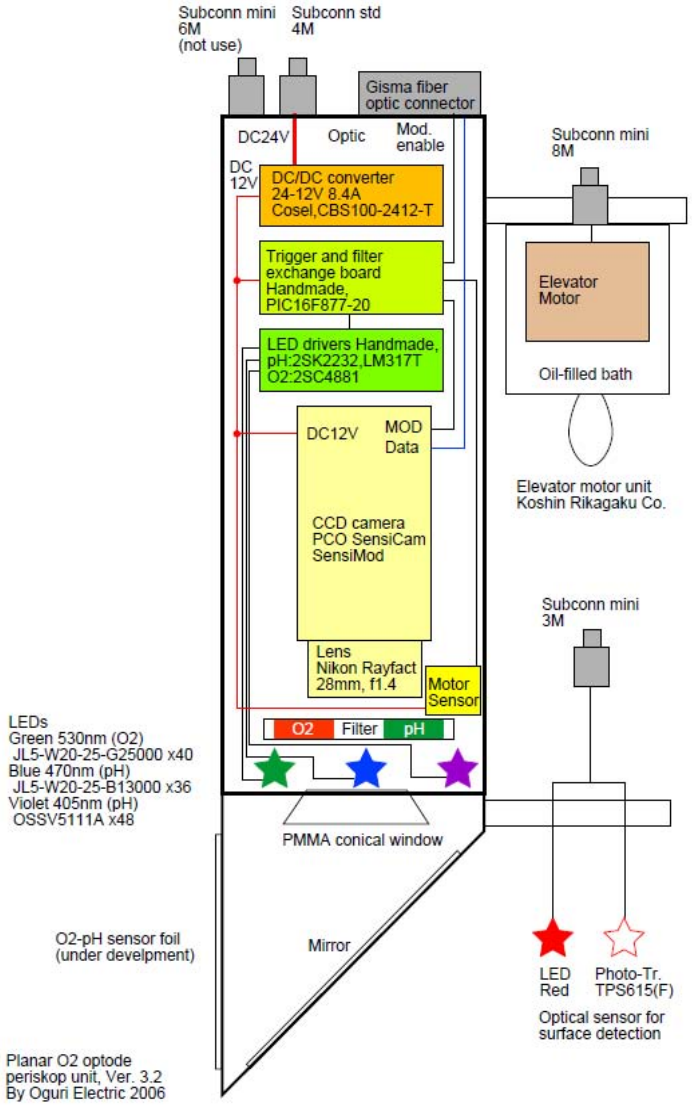


Fig. 1b. Schematic diagram of periskop cylinder, elevator motor and optical surface detector of the optode system.

These two cylinders were installed in a lander system. In addition to these equipments, acoustic transponder and ROV homer were installed (Fig. 2). In order to adjust the weight, weighing was carried out using with an analog weight meter (500 kg max) and a crane of the ship. The total weight of the system in air was ca. 270 kg, and that in seawater was ca. 25 kg, respectively. Before the dive, the lander is released from the ship. The landed location is summarized in Table 1.

Table 1. Location of the lander.

Latitude / Longitude	Water depth
35.00.200N / 139.13.336E	1218 m

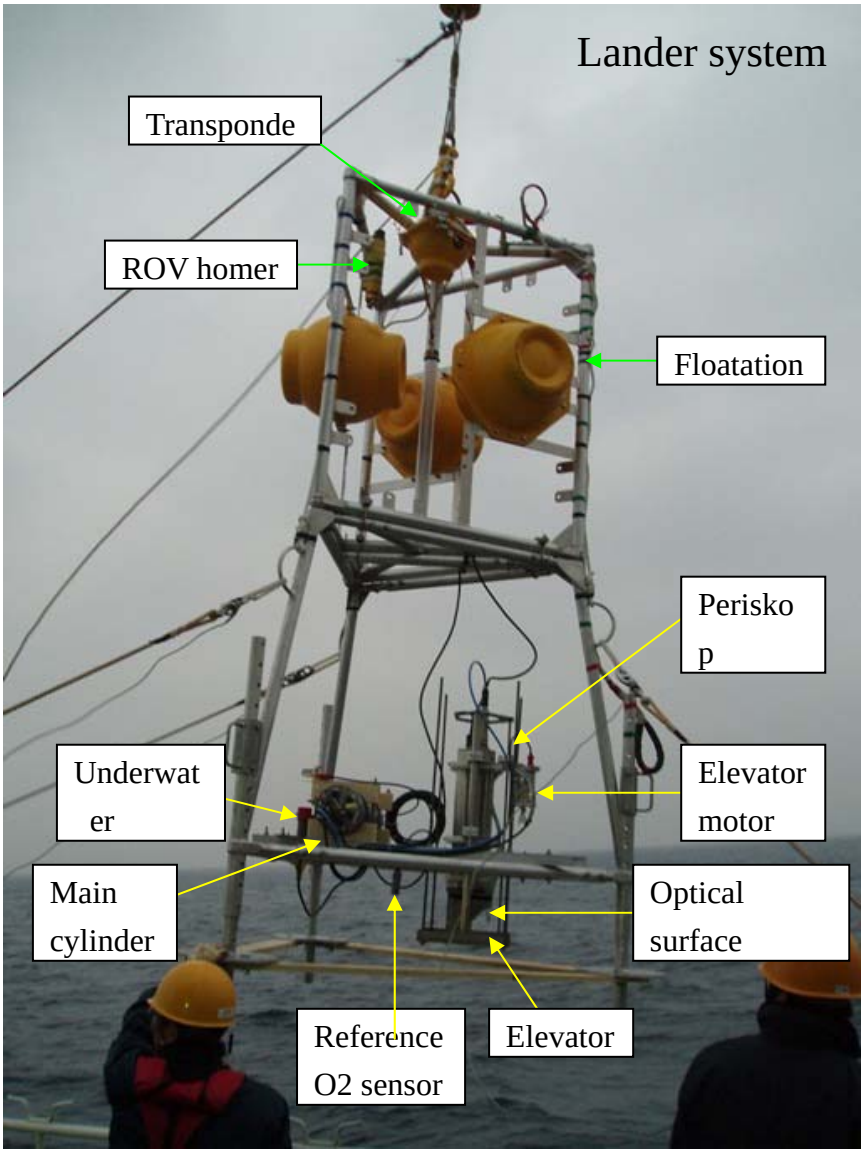


Fig. 2. Lander system and modules of the planar O2 optode system.

4-1-2.2 Extension of power cable and monitoring of power

The dive to connect the optode system to the Hatsushima observatory was carried out on 9th/Dec/ 2006, dive #622. Before the dive, underwater connection cable to supply high voltage was mounted on a rack in the payload. The cable had underwater connectors (4 pin, Ocean Design Inc.) to fit with the each receptacle in the observatory

and the lander, respectively. The total length of the cable was 100 m.

First, the planar O2 optode system was released from the ship. After reached the lander to the bottom, Hyperdolphin was moved the lander to the undisturbed sediment surface. Before connecting the extension cable to the Hatsushima observatory, electrical insulation of the cable from the land station to the observatory were confirmed at the land station. When the insulation was confirmed, one end of the extension cable was connected to the receptacle for high voltage supply at Hatsushima observatory. Then, correct connections between these cables were confirmed to measure resistance of seawater at another end of the extension cable in a very short time. After the confirmations, the cable in the payload was extended slowly and carefully (Fig. 3). When the Hyperdolphin was arrived at the lander, connector in another end was connected to the receptacle in the lander. Finally, high voltage regulated to DC 300V was supplied from the land station. The supply of the high voltage, starting up of the computer and the completion of the software startup were confirmed with a light from underwater LED lamp attached in the lander and the blinking patterns from illuminators in the periskop, respectively (Fig. 4a and 4b). When all the equipments and the software were ready, Hyperdolphin left the lander. Time table on the extension procedure is described in Table 1. The communications between the ship and the land station were made with telephone calls. Figs. 5 shows electric currents monitored at Hatsushima land station, indicating that the current supplied for the optode system was changed in relation to turning on and off with each module of the system.

Fig. 3. Cable extension from Hatsushima observatory to the lander. The extension cable was mounted on a special cable rack in the payload developed by “Hyperdolphin team”.

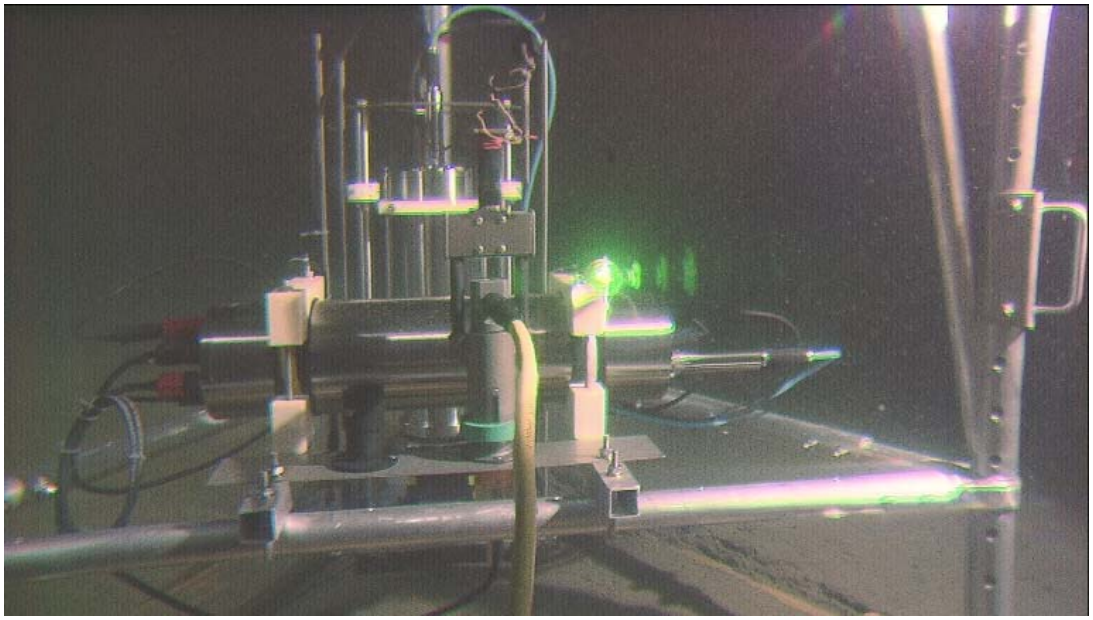


Fig. 4a. Underwater LED lamp indicates high voltage has supplied from the land station.

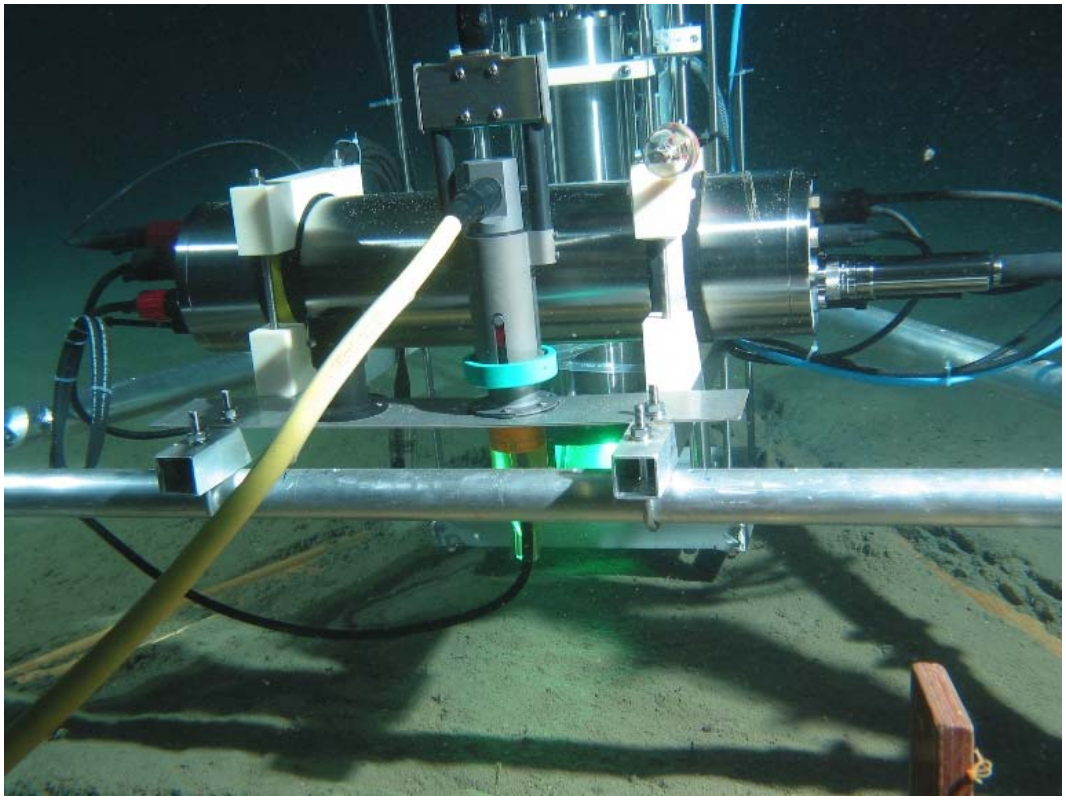


Fig. 4b. Underwater connector (front), main cylinder (center) and periskop cylinder on the elevator (back). In the periskop, green light illumination indicating booting up of the PC is appeared.

Table 2. Time and event during the cable extension.

Time	Events
7:21	Released the lander from the ship.
9:45	Hyperdolphin arrived at the lander.
10:03	Lander was moved and put on undisturbed sediment surface.
10:49	Electrical insulation of the cable and the safety connection had confirmed.
11:36	High voltage was on. LED lamp was on.
11:41	Confirmed the start up of the PC via LED illuminator in the periskop..
11:48	Confirmed the booting the software via blinking LED in t he periskop.
12:08	Elevator motor had stopped. The periskop was descent to the correct depth.

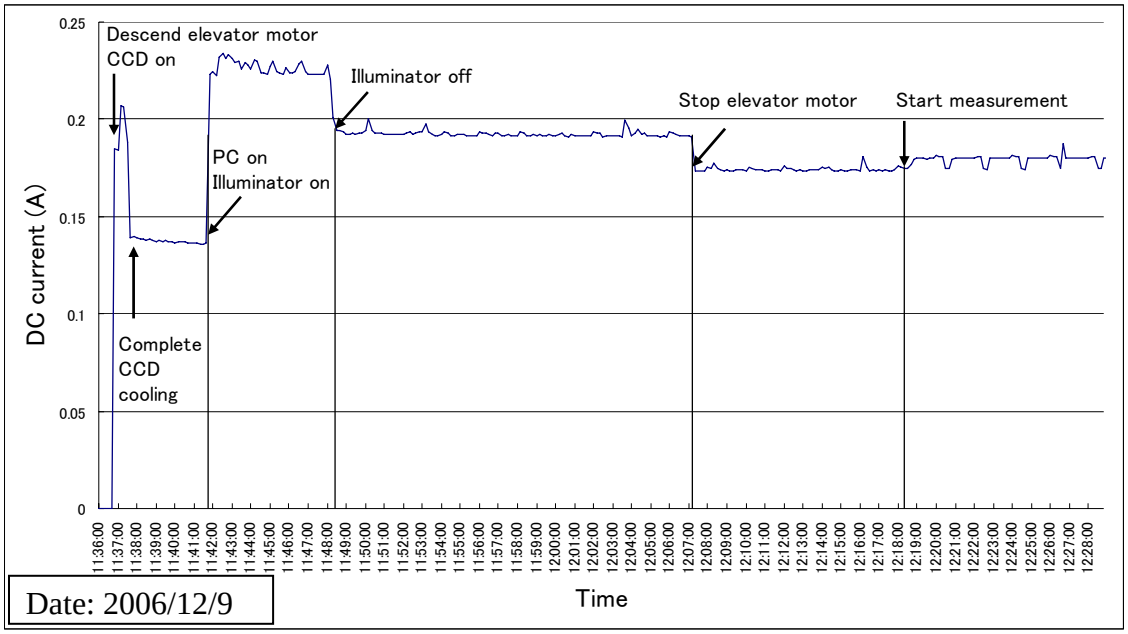


Fig. 5. Time-series changes of electric current and corresponding events. The current was monitored at Hatsushima land station and the data was sent to Yokohama Institute for Earth Sciences, JAMSTEC for real-time monitoring. DC voltage (300V) for the optode system was regulated by constant voltage power supply.

4-1-2.3 Measuring scheme

Principle of oxygen imaging we applied for is based on modulated luminescent lifetime imaging (Holst et al. 1998). Sensor foil was excited by green LED illuminator. After the excitation, phosphorescence from the sensor foil was acquired by the multi gateable CCD camera. To calculate lifetime images, two intensity images were

obtained: first image was got 1.2500 μsec after the excitation, and second one was 32.5000 μsec after excitation, respectively. The image acquisition was repeated for 1000 times in the CCD camera in order to get sufficient intensity. The modulation frequency for LED excitation was 5.0000 kHz and the shutter speed for each image acquisitions was 30.000 μsec. Each measurement was carried out every 2 minutes interval. Calibration, calculating lifetime and O2 images were carried out following the method described by Holst et al. (1998) and Holst and Grunwald (2001). For O2 imaging, MATLAB was used for the calculations.

4-1-2.4 Recovery of the system

Fig. 6 shows changes of the electric current observed at the land station. CCD camera was shut down and the elevator motor started ascending at 7:07 on 14th/Dec. At 7:47, the motor has stopped and the periskop cylinder has ascended from the sediment surface. However, shut down of the PC was not confirmed. The cause seems in a bug of the script program. At 10:12, whole power was shut down from the land station.

After the shut down, underwater connector in Hatsushima observatory was removed by Hyperdolphin. The open end was then connected to a resting port of the lander. With this operation, both ends of the extension cable were set to the lander. Finally, the lander system and the cable were hung up by Hyperdolphin.

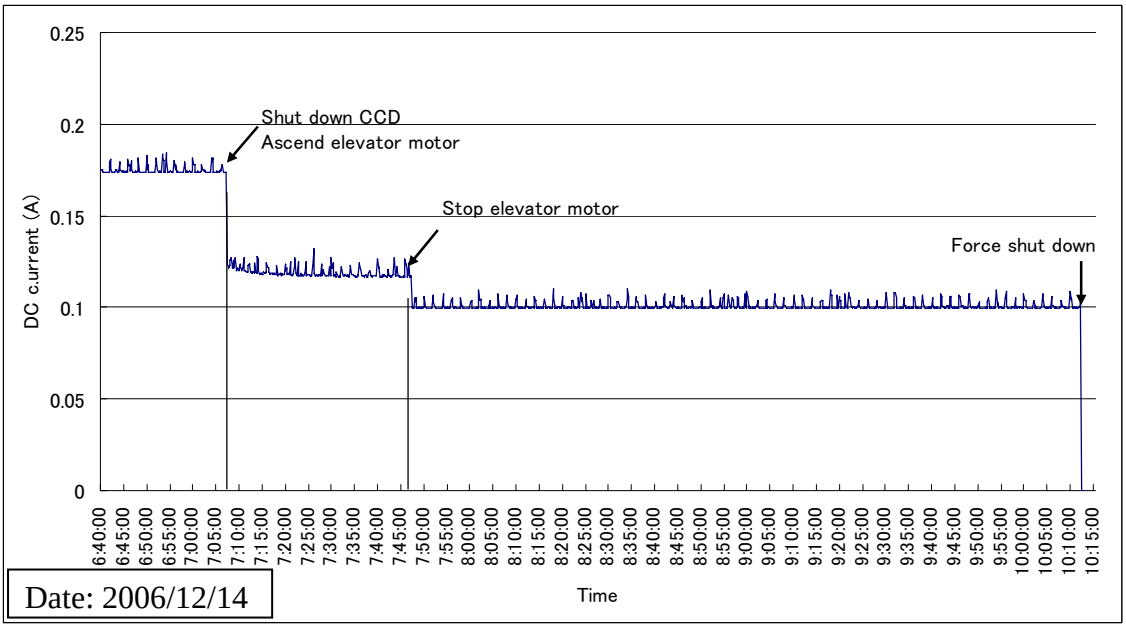


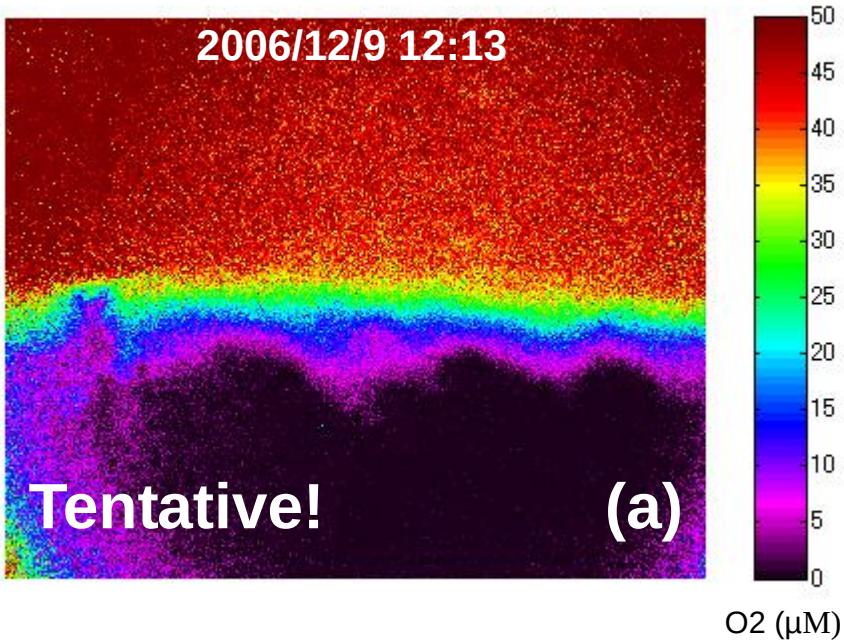
Fig. 6. Time-series changes of electric current from idling to shut down and the corresponding events. Because the PC was not shut down, supplied power was forced

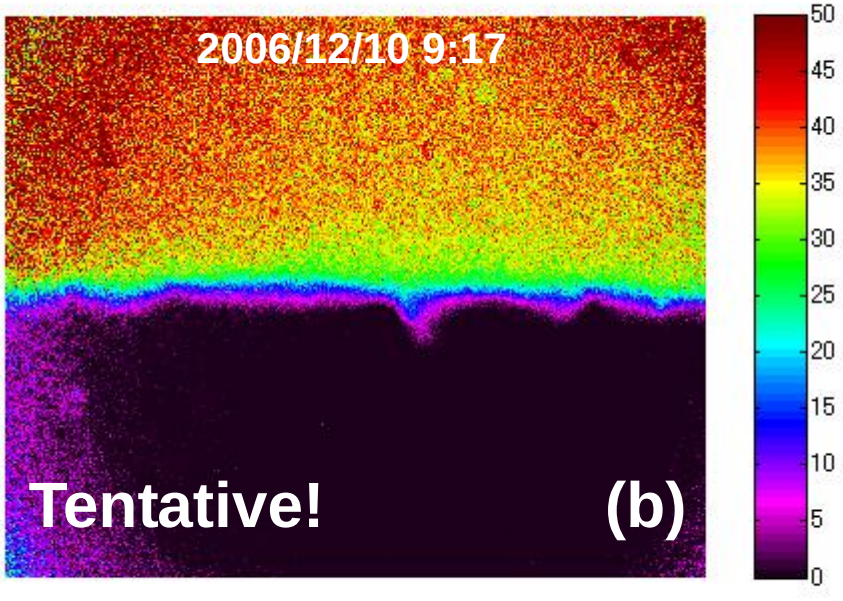
cut from the land station.

4-1-3. Result

4-1-3.1. Planar optode deployment

6288 images have obtained during the measurement. Using with these data, 3132 O2 images can be obtained. Examples of O2 distribution images taken at SWI at Hatsushima are shown in Fig. 7. For first image, O2 penetration depth seems deeper than other images. The cause may be a smearing when the periskop was descending or an existence of small space between sediment and the sensor foil. After one day, O2 penetration depth was shallower, and small topographic changes were seen. One obvious features that changing the surface topography and/or driving O2 irrigation are in benthic activities. Figs. 7b to 7d indicate development of small burrow by benthic animal. On the other hand, Figs. 7e and 7g showed centimeter scale topographic changes at the left size of these images. As to see these results, sediment surface at off Hatsushima is in high benthic activities.




2006/12/10 9:17
Tentative!
(b)
50
45
40
35
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25
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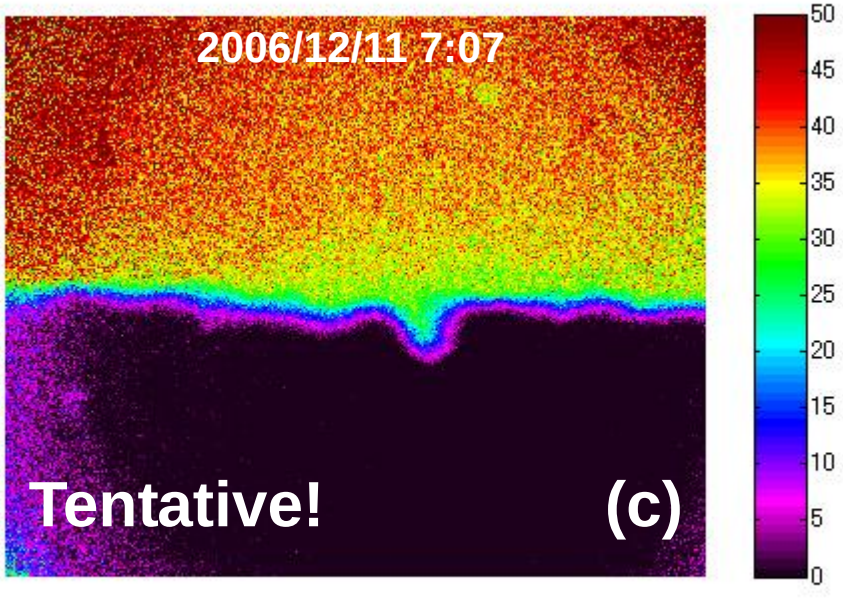
15
10
5
0
O2 (μM)


2006/12/11 7:07
Tentative!
(c)
50
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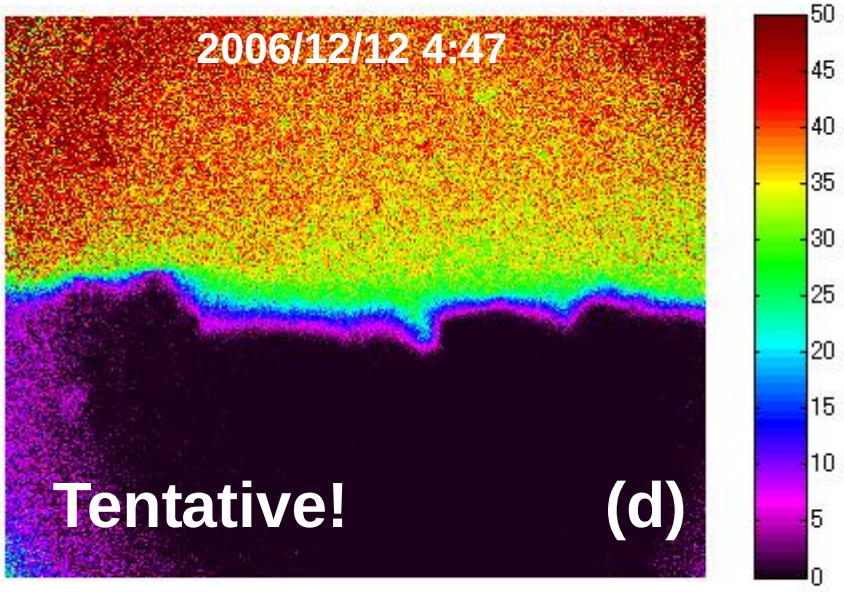
10
5
0
O2 (μM)


2006/12/12 4:47
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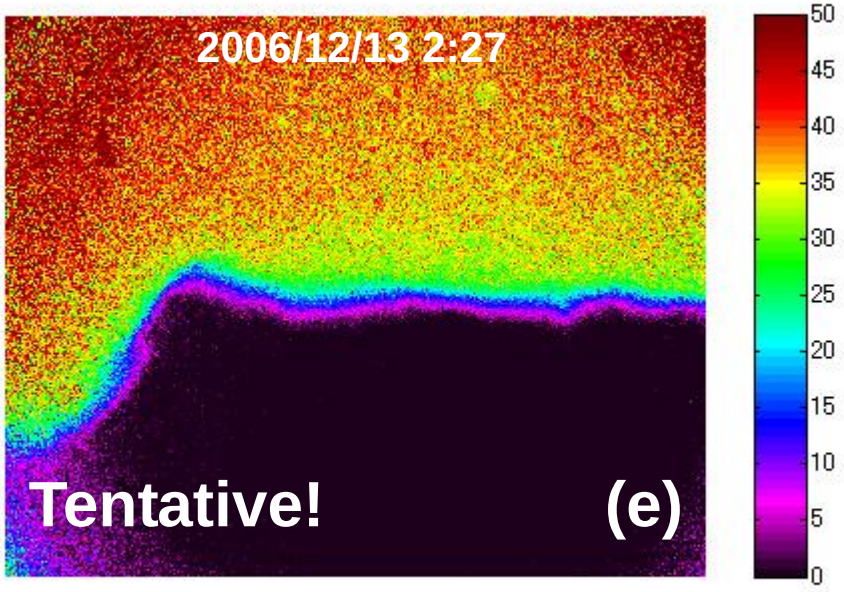
O2 (μM)


2006/12/13 2:27
Tentative!
(e)
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0
O2 (μM)

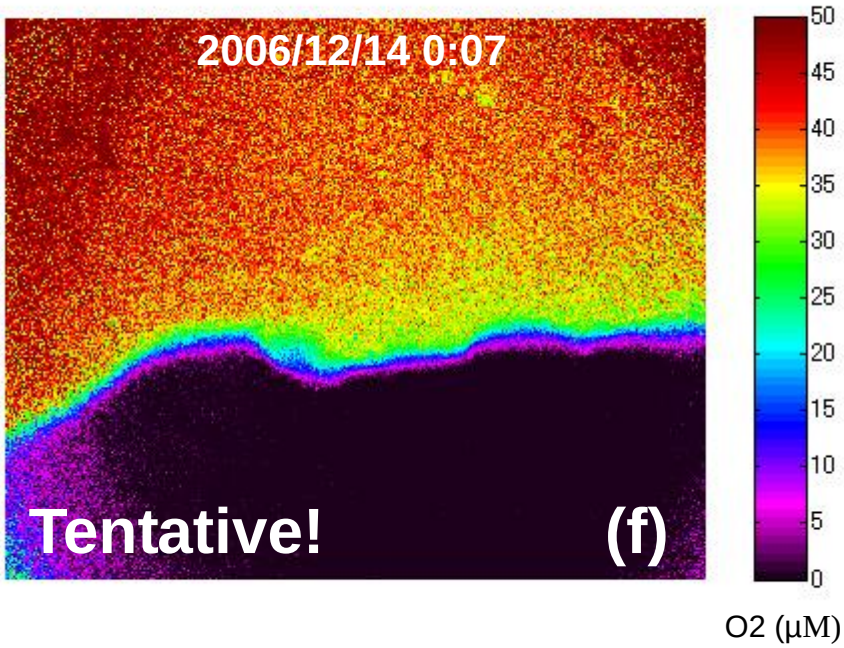

Fig. 7. Preliminary results of O2 distributions at SWI. The size of respective images are 6.0 cm x 7.5 cm. The range in O2 concentration is from zero to 50 μM.

4-1-3.2 O2 fluctuations observed by O2 optode sensor

Figs. 7a and 7b. show O2 concentration and temperature changes of the bottom seawater obtained by Aanderaa O2 optode sensor attached in our system, respectively. As our sensor had an offset, O2 concentrations were calculated subtracting of 7 μM, which was a difference between two Aanderaa sensors and the results from Winkler titration. Both O2 and temperature had small frustrations. For O2 concentration, they varied from 50.5 to 52.5 μM except for the higher value observed at 2:46 on 10th,Dec. For temperature, the values ranged from 2.74 to 3.09 ° C. These fluctuations may be a reflection of the changes of current which is caused by tide or internal wave. Anyway, these changes will be examined in future studies.

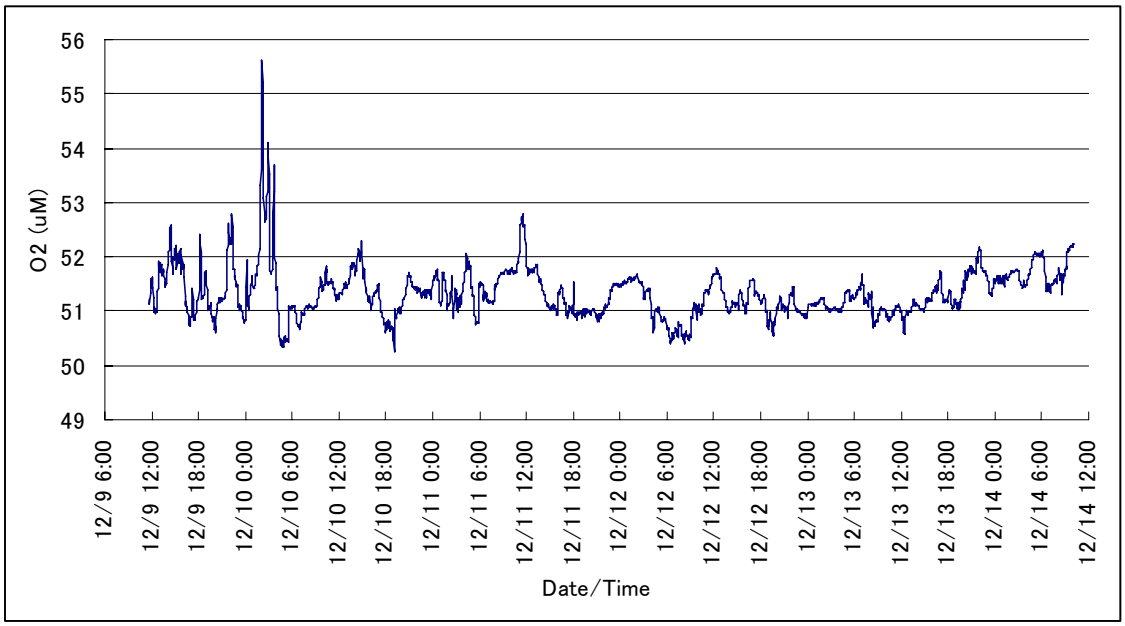

Fig. 8a. Time series changes of O2 concentration at off Hatsushima obtained by an Aanderaa O2 optode sensor.

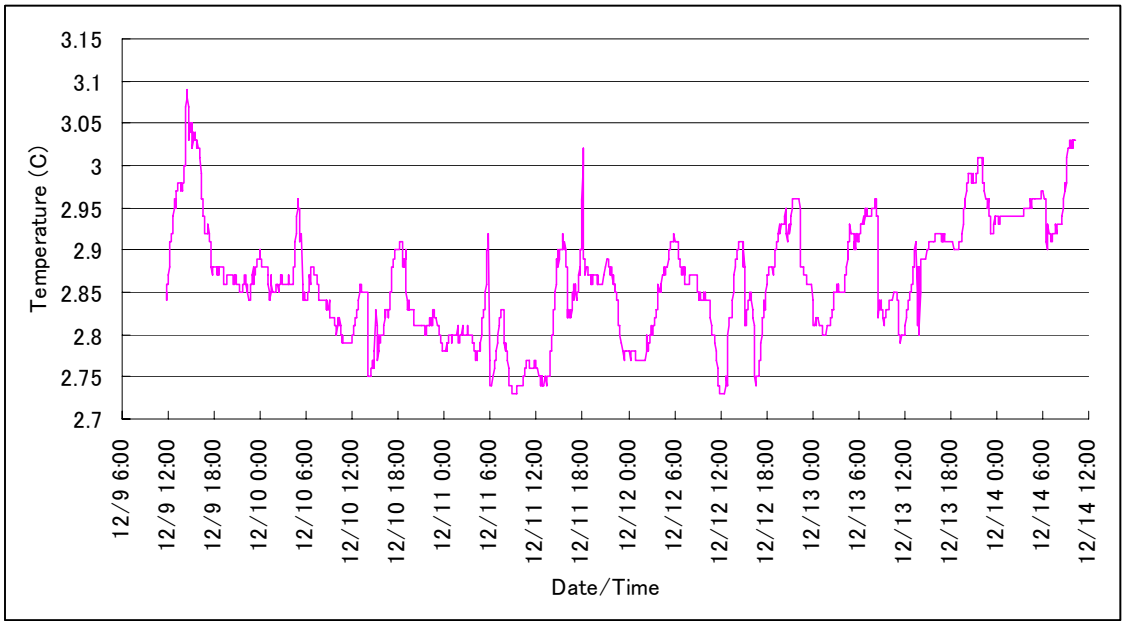

Fig. 8b. Time series changes of temperature at off Hatsushima.

4-1-4. Future studies

4-1-4.1 Quantifying O2 irrigation processes

Many data on O2 changes at SWI and water could be obtained. Using with the data,

we will study on interactions between O2 dynamics and benthic activities at SWI to visualize all the data. Using with the images, we analyze how much depths benthic animals irrigate O2 and mix the sediment. As well, gross O2 consumption rate will be calculated to know benthic activities. Further interest is a time-series changes of O2 distributions. O2 distributions obtained by Aanderaa O2 sensor indicated small fluctuations of O2 concentration in bottom water. If current intensities are changing due to tide or internal wave at the site, these may effect to O2 distributions at SWI. We will compare such data obtaining at Hatsushima observatory with the bottom water O2 concentration and the O2 distribution images.

4-1-4.2 Development of the planar optode system for long term O2-pH monitoring

Many technical developments for O2 imaging in situ have established through the cruise. However, small problems were found for the deployment. First, we will develop bottom detection scheme to set the periskop to the optimum position. One solution is an image processing in situ to obtain images during descending the elevator. Second, we will refine the script programs for automatic measurement and sequence control procedure, especially shut down routine of the PC. Third, we will finish developing O2-pH combined sensor foil to understand detailed O2 consumption and early diagenetic processes at SWI. These developments will make possible for long-term O2-pH monitoring in near future.

4-1-5. Acknowledgements

The experiment of planar O2 optode system was succeeded supporting by the following peoples: Captain Eikou Ukekura and the crew of R/V Natsushima, Kazuhiro Chiba and the Hyperdolphin Team, Frank Wenzhöfer (Max Planck Institute for Marine Microbiology), Saburo Sakai (IFREE, JAMSTEC), Kenichi Asakawa, Ryoichi Iwase, Takashi Yokobiki, Hidehiko Nakajyo, Shigehiko Morita, Ichiro Takahashi, Ai Takeda (MARITEC, JAMSTEC) and Kazuhisa Ito (Nippon Marine Enterprises, Ltd). This study is sponsored by JAMSTEC and Japan Society for the Promotion of Science.

4-1-6. References

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4-2. Cruise report - ”Danish team”

Ronnie N Glud, Henrik Staahl

4-2-1. Introduction

The work conducted during NT06-22 complement the work that was conducted during NT06-05 where we investigated the benthic biogeochemistry and O_2 microdistribution in central Sagami Bay (OBBII stn). This time we put special emphasis on the benthic N- cycling, the importance of foraminifera in the N-budget, and for the first time applied a transecting microprofiler equipped with 5 O_2 microelectrodes and a resistivity sensor.

4-2-2. Background

The efficiency of benthic mineralization processes, primarily driven by microbes, determines the fractions of C and N that are remobilized or retained in the sediment record. The sediment on one hand acts as a source of nutrients and dissolved inorganic carbon and thereby sustain the continued organic carbon production in the overlying water. On the other hand the sediment also acts as a sink in the C and N cycle by removing organic material via burial and transforming fixed N to N_2 by denitrification and anammox. The microbial activity of marine sediments thus plays a central role for the local as well as global C and N cycle. Most studies on benthic degradation processes have been confined to coastal settings and to a lesser extent the abyssal plains, but very little focus has been given to the continental slopes. These areas, especially if they are situated close to land, could play a key role by receiving large input of down-slope transported organic material and from the intensified water column production following upwelling. The central Sagami Bay represents such a location and the established database and logistic for the area offers a unique opportunity to evaluate the importance of deep slope sediments for regional (and global) element cycling.

During autumn 2003 detailed studies of the spatial variation in benthic O_2 dynamics and virus activity were performed in central Sagami Bay. The very large database on oxygen distribution documented an extensive small-scale variability (mainly expressed at spatial scales below 2 cm) in the O_2 penetration depth (a proxy for the benthic diagenetic activity) and a surprisingly high benthic activity with an average O_2 uptake of 2.6 +/- 1.6 mmol m^{-2} d^{-1} (n=45) which is equivalent to 8% of the estimated average primary production for the area (Nakatsuka et al. 2003). The average O_2 penetration depth amounted to 3.9 +/- 1.5 mm (n=347). The small scale variability was

also expressed in the horizontal variability in virus and bacterial abundances. Anoxic incubations documented that virus production was positively correlated to the metabolic activity of the bacteria and that virus infections were responsible for a prokaryotic mortality rate equivalent to 7-48% of the bacterial production.

The data obtained during spring 2006 (NT06-05) confirmed the pronounced small scale variability in the O_2 distribution and the abundance and production of benthic bacteria and virus (data are, however, still in the process of being analyzed). The microbial activity was, however, markedly lower that in autumn 2003 – the O_2 penetration depth varied between 4.5 and 11 mm (average 6.3 +/- 2.1 mm) (the microbial data still await full analysis), probably reflecting a situation prior to settlement of the spring bloom. Preliminary data showed that NO_3^- respiration was as important as the aerobic respiration at OBBII, and that anammox was responsible for 30-50% of the N_2 production at this location. Further we found that some foraminifera – primarily *Globobulimina affinis* and *G. Pacifica* stored large amounts of nitrate (upto 29 nmol NO_3^- pr cell). Thus they presumably contribute significantly to the N-dynamics by using nitrate as an electron-acceptor in their metabolism.

Primary goals of the present cruise were to:

- Complement the previous data on benthic mineralization activity (with the ultimate aim of establishing a seasonal/annual estimate of the benthic mineralization activity in central Sagami Bay.
- Applying a transecting microprofiler to obtain A) high-quality 3D-distribution of O_2 distribution at across the benthic interface, high-quality and high-resolution maps of the 2D benthic O_2 flux in relation to sediment structures and C) high-quality and high-resolution maps of 3D diffusion properties in relation to sediment structures using a resistivity sensor.
- Estimate the relative importance of benthic foraminifera for the benthic N-cycle, and the relation between internal nitrate content and the position in the vertical sediment profiles for different species.
- Quantify the benthic denitrification and anammox activity.

4-2-3. Materials & Methods

Lander system

To follow the in situ O_2 dynamics we applied a benthic lander system hosting a microprofiling unit equipped with 5 O_2 microelectrodes and 1 resistivity sensor. The

microprofiler was positioned at a sledge that moved horizontally within the lander frame in steps of 7 mm. Thereby we could obtain *in situ* transects, only separated by a few centimetres, of the O_2 distribution and sediment characteristics. The lander was deployed autonomously and sunk with an approximate speed of 15 m min^{-1}. After repositioning of the lander by the ROV, the measuring cycle was initiated by pressing a magnetic switch. Thereby the central cylinder gradually moved the sensors downwards in increments of 100 μm for a total distance of 5-7 cm and the sensor recordings were stored internally. Afterwards the sensors were moved back to the starting position and another motor moved the sledge of the microprofiler, horizontally along the bottom in 7mm increments. Sensors were calibrated from the readings in the bottom water of know O_2 concentration and in the anoxic sediment. At the end of the deployment (30-50 hours) the lander was hooked up to the ROV and brought onboard the ship.

Benthic Chamber

A small frame equipped with a central, stirred cylindrical chamber (i.d. 19 cm) was used to measure the total benthic exchange of O_2, NO_3^-, NH_4^+, and Dissolved Inorganic Carbon (DIC). Oxygen was measured continuously by two Elinor-microelectrodes, while five spring-loaded syringes were used to collect water from the chamber for later quantification of concentration changes in NO_3^-, NH_4^+ and DIC. The chamber was placed by the ROV and the water height inside the chamber was determined by the ROV-cameras. After the incubation the chamber was recovered by the ROV and brought back to the ship.

The total core incubation

The total exchange rates of O_2, NO_3^-, NH_4^+ and DIC were also measured in four recovered MBARI-cores placed at in situ temperature and O_2 concentration. After 12 h pre-incubation the cores were capped and water samples were recovered to monitor the concentration changes of the respective solutes. The cores were subsequently used to determine the denitrification rate by the Isotope Pairing technique (IPT) (along with 4 additional cores – in total IPT measurements were conducted on 8 cores). In parallel, homogenized sediment slices of 0.5- 3.0 cm thickness from 2 MBARI-cores were used to quantify the relative importance of anammox for the N_2 production. This was done by addition of i)$^{15}NO_3^-$, ii) $^{15}NH_4$ and iii) $^{15}NH_4 + {}^{14}NO_3$. Samples were extracted to follow the accumulation rates of $^{28}N_2$, $^{29}N_2$ and $^{30}N_2$ in a sediment slurry. The data will allow us to quantify the rates and relative importance of the anammox process for the total N_2

production in these sediments findings that will be complemented by and compared to values extracted from the IPT procedure.

Six sediment cores were recovered and will be brought back to Denmark to complement the previous investigations on the relative importance of microbial sulphate and metal respiration. This will be done by so-called back incubations in combination with $^{35}SO_4^{2-}$ addition experiments.

4-2-4. Preliminary Scientific results

Lander system: The in situ equipment was deployed twice at the Hatsushima and OBBII station, respectively. The system worked perfectly although that we underestimated the porosity at the Hatsushima station so that most profiles missed the sediment interface (the relative signal change of the resistivity sensor (e.g. 15% or 20%) defines the position of the sediment surface for the profiling program) – nevertheless we obtained a total of 25 O_2 microprofiles at this site. In central Sagami Bay we were more successful and obtained 136 O_2 microprofiles along 4 transects. The data confirmed the high spatial variability of the Sagami Bay sediments (Fig 1).

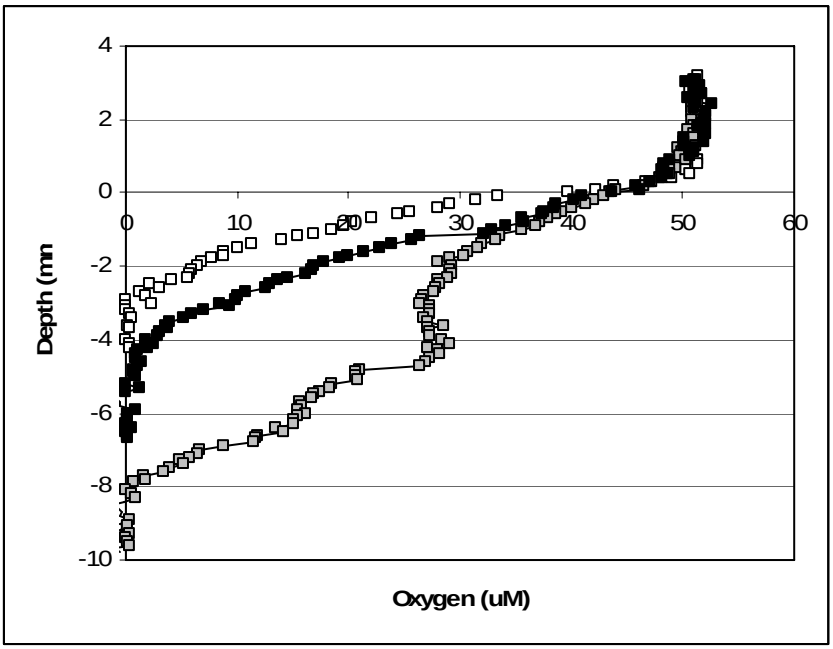


Fig 1. Three representative in situ profiles measured along a 23 cm transect at OBBII stn (Y=0 indicates the position of the sediment surface). In total 32 profiles were measured along this transect (for all 4 transects 126 profiles). In this figure we have aligned the

position of the sediment surface, but in reality the profiles reflected a topographic relief that can (and will) be extracted from the profiles for correct presentation of the O_2 distribution. The obtained profiles clearly reflect the small scale variability with a highly variable O_2 penetration depth. The deepest profile has penetrated through an animal burrow from -2 to -5 mm depth.

Combining the many profiles will allow us to construct 2D and 3D maps of the O_2 distribution in relation to the sediment surface over areas of up to 6 x 23 cm. Knowing the O_2 distribution and the diffusion properties (see below) of the sediment will allow us to model the 2 (or 3D) distribution of the volume specific O_2 consumption in the sediment - directly expressing the microbial activity. This will enable us to get insight in the distribution of potential microniches of intense microbial activity in the oxic zone – and to demonstrate the horizontal variability in the microbial activity at a high spatial resolution. The data will complement our present work of doing similar calculation of O_2 planar optode images obtained in spring 2006 at the same site.

In many instances we observed a flocculent layer of detritus that covered the sediment surface. This was apparent form characteristic breaks in the O_2-concentration profiles but also from the resistivity measurements. Sediment layers with different water content was apparent and from the transect and the variability in the layer thickness can be investigated. Vertical alignment between the respective profiles does, however, await further analysis in Denmark.

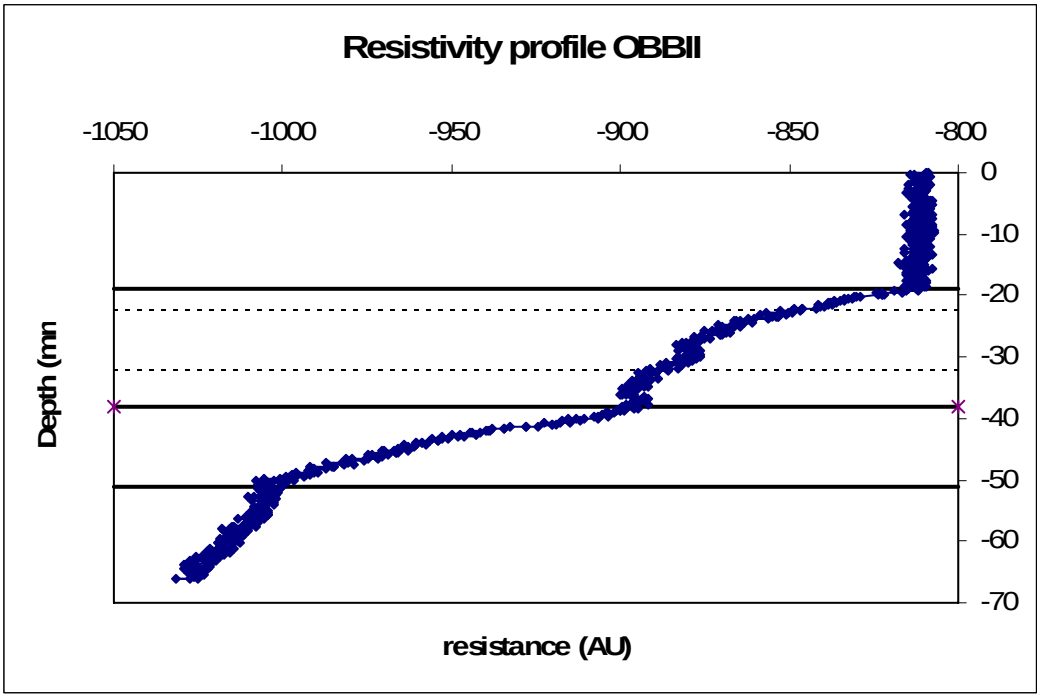


Fig 2. Representative in situ resistivity profile measured at OBB II (a transect of 32 profiles were obtained at this site). The first horizontal line indicates the position of the sediment surface. There after three distinctive layers with a gradual decrease in the water content is apparent. The zone boarded by the dotted lines marked the max and minimum O_2 penetration depth.

Benthic chamber: One deployment at OBBII was performed with the benthic chamber and it worked perfectly. During the incubation the O_2 concentration decreased from 51 to 17 μM with an initial O_2 uptake rate of 0.9 mmol m^{-2} d^{-1} (preliminary calculations) which was only slightly higher than in the early spring (prior to bloom settlement) of 0.7 mmol m^{-2} d^{-1}. During incubations samples for NO_3^-, DIC, NH_4^+ were taken but remain to be analysed in order to establish the benthic exchange rates of these solutes.

N cycling and foraminifera: All measurements of denitrification and anammox remain to be analysed. In order to evaluate the potential importance of nitrate-accumulating foraminifera for the benthic N cycling the upper 7 cm of a sediment core from OBBII was divided into 6 slices at the number of foraminifera withhold by a 125μm mesh were collected a total of eight species (and approximately 440 individuals) were collected by Hidetaka Nomaki. The specimens were divided into subsamples according to taxa, size and depth. Upon return to Denmark the intracellular nitrate concentration as a function

of species, sediment depth and size will be analyzed will be evaluated later. Along with analysis on isotopic fractionation (and the preliminary data collected during cruise NT06-05) the data will allow a first quantitative approximation of the importance of foraminifera for benthic N cycling (and mineralization) and elucidate which of the dominant species that are involved.

4-2-5. Future studies

Obviously the analysis and the full evaluations of the current efforts will inspire to future studies in Sagami Bay – especially in relation to benthic N-cycling (e.g. anammox, denitrification coupling between N and metal cycling, importance of nitrate accumulating meiofauna).

However, all ready now our preliminary data on the importance of anammox and foraminifera at this site call for a more detailed investigation. We would very much like to deploy our profiling lander (in transecting mode) equipped with a nitrate microsensor. We have just succeeded in adapting the “state of the art” nitrate biosensor to our lander and it would be very interesting to deploy this setup at the OBII stn in order to precisely define the benthic nitrate distribution. This work would be complemented by insertion of gel-pipers in situ. Thereby, we could resolve the fine scale-distribution of nitrate and ammonia in the surface sediment of Sagami Bay and better couple the distribution of foraminifera in relation to these solutes.

It is obvious that the Sagami Bay sediment express high spatial and temporal dynamics. The existing possibility to connect our measuring modules (microprofiler, “intelligent” chamber) in parallel with the planar optode to the Hatsushima sea-floor observatory for power supply and data transfer, offers a unique opportunity to study temporal and spatial variability in benthic solute distribution (O_2, H_2S, pH) over a longer period of time. This potential ought to be explored. Such an effort would, however, at present be constrained to work at the seep sites – to establish a similar possibility in central Sagami Bay would been extremely interesting for studying more representative deep slope sediments. Small scale benthic variability could be investigated by transecting vehicles and temporal dynamics in solute distribution of important biogeochemical constituents could be studied on scales from seconds to seasonal changes. We would be very interested in a collaboration adapting our instrumentations to such platforms and to explore the potential for transecting instrumentation.

Another exciting possibility would be to develop and adapt an eddy-correlation-instrument to the permanent station thereby we could resolve

variations in the benthic O_2 uptake both on short term and long-term time scales – we would like to explore this potential as a collaborative effort together with our colleagues at JAMSTEC.

Despite our prime interest in the more “normal” sediments of Sagami Bay, the diversity in biogeochemical processes around the seeps sites as evident from the different microbial mats, sediment coloration and fauna occurrence, also has our interest. The microprofiling and planar optode facilities could easily be deployed at such sites and would provide detailed information on the chemical conditions at these locations the functioning of the different microbial communities and the seeps themselves. This includes virus-bacterial interactions in microbial communities with a relatively low diversity.

It appears that the benthic macrofauna play a key role in the function of the sediment. The sediment is densely populated by a diverse fauna dominated by polycheats. They must be important for the bioturbation (maintaining a high microbial metal respiration?), for structuring the patchiness in microbial activity, and for the initial phases in the degradation cascade. Detailed laboratory based investigations with “state of the art” O_2 microsensing equipment around recovered specimens of infauna would complement the in situ work extremely well. This would allow making a coupling between benthic O_2 dynamics and fauna behaviour (bioirrigation and bioturbation) and would provide important background information for detailed biogeochemical studies of the sediments. We propose to undertake such efforts.

4-2-6. Financial support

The described activities were sponsored by JAMSTEC, The Science Foundation for Nature and Universe – DK (including the Galathea-project).

4-2-7. Sample list:

Bottom water all used in conjunction with core incubation

Total 18 MBARI-cores at OBBII:.

-2 for foraminifera picking

-2 for anammox measurements

-4 for total core exchange incubation and denitrification

-4 for denitrification

-6 for bringing back to Denmark for further analysis on sulphate reduction and metal respiration.

4-3. Long-term fate of organic carbon on the deep-sea floor-*In situ* tracer experimental study-

Hidetaka Nomaki, Hiroshi Kitazato

4-3-1. Introduction

Phytodetritus, originated from primary production, transports substantial amount of carbon from ocean surface to the seafloor. The phytodetritus and its degraded components are thought to be major food sources for deep-sea benthic ecosystems. Some pervious in situ ^{13}C-tracer experiments revealed that phytodetritus was quickly incorporated into benthic foraminifera and bacteria in a day time scale. At the same time, organic carbon produced at the seafloor by microbial activity from dissolved organic carbon (DOC) is also an important food source for the deep-sea benthic ecosystems. Furthermore, long-term fate of ^{13}C-labeled organic matter provides us a new insight for paleoceanographic application of lipid biomarkers. To know the carbon pathways originated from phytodetritus and DOC on the seafloor, we operated a stable carbon isotope labeled experiment *in situ* both for 2 days and for a year. Incorporation of labeled algal carbon and glucose into benthic organisms will be analyzed each organic compound level.

4-3-2. Materials and Methods

Total 4 culture cores were prepared for the experiment (Figure 1, Table 1). The surface sediment area of the core is 52.8 cm^2 (ϕ=8.2cm). Two cores were prepared for a long-term incubation. They have 6 holes (ϕ=1.0cm) on the upper 2 cm part of the polycarbonate tube. These holes were designed for allowing a seawater exchange between inside and outside of the core. All the holes were sealed with plankton net. Every core has couple of 5ml syringes that can contain ^{13}C-labeled algae, *Chlorella sp.*, and uniformly ^{13}C-labeled glucose (Cambridge Isotope Co. ltd). The culture cores are named C-*n* and G-*n*, where C and G indicate ^{13}C-labeled food materials (Chlorella and Glucose, respectively), and *n* indicates incubation period (2 day = 2 and year = y).

Three culture cores (G-2, G-y, and C-2) were settled on the seafloor (water depth 1453 m) by the ROV Hyperdolphin at dive #625 (11th December). Culture cores were placed 26m away from the OBB2 station and kept some tens cm away from each other (Figure 1, 2). After positioning the culture cores, ^{13}C-labeled food materials were

introduced to the surface sediments (one core for ^{13}C-Chlorella, and two cores for ^{13}C-Glucose). On the dive # 627 (13th December), another core equipped with the ^{13}C-Chlorella (C-y) was additionally settled on the seafloor some tens cm away from the G-y. After finishing the installation of C-y, C-2 and G-2 cores were recovered on board. The rest 2 cores (C-y and G-y) will be incubated for a year on the seafloor, and be recovered by *Hyperdolphin* cruise which will be held in January 2008.

On the Dive #625, one reference sediment core was sampled at some tens meters away from the incubation station. The inner diameter of the core was same to culture cores (ϕ=8.2cm).

4-3-3. Preliminary results: On board processing

On board, recovered culture cores (C-2 and G-2) and a reference core were kept at 4°C prior to core processing (within one hour). Overlying water was collected for the determination of ^{13}C concentration in dissolved inorganic carbon (DIC). They were fixed by adding a drop of $AgCl_2$ solution and preserved at 4°C. Sediments were sliced at 1-cm intervals from 0 to 5 cm in depth followed by 5-7, 7-10, 10-15cm sediment depth samples (Table 1). Subsamples (15 cm^3) of the sediments were taken for an analysis of bulk organic matter. These samples were kept frozen at –80°C until the analysis. The remaining sediments of 0 to 5cm in depth were used for the determination of carbon isotopic compositions of lipid compounds in benthic organisms. They were sieved on a 125-μm mesh with seawater and then stored at –80°C prior to the isolation of benthic organisms from the sediments.

4-3-4. Future works

Mineralization rate of organic carbon by total benthic community will be evaluated from ^{13}C concentrations in DIC of the overlying water. Benthic foraminifera and metazoans will be picked out from the sieved sediments. Lipids will be extracted from both bulk sediment and organism samples. Identification and quantification of separated lipids will be performed by GC/MS. Compounds specific carbon isotopic compositions will be determined by using GC/C/MS. Using these data, incorporation and alteration of algae (phytodetritus) and glucose (DOC) by organisms will be examined.

Table 1. Sample list of *in situ* experimental sediment cores.

Core name	C-2	G-2	C-y	G-y	Reference
Recovered Dive #	627	627	Jan. 2008	Jan. 2008	625
Set Dive #	625	625	627	625	—
Overlying water	2 samples	2 samples	—	—	3 samples
0-1cm	BS+Foram	BS+Foram	—	—	BS+Foram
1-2cm	BS+Foram	BS+Foram	—	—	BS+Foram
2-3cm	BS+Foram	BS+Foram	—	—	BS+Foram
3-4cm	BS+Foram	BS+Foram	—	—	BS+Foram
4-5cm	BS+Foram	BS+Foram	—	—	BS+Foram
5-7cm	BS	BS	—	—	BS
7-10cm	BS	BS	—	—	BS
10-15cm	BS	BS	—	—	BS

BS = bulk sediment sample

Foram = foraminifera and metazoan meio-macrofauna samples

— = no sample

Figure 1. I-K type *in situ* feeding cores (G-2, G-y, C-2, and C-y cores from the left of the picture). Both G-y and C-y cores have 6 holes (ϕ = 1cm) covered with plankton net on the top 1cm of the polycarbonate tube.

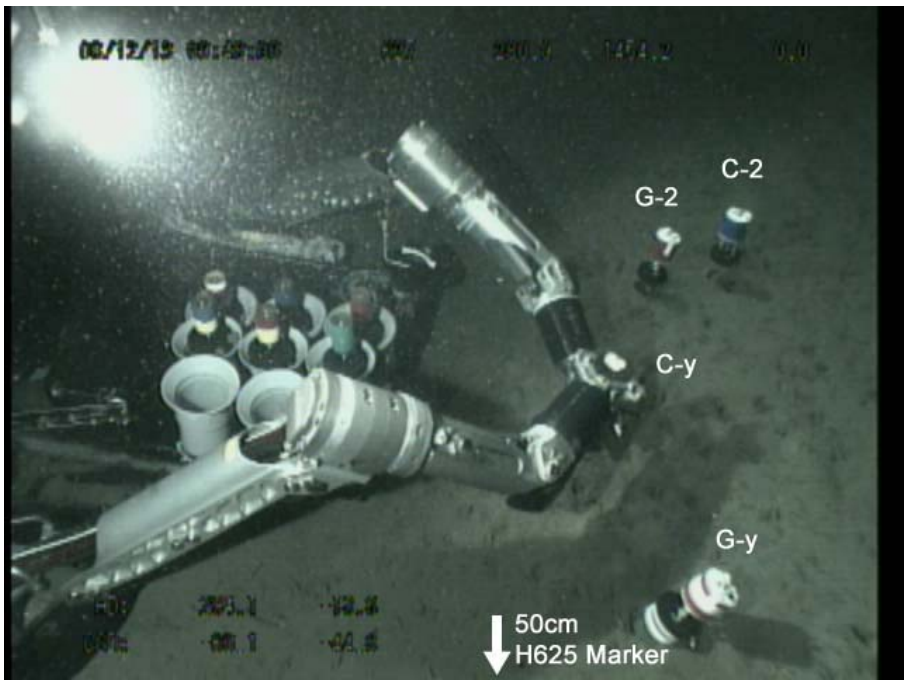


Figure 2. Positions of the feeding cores on the deep-sea floor.

4-4. In situ marking experiment for estimation of shell growth rate of *Calyptogena* clams

Yohei Tada, Katsunori Fujikura, Hiroshi Kitazato

4-4-1. Introduction

Calyptogena, one of the dominant genus at hydrothermal vent and cold seep community, are well known as large shell deep sea clam. General deep sea clams have small shells and low (few mm/y) growth rates (*e.g.*, Turekian *et al*., 1975). Several workers indicate the high growth rate of hydrothermal clam *Calyptogena magnifica* as 5 ~ 2 cm/y in younger part (less than 10 cm shell length) and <1 cm/y in older part (*e.g.*, Lutz *et al*., 1985; Luts and Kennish, 1993). In our *in situ* growth experiments on NT06-04 and NT06-05 cruises, we applied a traditional mark & recovery method to cold seep clam *Calyptogena soyoae/okutanii* (7 ~ 9 cm shell length). The results show that their growth rates are 30 ~ 50 um/10 days (about 1 mm/y). Our results indicate that the growth rate of cold seep *Calyptogena* is significantly lower than the hydrothermal *Calyptogena* species and approximates to general deep sea clam's one. However, these results are depended on short term experiments (during 10 days). If some stresses temporally prevent shell growth, the previous shell growth rates mean 30 ~ 50 μm/few days (= 1 ~ 10 mm/y). To eliminate such a temporal growth break, we should run more long term *in situ* growth experiment under the same conditions.

4-4-2. Proporsals

To estimate the growth rate, we will recover living stained *Calyptogena* specimens during Dive 623 on December 10, 2006. These specimens stained by $SrCl_2$ and calcein fluorescence solution during Dive 528 in NT06-04 cruise on March 15, 2006, and have grown 265 days after the staining experiment. To obtain environmental data, we set CTD (for seawater temperature, pressure and conductivity) and TD (for temperature and pressure) in Calyptogena colony during this cruise. Sediment samples are collected to extract porewater samples going to analyze stable oxygen isotopic compositions.

4-4-3. Methods

Stained *Calyptogena* specimens are collected using by slab gun mounted on HPD. Seawater temperature, pressure and conductivity are measured every 10 minutes by CTD *DST CTD* and temperature and pressure are measured every 2 minutes by TD

DST centi ex (Star-Oddi Co.) during Dive #623 and #629 at the site of ID 31 ROV Homer (Fig. 1). Machine precisely are ± 0.1 $°C_{temp}$, ± 0.8 $mS/cm_{conductivity}$ and ± 0.6%FS_{depth} for *DST CTD* and ± 0.1 $°C_{temperature}$ and ± 0.4%FS_{depth} for *DST centi ex*, respectively. Pore waters are taken from sediment cores by K-T type extraction device. The sediment cores are sampled from several *Calyptogena* colonies around the Hatsushima Station at Off Hatsushima Island (Fig. 2), using by MBARI type push core. To cut the sediments, we use Kitazato type core cutter.

4-4-4. Scientific Results

After recovered Fujikura type Marking Box, we collected 23 stained *Calyptogena soyoae/okutanii*, 1 *Phymorhynchus buccinoides*, 1 *Bathyacmaea nipponica*, several *Polychaeta* spp. and 5 *Ophiuroidea*. *Calyptoena* and *Ophiuroidea* were frozen at -80 °C and *Phymorhynchus*, *Bathyacmaea* and *Polychaeta* were fixed with 70% ethanol.

Core 1 and 2 were sampled at 35°0.69’N, 139°13.401’E, near by ID 53 ROV Homer, and core 3 and 6 were sampled at 35°0.095’N, 139°13.479’E, near by ID 31 ROV Homer. Core 4 and 5 were collected adjacently to the CTD and TD. The core 1, 13 cm long, included a *Calyptogena* specimens, burrowing into sediment at 7.5 cm depth (Fig. 3a, b). From the core 2, 13 cm long, we collected overlying water and bulk sediment frozen at -80 °C. The core 3 was 10 cm long (Fig. 3c). The core 4 and 5 were composed by sand and the core 4 included many clam worms (Fig. 3d, e). The core 6 was composed by brown and black silt with hydrogen sulfide smell. The sediments of core 3 and 4 were divided at 1 cm intervals from 0 to 5 cm depth and 2.5 cm intervals from 5 to 10 cm depth and filled into the syringes. From the core 1, 5 and 6, three parts of sediments, 0 – 5, 5 – 7.5 and 7.5 – 10 cm depth, were sampled and filled into 50 ml syringes attached 50 μm mesh filters to the top of syringes. Using by K-T type extraction device, we got 5 – 12 ml pore waters from each sediment sample.

The data of *DST CTD* and *DST centi ex* were shown in Figure 4. Throughout the experiment, seawater temperature and salinity were slightly rising and falling, respectively.

4-4-5. Proposal for future study

After the measurements of wet weight, dry weight, shell size and total carbon of soft tissue, the several shells of *Calyptogena* specimens are embedded in resin and cut along the maximum growth axis. The calcein-fluorescent bands on the shell cross sections are determined by the fluorescent microscopy and the laser scanning

microscopy. Sr enriched bands are determined by the backscattering electron image. These analyses reveal the growth amount during 265 days.

The pore water samples derived from sediment cores are analyzed stable oxygen isotope compositions and discussed with in situ seawater temperature and salinity values calculated from the CTD data.

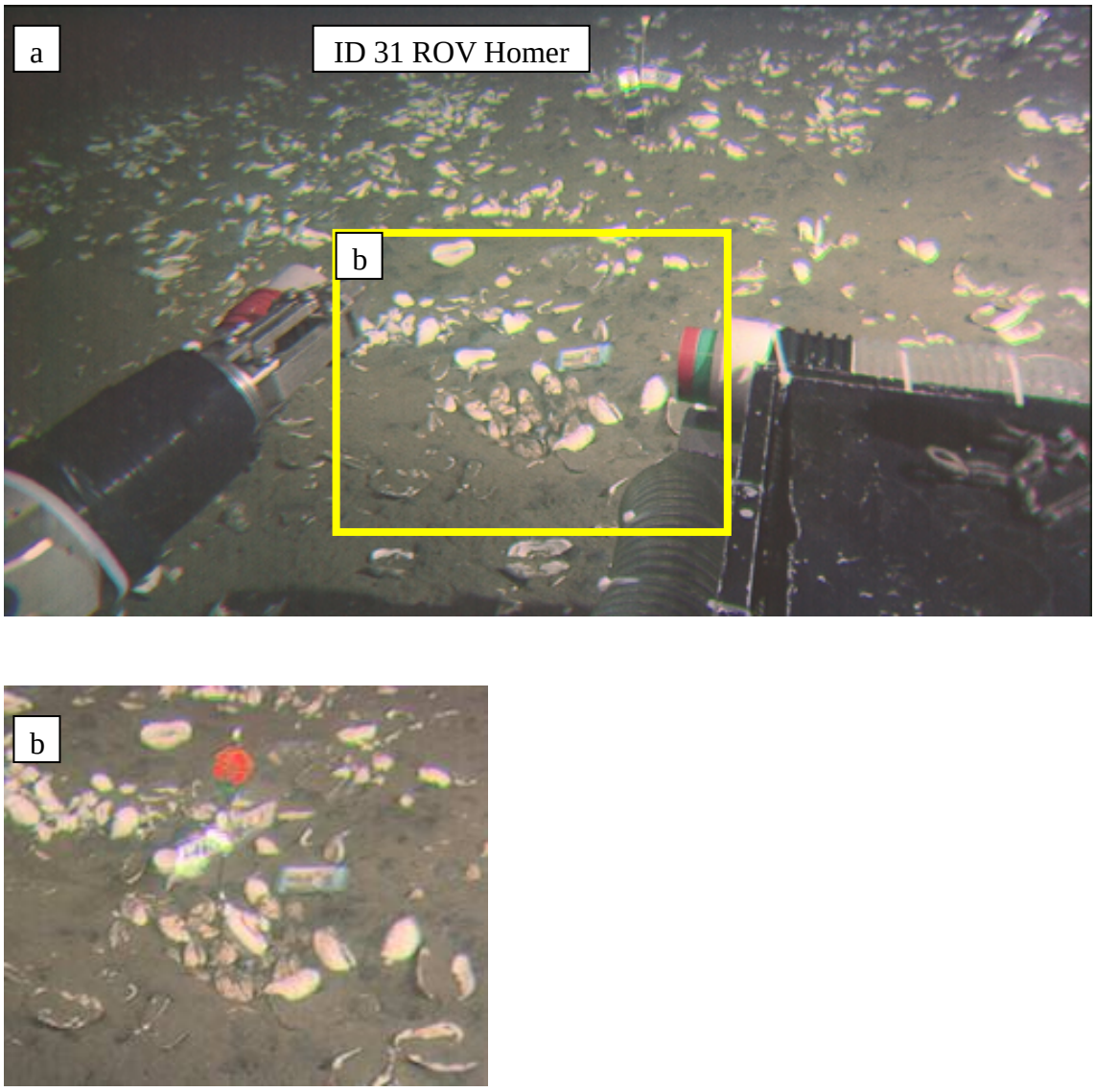


Fig. 1. (a) Measurement site of CTD is adjacent to ID 31 ROV Homer. (b) *DST CTD* and *DST centi ex* were set on living *Calyptogena* specimens.

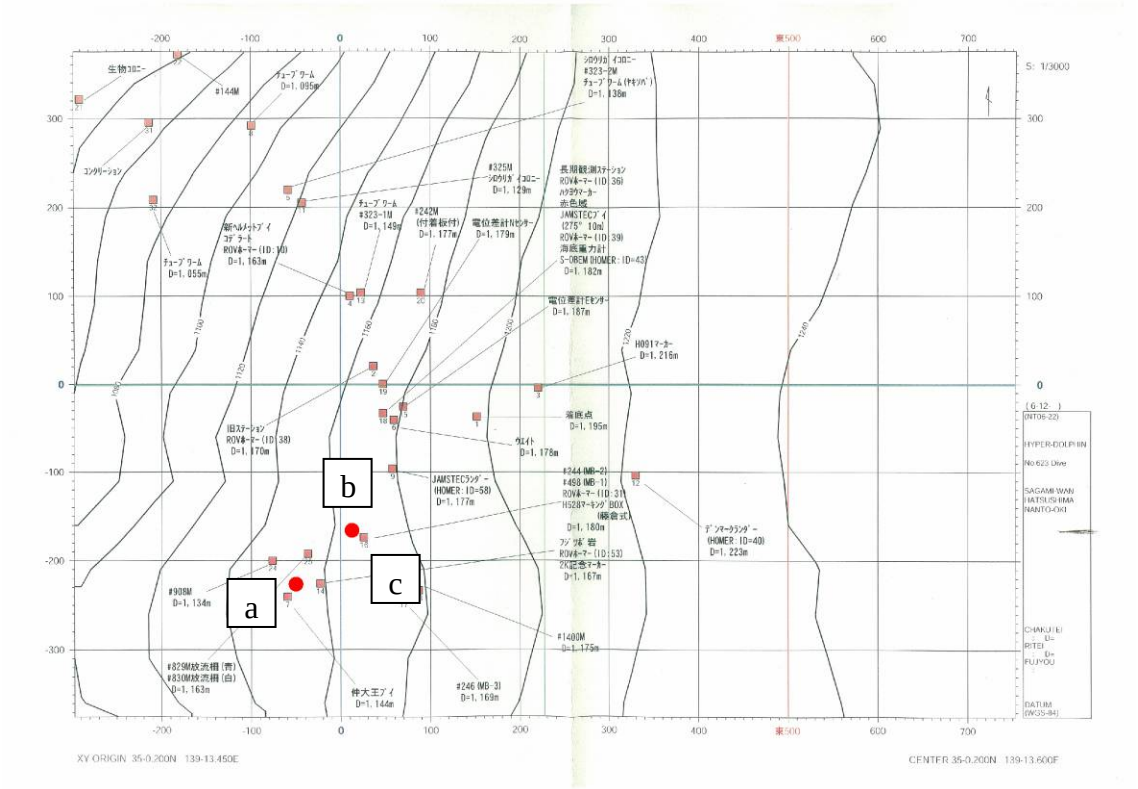


Fig. 2. (a) Core 1 and 2 were collected from near by ID 53 ROV Homer, (b) Core 3 was near by ID 31 ROV Homer, (c) and Core 4 – 6 were at ID 31 ROV Homer.

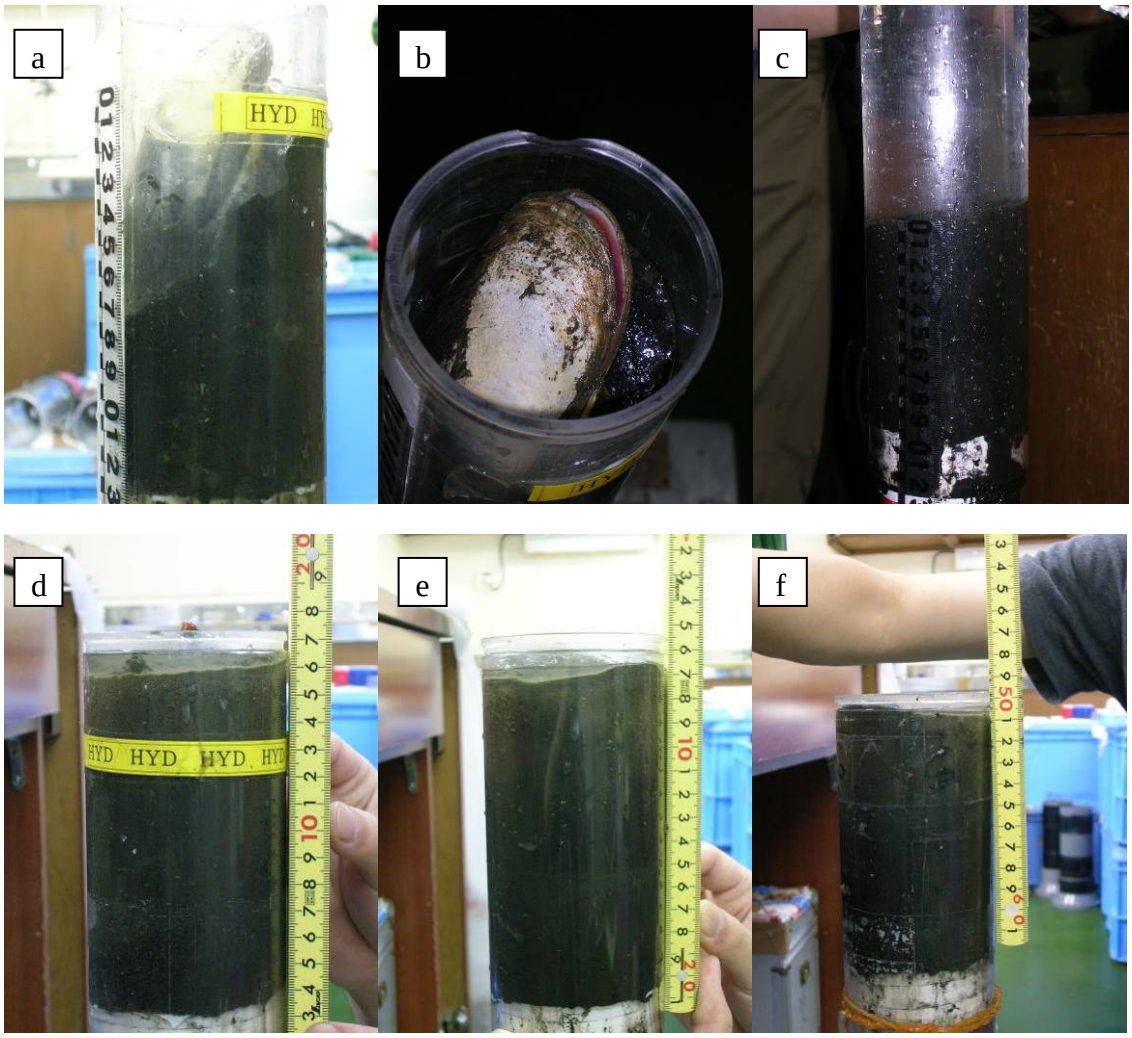


Fig. 3. (a), (b) Core 2 kept the habitat of *Calyptogena*. This fresh specimen had burrowed into sediment at 7.5 cm depth. (c) Core 3, about 10 cm long, was composed by black silt with the smell of hydrogen sulfide. Sediments of core 4 (d), 12 cm long, and core 5 (e), 13 cm long, were mainly brown sand and included many clam worms. (f) Core 6, 11 cm long, was composed by brown and black silt with H_2S smell.

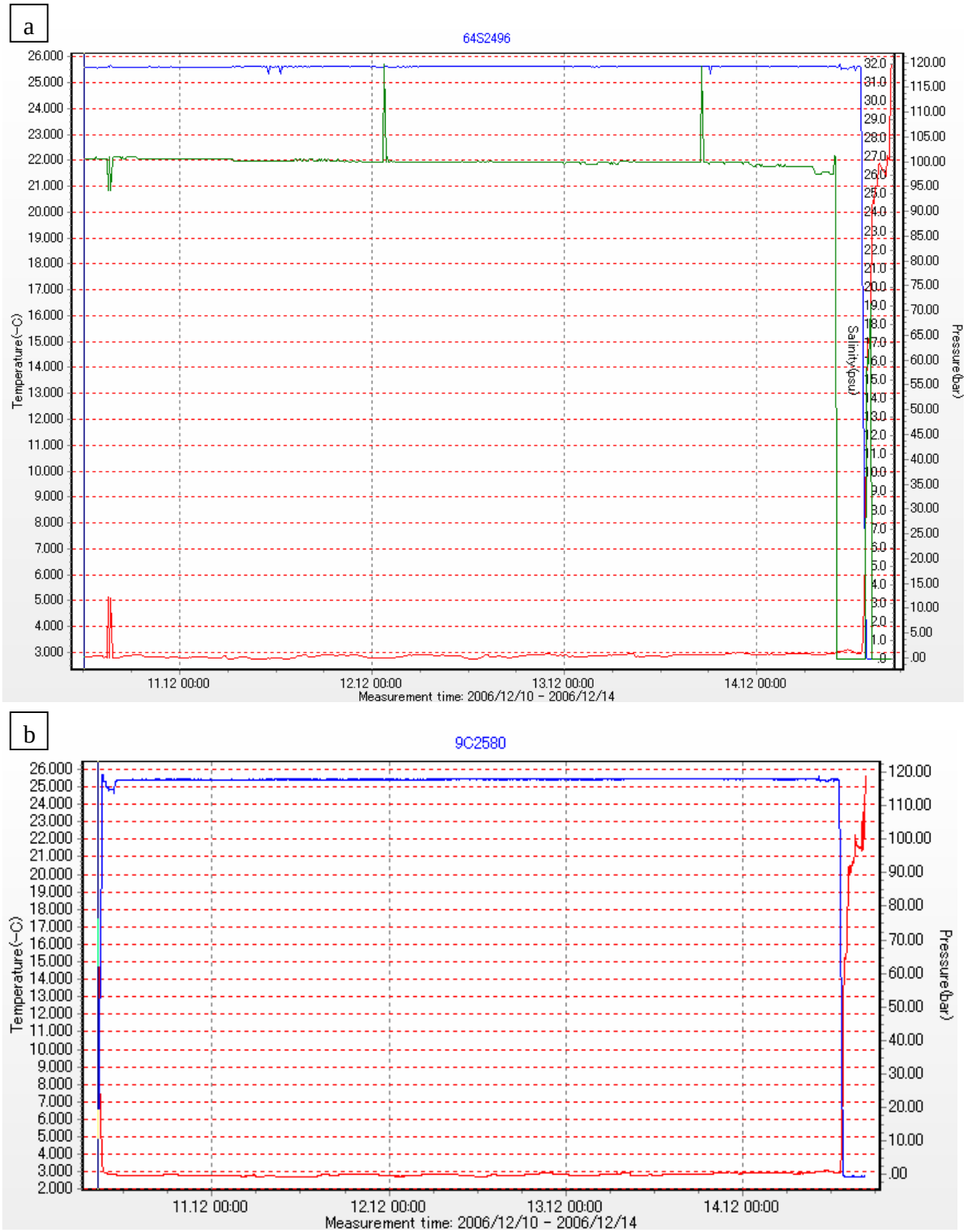


Fig. 4. (a) CTD data from 12:00 on December 10 to 9:30 on December 14, 2006. Red line means seawater temperature, green one is conductivity and blue one is pressure. (b) TD data from 11:08 on December 10 to 9:34 on December 14, 2006. Legend is same as (a).

4-5. Marking experiment for estimation of *Calyptogena* clams, feeding ecology of snail *Phymorhynchus buccinoides*, and taxonomical study of shrimp *Alvinocaris longirostris*

Katsunori FUJIKURA (JAMSTEC)

4-5-1. Proposals

(1) Marking experiment for growth rate estimation of *Calyptogena* clams

Growth rate is very important factor to understand animal ecology. Our knowledge of the life history and growth of most deep-sea animals is very limited due to the logistic difficulties of deep-sea investigations. Vesicomyid bivalves are a common taxon at deep-sea vents and seeps. We have a few data of growth rate of vesicomyid bivalves such as *Calyptogena magnifica, C. kilmeri, C. pacifica* and *Vesicomya gigas* (Lutz et al, 1985, Barry et al. in press). However, there is no growth rate data of Japanese vesicomyid bivalves. To measure for growth rate of bivalves, common method is marked-release-recapture. This is 1) collecting living animals from fields, 2) measuring size of shell parameter including length, height and width using a slide caliper, 3) marking on shell such as numbering or painting, 4) release to field, 5) recovering marked animals a couple of month later. This method is useful for shallow water bivalves. However, it is difficult to apply for deep-sea animals due to high stress by recovering from deep sea. Therefore, we tried *in-situ* marked-release-recapture for estimation of vesicomyid clams, *C. soyoae* and/or *C. okutanii*, in seep areas, the Off Hatsushima site, Sagami Bay.

(2) Feeding ecology of snail *Phymorhynchus buccinoides*

Gastropod, *Phymorhynchus buccinoides*, is endemic species of seep community at the Off Hatsushima field, Sagami Bay (Fujikura et al. 2002). This species belongs to family Turridae and has no radula in its mouth (Okutani et al. 1993). To understand of food web of Off Hatsushima seep community, we have studied anatomy, histology, stomach contents and stable isotope analysis of *P. buccinoides*. Preliminary results showed stable isotope values of *P. buccinoides* were almost same it of symbiont bacteria having mussel, *Bathymodiolus platifrons* (Toshiro Yamanaka, unpublished data), no contents found in their stomach (Takenori Sasaki, unpublished data) and no symbiont bacteria found in their gill cells (Takeo Yoshida, unpublished data). To find out feeding ecology of *P. buccinoides*, we conducted in-situ experiments including

deployment a fish and crushed *B. platifrons* at *P. buccinoides* habitat.

(3) Taxonomical study of shrimp *Alvinocaris longirostris*

The caridean shrimp family Alvinocarididae is known from chemosynthetic communities associated with hydrothermal vents and cold seeps. In western Pacific, nine species belonging to six genera of alvinocaridid shrimps were reported. *Alvinocaris longirostris* (Kikuchi and Ohta, 1995) have the most widely dispersal in alvinocaridid shrimps in East Pacific Ocean. This species collected from vent and seep sites on Sagami Bay, Hatoma Knoll, Iheya Ridge, Daiyon Yonaguni Knoll and Manus Basin. The purpose of present study is to analyze biogeography of *A.longirostris* by molecular method.

4-5-2. Methods

4-5-2.1. *In-situ* Experiments

(1) Marking experiment for growth rate estimation of *Calyptogena* clams

In-situ marking experiment for estimation of vesicomyid clams conducted on March 15, 2006, 35°00.093'N, 139°13.499'E, 1175m using ROV Hyper-Dolphin (#528) as follow.

1) Put on marking box on bivalve aggregation,
2) Inject chemical ($SrCl_2$ $6H_2O$ & Calcein) in marking box. *Calyptogena* shells were marked with $SrCl_2$ hexahydrate ($SrCl_2 \cdot 6H_2O$, Wako Pure Chemical Industries, Osaka, Japan). They were also marked by immersion in the diluted fluorescent chemical calcein ($C_{30}H_{26}N_2O_{13} \cdot HCl$, Wako Pure Chemical Industries). The chemicals were dissolved at concentrations of 2.88 g/l $SrCl_2$ and 0.7 g l/1 calcein.

Fig. 1. Chemical injection into marking box.

3) Open marking box 17-24 hours later.

Marked vesicomyid clams were recovered on Hyper-Dolphin #623, December 10,

2006.

4) Shell preparation:

After culling, the shells were cleaned of adhering tissue and dried in an oven (60°C) for 24 h. A transverse section was cut across the longest shell axis, and the ventral part was divided into anterior and posterior sections. Methacrylate-based resin was used as embedding medium. Each shell was first embedded in the resin. For SEM, the cross sections were ground with 600-grit sandpaper and then wet-polished using 9 μm, 3 μm, and finally 0.05 μm polishing suspension. For fluorescence optical microscopy fitted with an ultraviolet (UV) light source and a fluorescence filter, embedded shells were sliced into approximately 200 μm sections. The sections were attached to glass slides and the facings wet-polished with a 9 μm polishing suspension.

5) Detection of incorporated bands

The embedded shells were carbon-coated using a vacuum-evaporator. This treatment produced bands of Sr-enriched areas in the shells that were detectable in a back-scattered electron image under SEM. Calcein was detected by examining the sectioned shells under fluorescence optical microscopy fitted with an ultraviolet (UV) light source and a fluorescence filter.

6) Growth rate

Once the position of a bright band ($SrCl_2$) or a fluorescent band (calcein) had been determined, the growth increment between the band and the shell margin was measured under SEM or under optical microscopy. Growth increaments were measured as follows:

- A tangential line was drawn close to an incorporated band on the sectioned shell;
- a perpendicular line was drawn from a tangential line to the shell margin;
- the maximum length of the perpendicular line from the tangential line to the shell margin was regarded as the growth increment of the anterior or posterior part of the sectioned shell;
- the total growth increment equalled the sum of both the anterior and posterior growth increments.

Growth rate was calculated using the formula growth rate (μm d) = L/D, where Lis the total growth increase and Dis the number of days post-treatment.

(2) Feeding ecology of snail *Phymorhynchus buccinoides*

We deployed fresh fish (mickel) and crushed *B. platifrons* at *P. buccinoides* habitat in HPD #623. A couple of hours later, we revisited to deployment site and observed behavior of *P. buccinoides.*

(3) Taxonomical study of shrimp *Alvinocaris longirostris*

A. longirostris were collected by suction sampler. Samples were preserved in freezer for molecular analysis. When we compeered the mtDNA COI region sequence of *A.longirostris* among these localities, it was clarified that there was no genetic difference among shrimps from these localities. Genomic DNA will be extracted from muscle. Mitochondrial cytochrome oxidase I (COI) gene will be amplified from total DNA by polymerase chain reaction (PCR) using universal primer HCO2198 and LCO1490 (Folmer et al., 1994) and DNA will be sequenced by 3130 genetic analyzer.

4-5-3. Preliminary Scientific Results

4-5-3.1. *In-situ* Experiments

(1) Marking experiment for growth rate estimation of *Calyptogena* clams

Twenty-three specimens of *Calyptogena soyoae/okutanii* were collected within *in-situ* marking box (Fig. 1). No fresh dead shell found. Therefore, all specimens lived during *in-situ* experiment period 271 days from injected chemical to recaptured days.

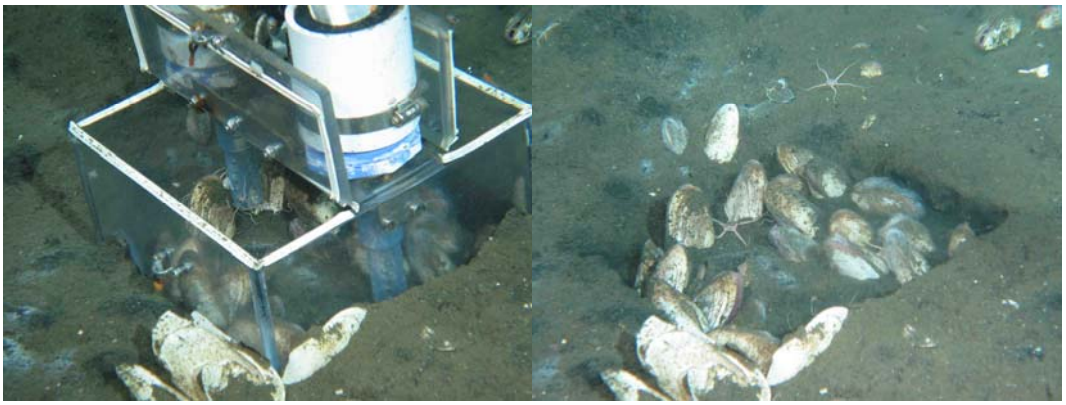


Fig. 1. Left: Chemical injected specimens of *Calyptogena soyoae/okutanii* in marking box. Right: All specimens lived for 271 days after chemical injection.

(2) Feeding ecology of snail *Phymorhynchus buccinoides*

Three hours later from deployment a fish and crushed *B. platifrons* at *P. buccinoides* habitat, we revisited deployment. A lot of specimens of *P. buccinoides* were aggregated on crushed *B. platifrons* (Fig. 2). Therefore, *P. buccinoides* eat *B. platifrons.* Unfortunately, we could not find a fresh fish (mickel) due to movement by animals, probably.

Fig. 2. Left: before deployment a fish and crushed *B. platifrons* at *P. buccinoides* habitat. Right: three hours later from deployment, aggregation of *P. buccinoides*.

(3) Taxonomical study of shrimp *Alvinocaris longirostris*

When we research the difference of genetic diversity of *A.longirostris* among habitats in Hatoma Knoll, Iheya Ridge, Daiyon Yonaguni Knoll and Manus Basin, It was found that the genetic diversity of the shrimps collected from Manus Basin was higher than other localities. Therefore, It was suppose that the origin of dispersal of *A.longirostris* position near Manus basin. If we get enough number of samples to analyse the genetic diversity, we can estimate the dispersal route and method of *A.longirostris.*

4-5-4. Proposals for future study

(1) Marking experiment for growth rate estimation of *Calyptogena* clams

These samples will be analyzed to detect strontium and calcein marked bands of shell section by back scattered images of the scanning electron micrograph and optical micrograph (Fujikura et al. 2004). Shell size, wet weight, dry weight and carbon weight will be measured. We will estimate growth rate, life span and production rate. These results will be published to science journal.

Co-wokers: Jim Barry & Patric Whaling (MBARI), Tadashi Maruyama & Hiroshi Kitazato(JAMSTEC), Kenji Okoshi (Ishinomaki Senshu Univ.), Yohei Tada (Tokyo Univ.).

(2) Feeding ecology of snail *Phymorhynchus buccinoides*

Co-wokers: Takenori Sasaki (Tokyo Univ.), Toshiro Yamanaka (Kyushu Univ.), Takeo

Yoshida & Tadashi Maruyama (JAMSTEC).

(3) Taxonomical study of shrimp *Alvinocaris longirostris*

We would like to know distribution pattern. Hence, it is necessary to find the genetic diversity of *A.longirostris* among these localities. Since there is no sample from Sagami Bay, we hope to get the shrimp on the NT 06-22 cruise.

Co-wokers: Noboru Nemoto & Seiichi Watanabe (Tokyo Univ. of Marine science & Technology), Shinji Tsuchida (JAMSTEC).

(4) Taxonomical study of polychaeta worms

Co-wokers: Eijiro Nishi (Yokohama National Univ.) / Tomoyuki Miura (Miyazaki Univ).

4-6. Seismometer Installation to Seafloor benchmark

Eiichiro Araki

4-6-1. Proposal

A seafloor benchmark (BM, Figure 1) was installed in offshore of Hatsushima Island in Sagami bay during JAMSTEC Kaiyo KY05-14 cruise on December 26, 2005 by Navigable Sampling System (NSS) at Dive #49. The seafloor benchmark is a 4m casing and seafloor reference plate installed in the sediment with inside of the casing empty. A thermometer string with data logger (NABE-1) was installed in the benchmark on December 27, 2005 also by NSS (Dive #50).

In this cruise, we plan to recover the thermometer string from the benchmark, and to install a borehole broadband seismometer in the seafloor benchmark. We connect seismic data recorder with batteries (SAM) to the borehole seismometer with cable to start approximately one-year continuous observation of broadband seismic signal at the site. The broadband seismic observation at this particular site is not only important as one of the sites of the seafloor seismic network around Japan, but as key observatory to look into the processes that take place in the boundary between the Philippine Sea Plate and the Japanese Island. Local seismic activity is active, and the site is also adjacent to a buried dyke-like structure discovered by recent seismic reflection survey.

The site is approximately 1km apart from off-Hatsushima submarine cable observatory, where short-period seismic, pressure, seafloor current, and CTD observation data are available to compare with the broadband seismic data from the benchmark.

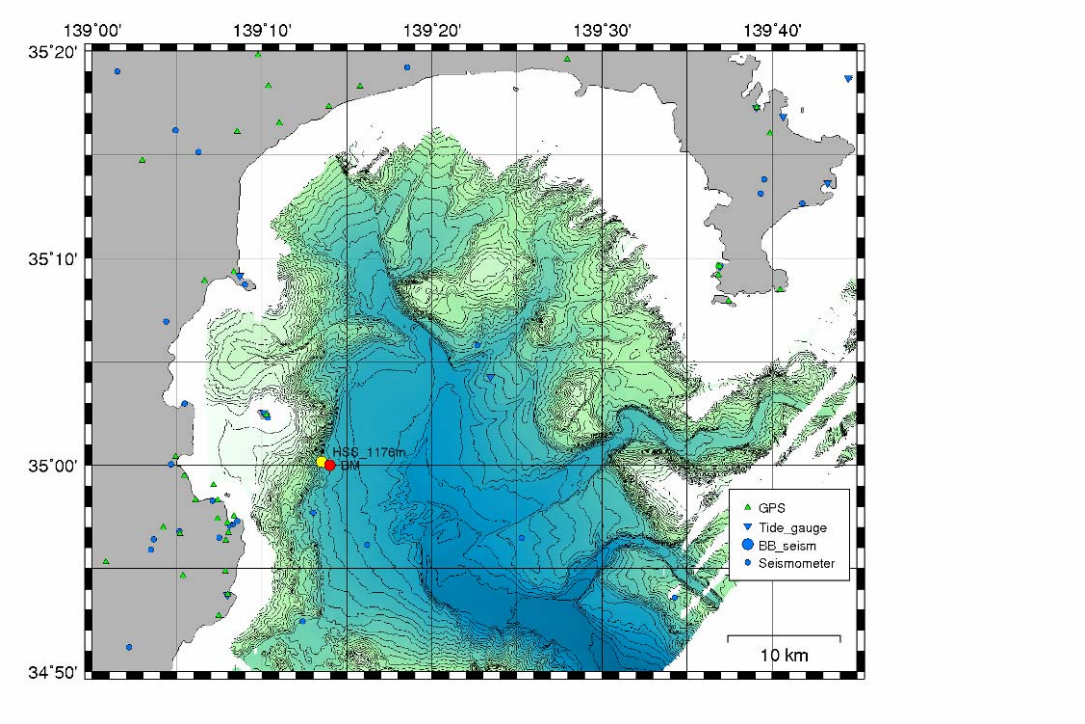


Figure 1 Location of the seafloor benchmark off Hatsushima Island, Sagami-bay, Japan ("BM"). Distribution of land and seafloor seismometer, tide-gauges, and geodetic GPS stations are shown.

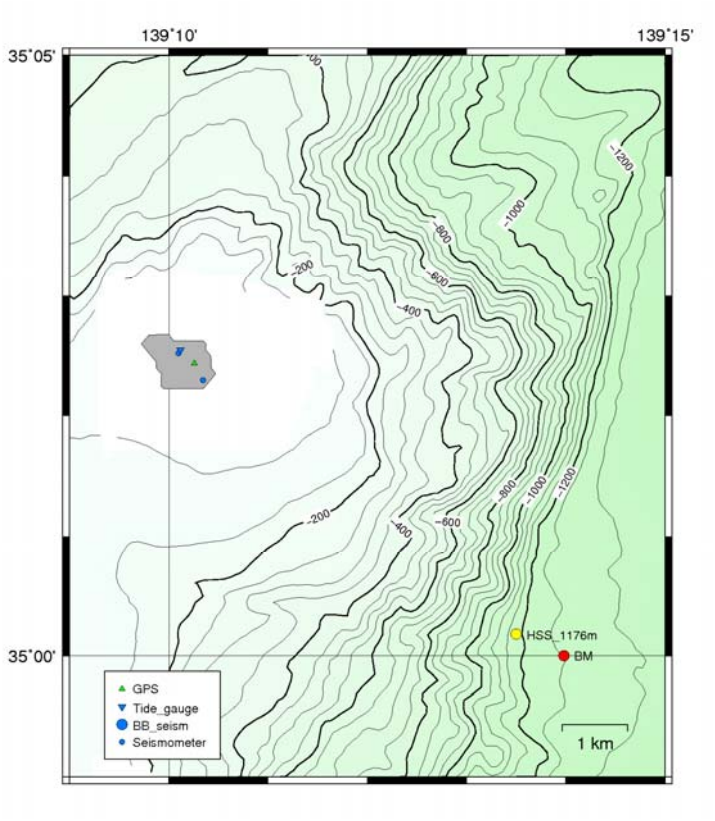


Figure 2 Local map near the seafloor benchmark (BM) off Hatsushima Island.

4-6-2. Methods

4-6-2.1 The seafloor benchmark borehole seismic system

We install a seafloor benchmark borehole seismic system in the seafloor benchmark borehole (BM) off Hatsushima, Sagami-bay, Japan. The location of the benchmark is 35-0.00'N 139-14.01'E at 1250mbsf which is approximately 1km east of off Hatsushima cable observatory. On December 26, 2005, the benchmark is deployed by NSS during JAMSTEC Kaiyo KY05-14 cruise. On the benchmark, mini acoustic transponder is installed (ID#69) to help identifying.

Seafloor benchmark borehole seismic system is consisted from a borehole seismometer installed in the seafloor benchmark and a data recorder with batteries in the seafloor.

The borehole seismometer (Figure 3) is borehole broadband seismometer housed in a 1.3m length cylinder. The seismometer is inserted in the benchmark borehole and kept in place by bow spring at the bottom, and the end stopper at the top of the seismometer cylinder. The weight of the borehole seismometer in air is 43kg and the weight in water is approx. 27kg. The eye bolt installed at the top of the seismometer can

be used to recover the seismometer from the borehole (maximum applicable hook is of 1t).

When we install the cylinder in the benchmark borehole, a handle (Figure 3) is attached to hold the cylinder by manipulator. The handle can be removed by releasing a latch of the handle. When installed, only a minimum part of the seismometer package will appear above the seafloor, minimizing effect of seafloor current flow to move the seismometer.

In the seismometer cylinder, three component broadband seismic sensor CMG-1T from Guralp Systems (UK) and 24bit digitizer (DM-24mkII) are installed. The seismometer samples at 100 samples/second for recording and 20/4 samples/second for monitoring by ROV. Sensitivity and configuration of channels of the borehole seismometer are summarized as the Table 2. The broadband sensor has 360 second period response, and it is capable of resolving tidal gravity change.

From the seismometer, 5m cable is connected to an underwater mating connector (UMC). We connect seafloor data recorder called SAM (Figure 4) to feed power to the borehole seismometer and record data. The use of UMC enables us to replace SAM without recovering seismometer which we want to keep in the stable environment in the benchmark borehole. Data from the seismometer is transmitted to the SAM through a RS232C serial link at 38400bps speed. All the data are stored in hard-disc drives (total capacity of 26GB) in the SAM, while slow data sets (20/4 sps data) are transmitted to the other UMC (4pin red color) at which ROV can connect for communication. The format of the seismic data is GCF (Guralp Compressed Format). The slow data is transmitted from SAM at 9600bps. The UMC to the seismometer is yellow 8pin. Table 1 summarizes the pin assignment of the connectors.

All the power for the seismometer is fed from the SAM by a stack of Lithium batteries (six GS-Yuasa CL-1300L batteries in series). Connection by ROV is also necessary to perform initial set up of the seismometer to unlock seismometer's mass, leveling, and centering. Once set up, the seismometer runs continuously. If the seismic mass goes off, the digitizer will automatically re-center it.

The power consumption of the system is approximately 1.9W for the borehole seismometer and the 1.2W (an average) for the SAM. We expect approximately 300days of observation before the batteries run out. We can replace the batteries and recorder by ROV.

The timing of the observation is governed by a precision clock in the SAM recorder which can be adjusted to GPS before deployment. The clock in the borehole seismometer will synchronize to the SAM recorder during the observation. Table 3 is

the result of clock calibration of SAM recorder before the deployment.

The SAM recorder is too large to be brought to the seafloor with ROV. We deploy the SAM as a mooring (Figure 5). Before transporting the SAM to connect to the borehole seismometer, ROV remove the anchor weight by pulling trigger pin, and cut the rope above the SAM. A mini acoustic transponder (ID #45) was attached to find the SAM easily in the seafloor.

1. 8-pin male receptacle UMC of the borehole seismometer

Pin #	Function	Connection of VMG-4-BCL
1	Power ground	3
2	Power 10-36VDC	1
6	RS232C TX (seismometer to recorder)	4
7	RS232C RX (recorder to seismometer)	2
8	RS232C COM (connected to #1 power ground)	3

* SAM will not emit signal (1pps) unless SAM receive line is activated by minus voltage. SAM output voltage is 18V nominal.

2. 4-pin female plug UMC of the SAM recorder

Pin#	Function
1	N/C
2	RS232C RX (ROV to SAM)
3	RS232C COM
4	RS232C TX (SAM to ROV)

Table 1. Connection of the borehole seismometer and ROV

Guralp CMG1T

WO2176	S/N	DB97	
	Sensor	T1060	360sec velocity
	Calibration resistor	51k	
	Power	35.6mA	12Vinput

Velocity		Digitizer sensitivity	Sensor sensitivity	Total sensitivity	
1060Z2	Vertical	0.778 uV/bit	3194 V/m/s(single)	2.434700E-10 m/s/bit	
1060N2	N/S	0.777 uV/bit	3232 V/m/s(single)	2.759370E-10 m/s/bit	
1060E2	E/W	0.775 uV/bit	3178 V/m/s(single)	3.215080E-10 m/s/bit	
Mass Position					F/B coil constant
1060M8	Vertical	132.800 uV/bit	2553 V/m/s(single)	5.201900E-08 m/s**2/bit	0.00468 A/m/s**2
1060M9	N/S	132.800 uV/bit	2815 V/m/s(single)	4.717700E-08 m/s**2/bit	0.00516 A/m/s**2
1060MA	E/W	132.810 uV/bit	2411 V/m/s(single)	5.508600E-08 m/s**2/bit	0.00442 A/m/s**2

Temperature			
Range	233-373	K	
Accuracy	±5	%	
1060ME	0.013	K/bit	
Cal signal monitor			
1060MB	132.500	uV/bit	@4sps
Aux channels			
1060MC	265.050	uV/bit	
1060MD	265.320	uV/bit	

Table 2 Sensitivity of the borehole seismometer

Internal Clock 65,250 MicroSeconds Fast Freq error -50 e-9 2006 Dec 8 07:01:00 o/s=-4010655 drift= -178 342:07:00:59.935210585 -0.0647894
Internal Clock 65,250 MicroSeconds Fast Freq error -50 e-9 2006 Dec 8 07:02:00 o/s=-4010836 drift= -179 342:07:01:59.935207475 - 0.06479252
Internal Clock 65,250 MicroSeconds Fast Freq error -50 e-9 2006 Dec 8 07:03:00 o/s=-4011013 drift= -178 342:07:02:59.935204445 - 0.064795555
Internal Clock 65,250 MicroSeconds Fast Freq error -50 e-9 2006 Dec 8 07:04:00 o/s=-4011186 drift= -175 342:07:03:59.935201580 - 0.06479841
Internal Clock 65,250 MicroSeconds Fast Freq error -49 e-9 2006 Dec 8 07:05:00 o/s=-4011359 drift= -174 342:07:04:59.935198840 - 0.06480116

Table 3. Result of clock calibration of the SAM recorder.

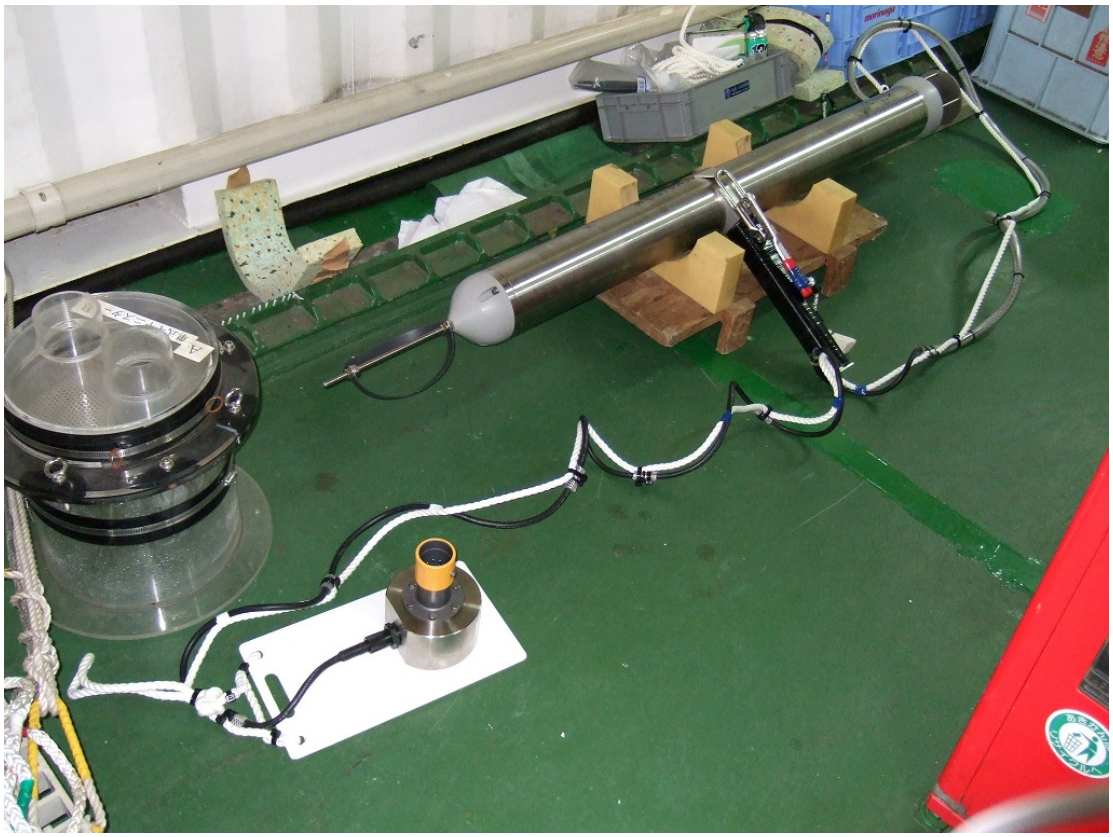


Figure 3 Seafloor benchmark borehole seismometer (Guralp CMG1TD)

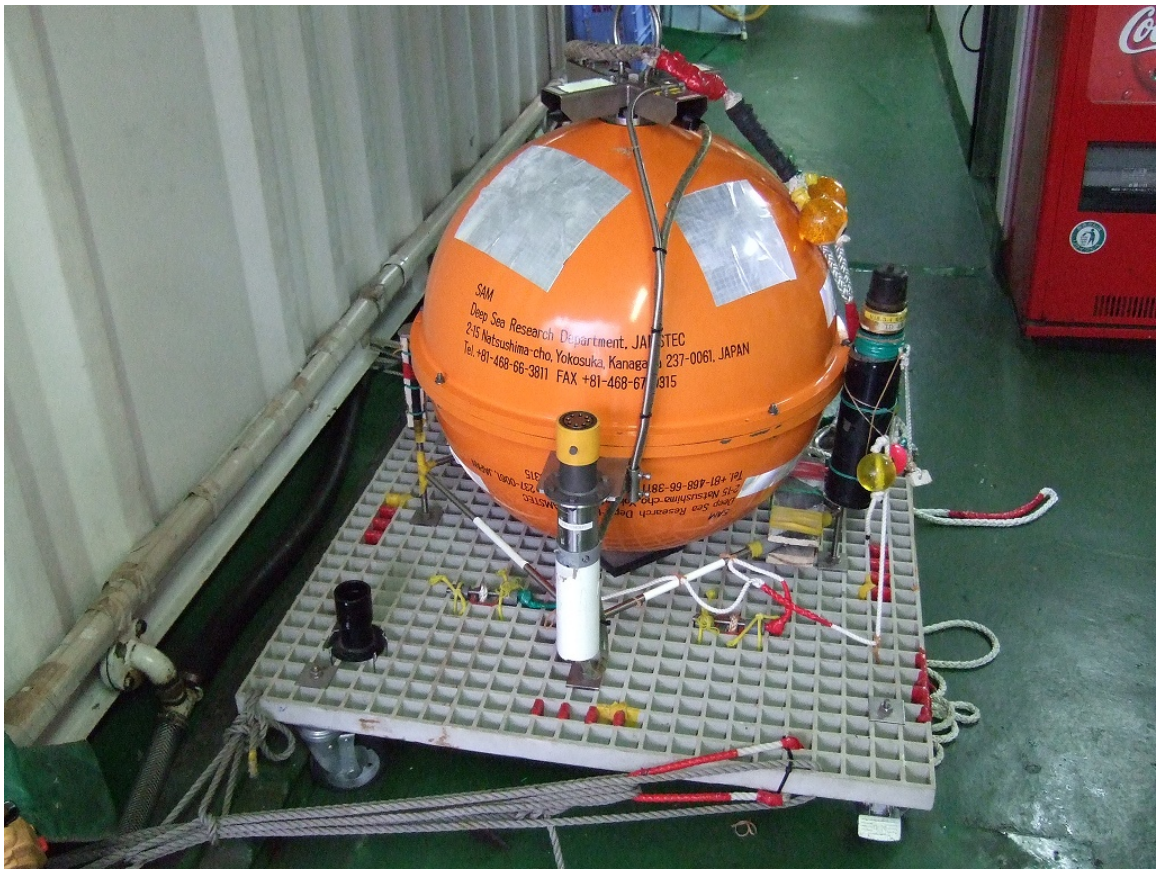


Figure 4 Recorder for the seafloor benchmark borehole seismometer.

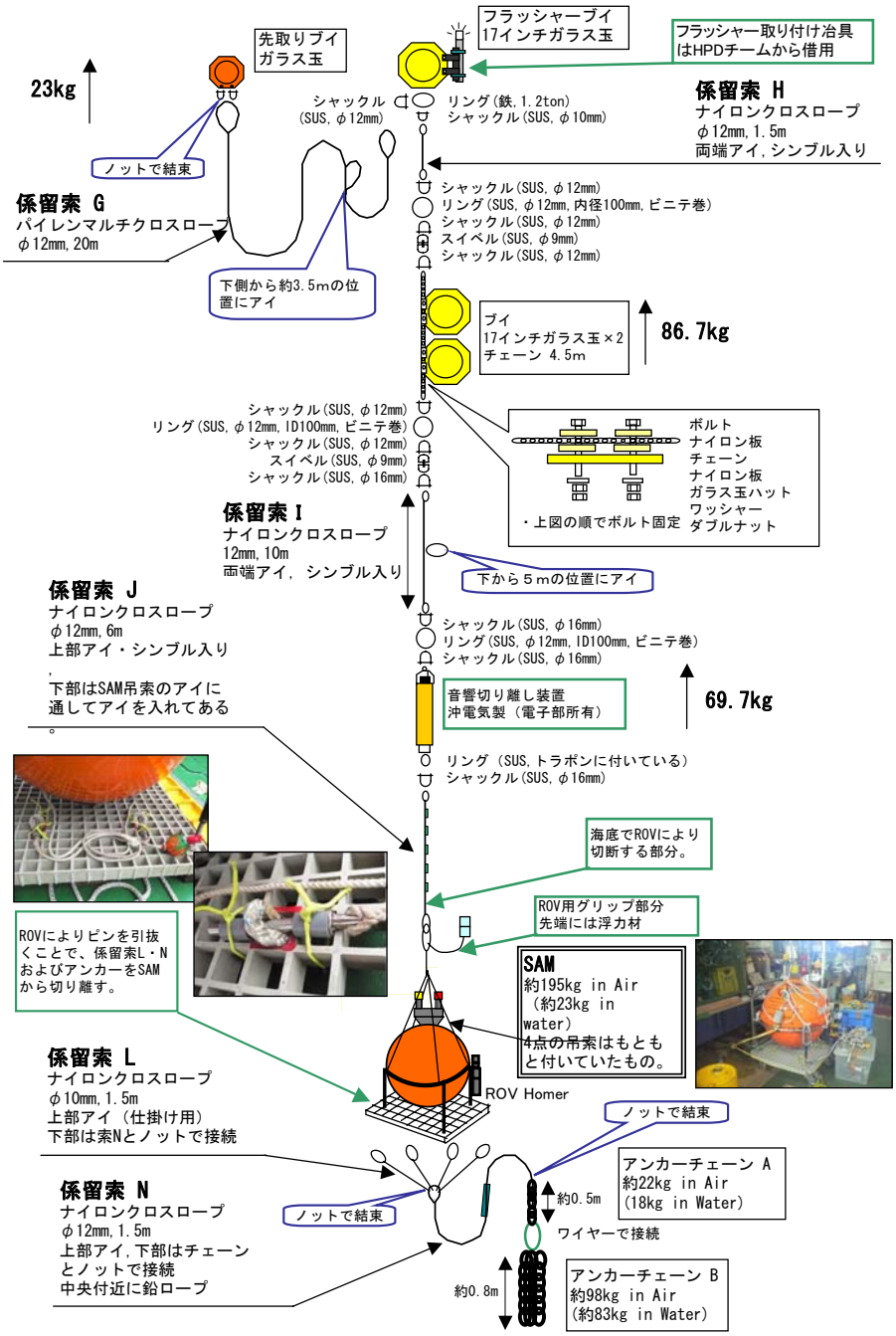


Figure 5. Mooring system used to deploy SAM recorder in the seafloor.

4-6-2.2 Recovery of thermometer string.

The thermometer string was installed in the seafloor benchmark borehole during JAMSTEC Kaiyo KY05-14 cruise on December 27, 2005. Six thermometers (thermistors) were installed from the 0.2m below the seafloor by 0.7m interval. The hole entrance was plugged by a dish (retrofitted from Chinese wok) to prevent water circulation due to tidal seafloor current. A 4.3m cable connects the thermometers and

the recorder at seafloor.

To recover the thermometer string, the ROV Hyper Dolphin takes the dish and pulls out the string below. After installation of the borehole seismometer, the seafloor recorder will be recovered. The data recorder was installed at the point 4m apart in 300 degrees from the north from the benchmark.

4-6-3. Dive results

4-6-3.1 Deployment of SAM recorder

Deployment of SAM recorder was conducted on December 9th as Table 4.

Time is JST
1431 Deploy SAM (35-00.0605N 139-14.0480E D=1276m)
1446 Landed at seafloor, acoustic positioning (35-00.031N 139-14.017E D=1240m)
1450 Attempt release, failed probably due to ship is too close to the target.
1459 Release command received (at SR=1750m)
1513 Buoys on surface
1524 Recovery of equipments

Table 4 Operation log of the SAM deployment

4-6-3.2 Installation of the seafloor benchmark borehole seismometer

Installation of borehole seismometer in the seafloor benchmark borehole was conducted in the Dive 626 of the Hyper Dolphin on December 12, 2006. Payload for the dive (Figure 6) was seafloor benchmark borehole seismometer with handle attached, yellow cable with UMCs, UMC connector with cable and isolating unit, hooks, and a cutter.

The ROV operation proceeded as described in the Table 5. We retrieved the thermometer string from the borehole. The surface of borehole tube appeared very clean without corrosion on the surface (Figure 7). Then we inserted borehole seismometer in the hole (Figure 8). Insertion in the hole was conducted using the handle attached on the seismometer, which we need remove to fully insert the seismometer in the hole (Figures 9, 10, 11). When installed, the top of the seismometer appears on the benchmark, with a cable coming out of the seismometer (Figure 12). The cable was arranged to minimize seafloor current move the cable to vibrate. To damp vibration of the cable, folks were also installed onto the cable (red and yellow folks, Figure 13).

We brought SAM recorder, deployed as a mooring on December 8, to the end of the cable from the seismometer. UMC at the end of the cable was connected to SAM UMC to start seismometer observation. Then we connected UMC from the Hyper Dolphin to check status of seismometer and get initial seismic data. The seismometer was set up to automatically start observation as power is fed from SAM, unlocking seismic masses and leveling them. One of the components (N/S) failed unlocking automatically. So, we issued a command to manually unlock the N/S mass, and it was successful. We kept connection to SAM for two hours from the start of the observation,

and monitored continuous seismic data from the borehole seismometer.

During the monitoring, we attempted to move the basket of the Hyper Dolphin twice. The motion of the table was captured by the seismometer clearly.

Finally, we disconnected UMC on the SAM and started continuous off-line seismic observation at the seafloor benchmark.

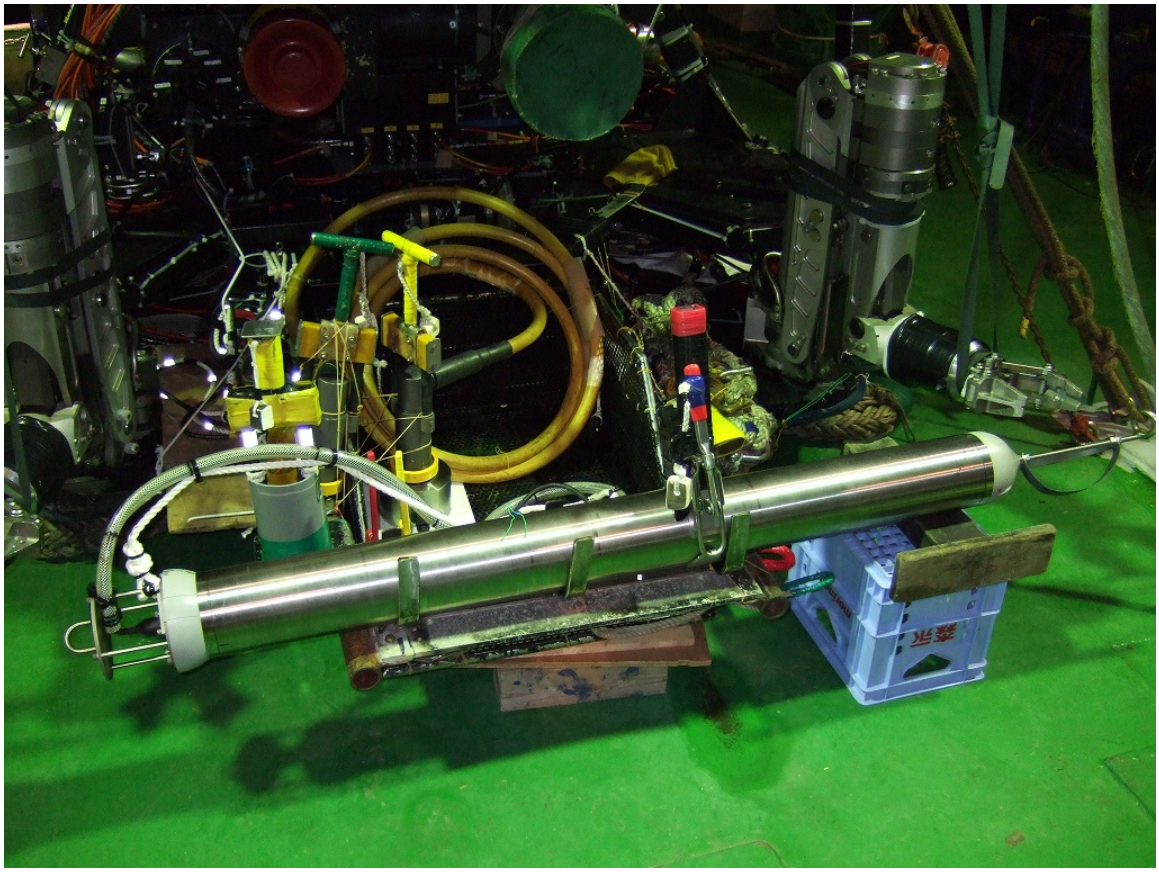


Figure 6. Hyper Dolphin Dive #626 payload (December 12, 2006)

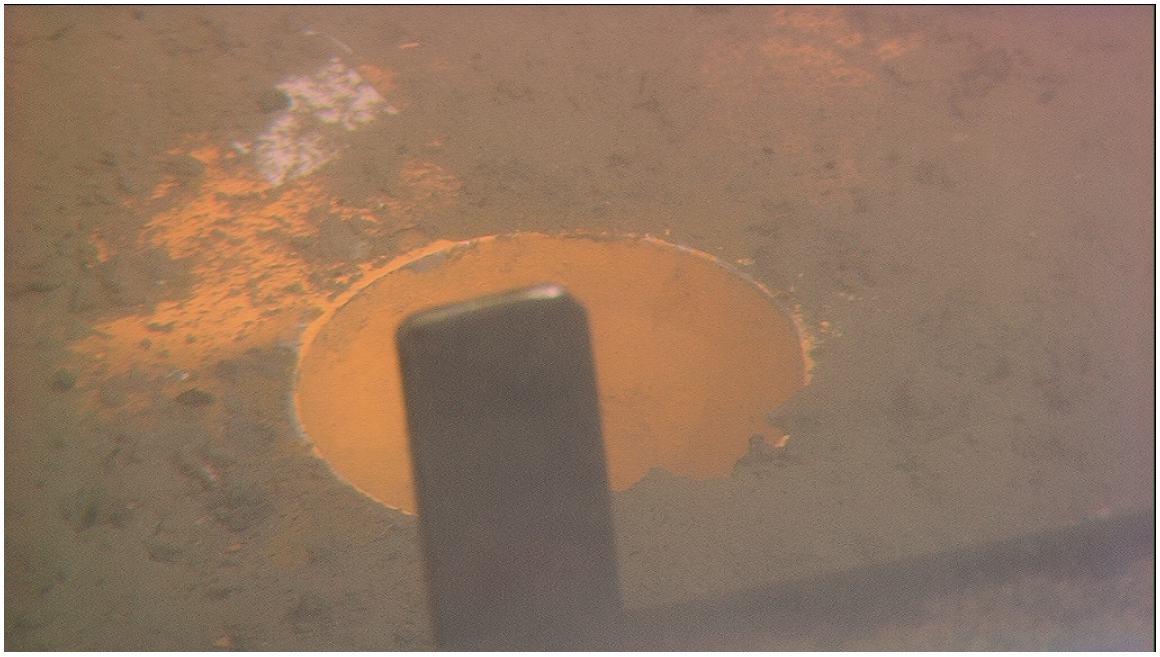


Figure 7. Appearance of seafloor benchmark borehole 1 year after deployment (Dec. 12).

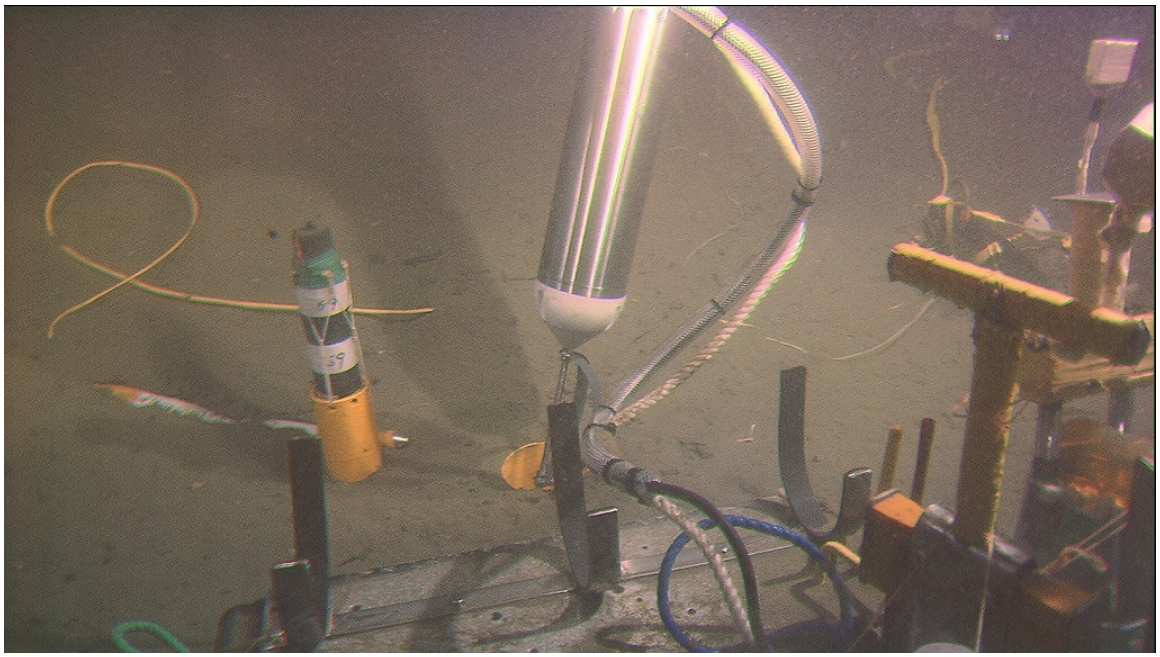


Figure 8. Borehole seismometer being inserted into the benchmark borehole.

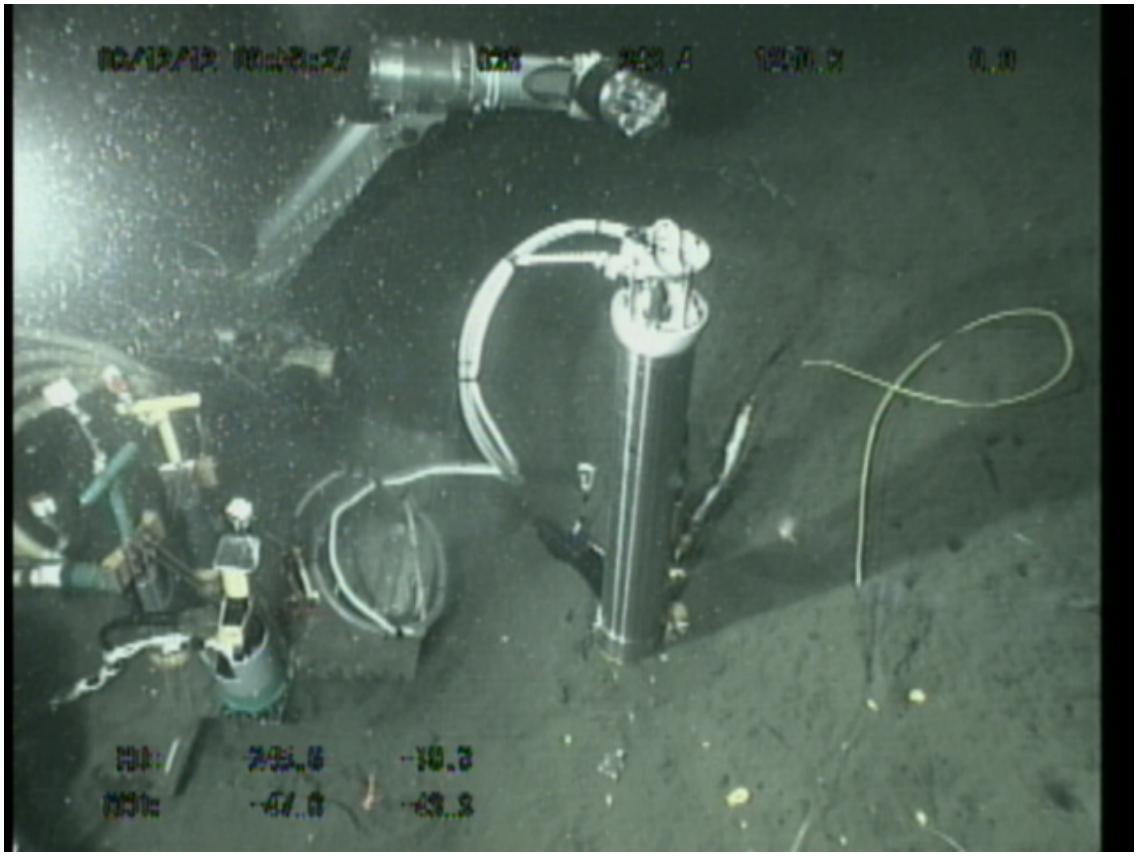


Figure 9. The borehole seismometer was halfway inserted to the hole.

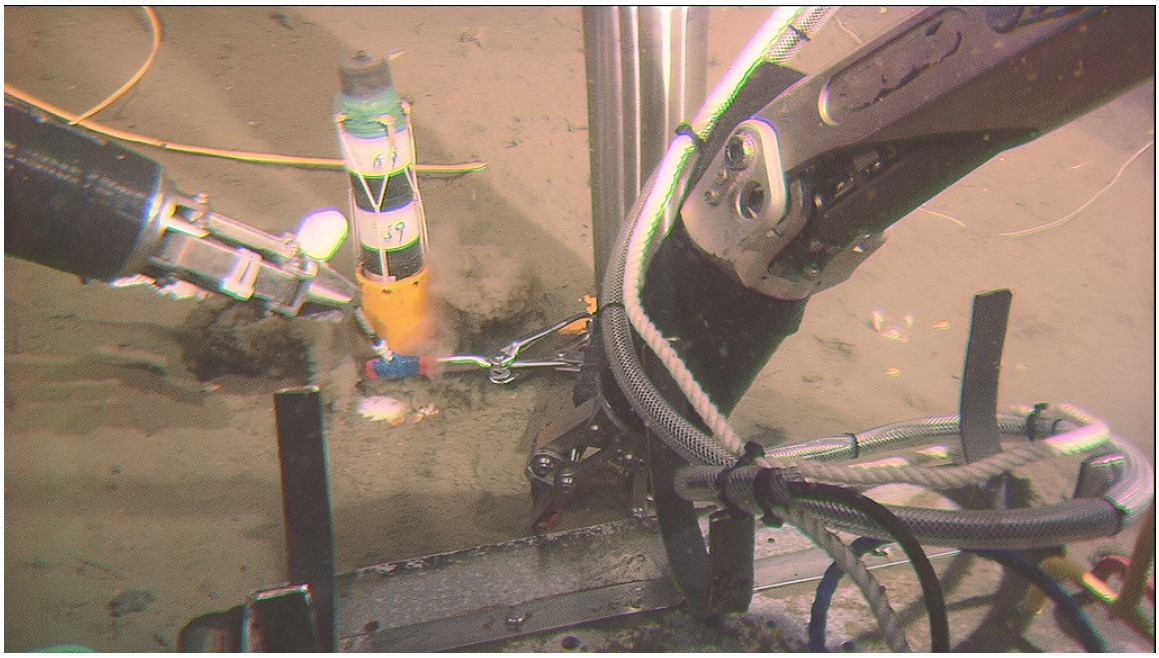


Figure 10. Detach handle from the seismometer.

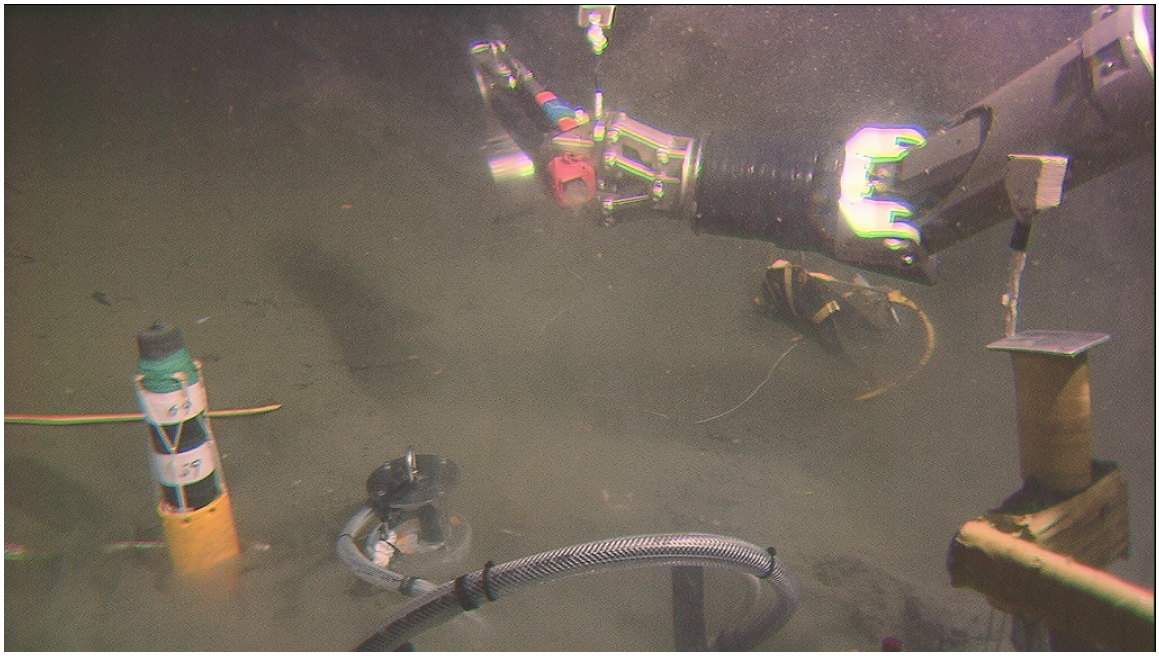


Figure 11. The seismometer was completely in the hole by gravity.

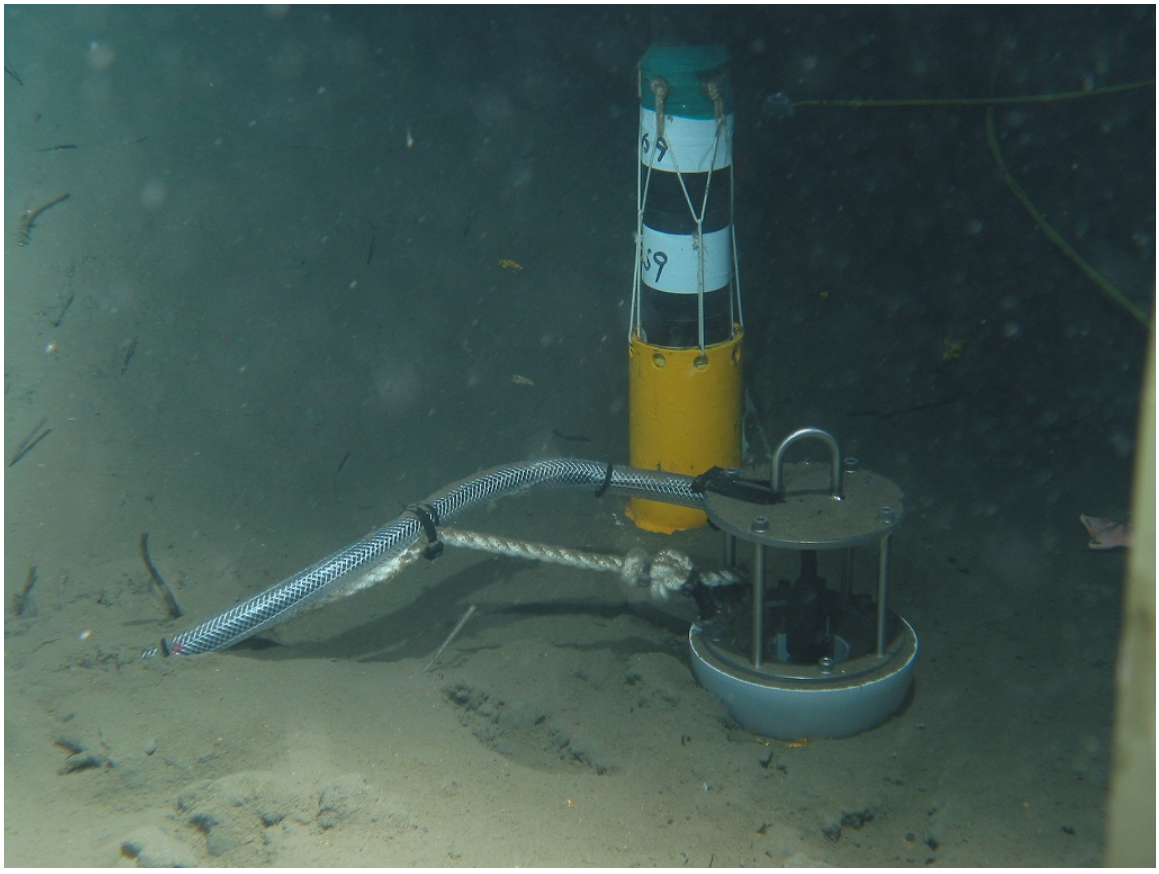


Figure 12. The seafloor benchmark borehole seismometer in the seafloor benchmark. Behind the seismometer is mini acoustic transponder in a holder.

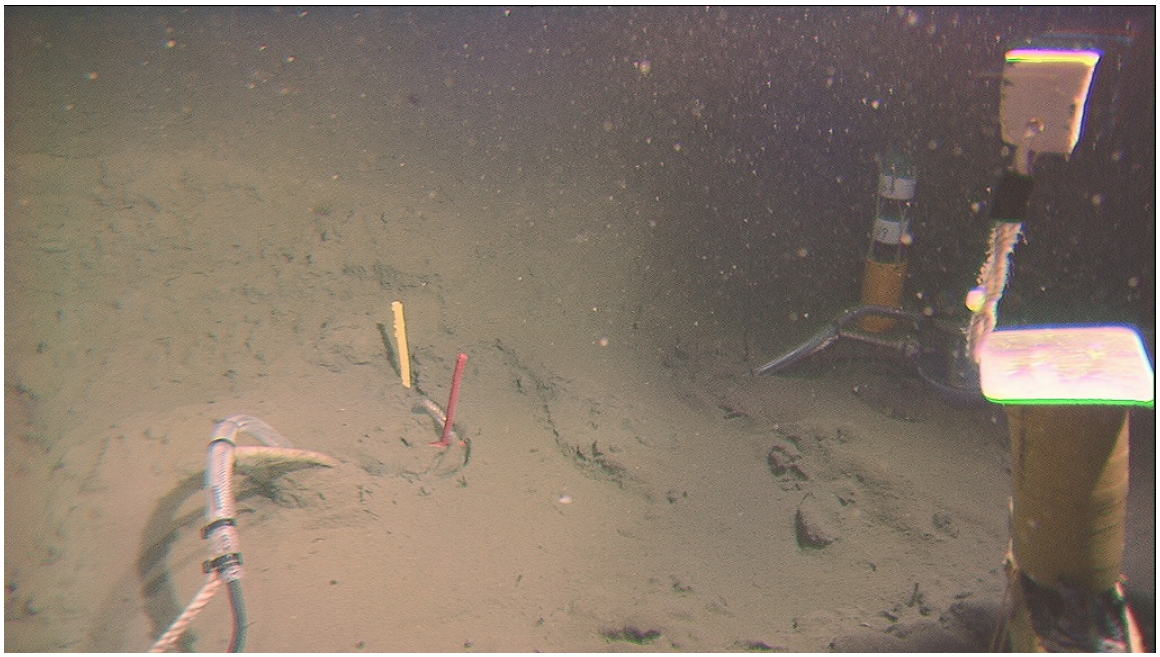


Figure 13. To damp vibration of the cable, folks were installed onto the cable (red and yellow ones).

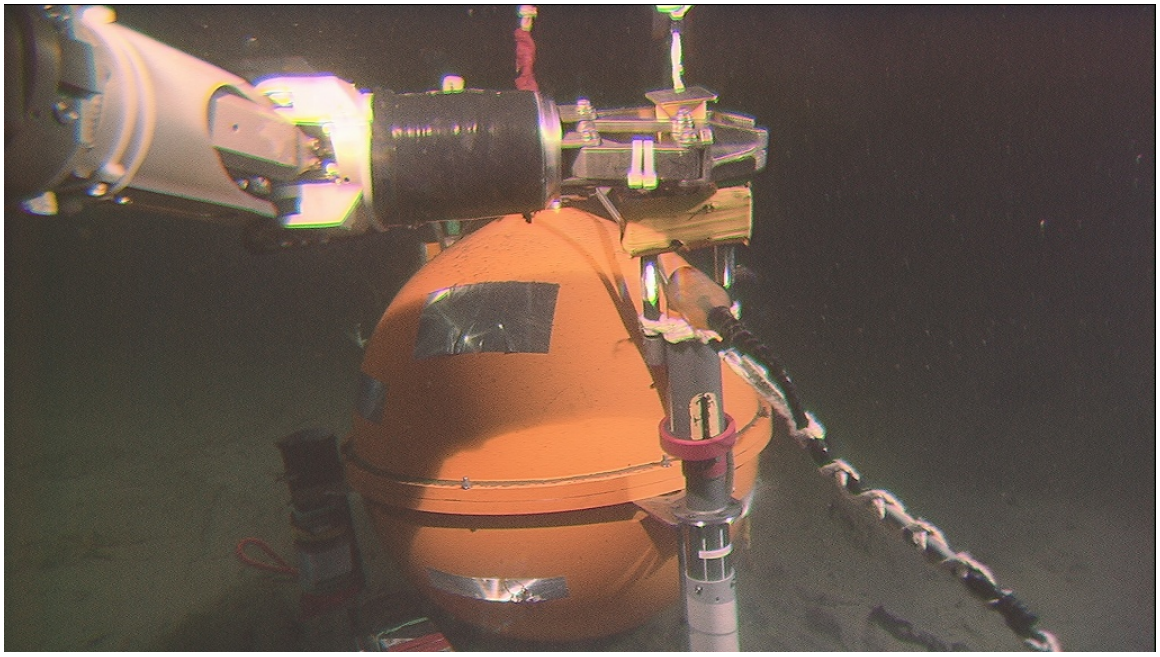


Figure 14 ROV cable was connected to SAM to check initial data from the seismometer.

4-6-3.3 Recovery of thermometer string.

On the same ROV dive as the seismometer installation, we recovered the thermometer string from the seafloor benchmark. Figure 15 is the photograph of the thermometer string in the seafloor benchmark borehole and the data logger connected by a 4m cable. The seafloor benchmark borehole was sealed by a Chinese wok (Figure 16), in which a thermometer cable penetrating in the center. The wok did not suffer severe corrosion after one-year observation (Figure 16). Before the installation of the borehole seismometer, we bring the string from the borehole. After installation of the seismometer, we recovered the data logger, the wok, and the string in the basket of Hyper Dolphin (Figures 17, 18). The recovered thermometer string looks fine (Figure 19) without apparent damage or corrosion.

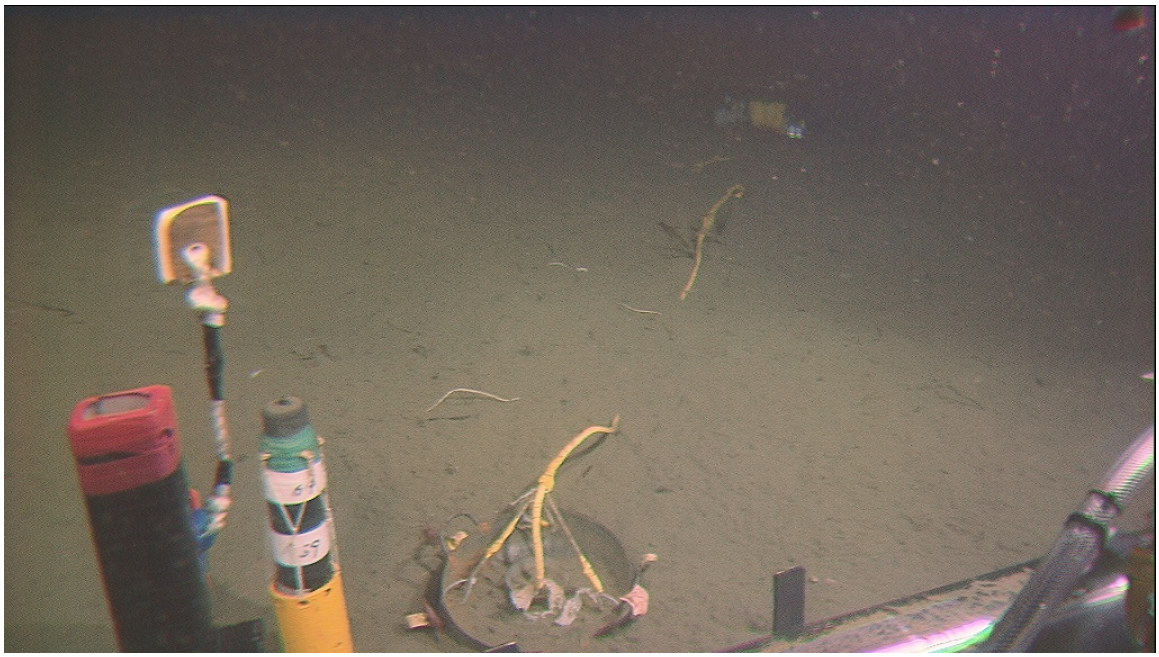


Figure 15. NABE-1 thermometer string in the seafloor benchmark hole before recovery (Dec. 12, 2006)

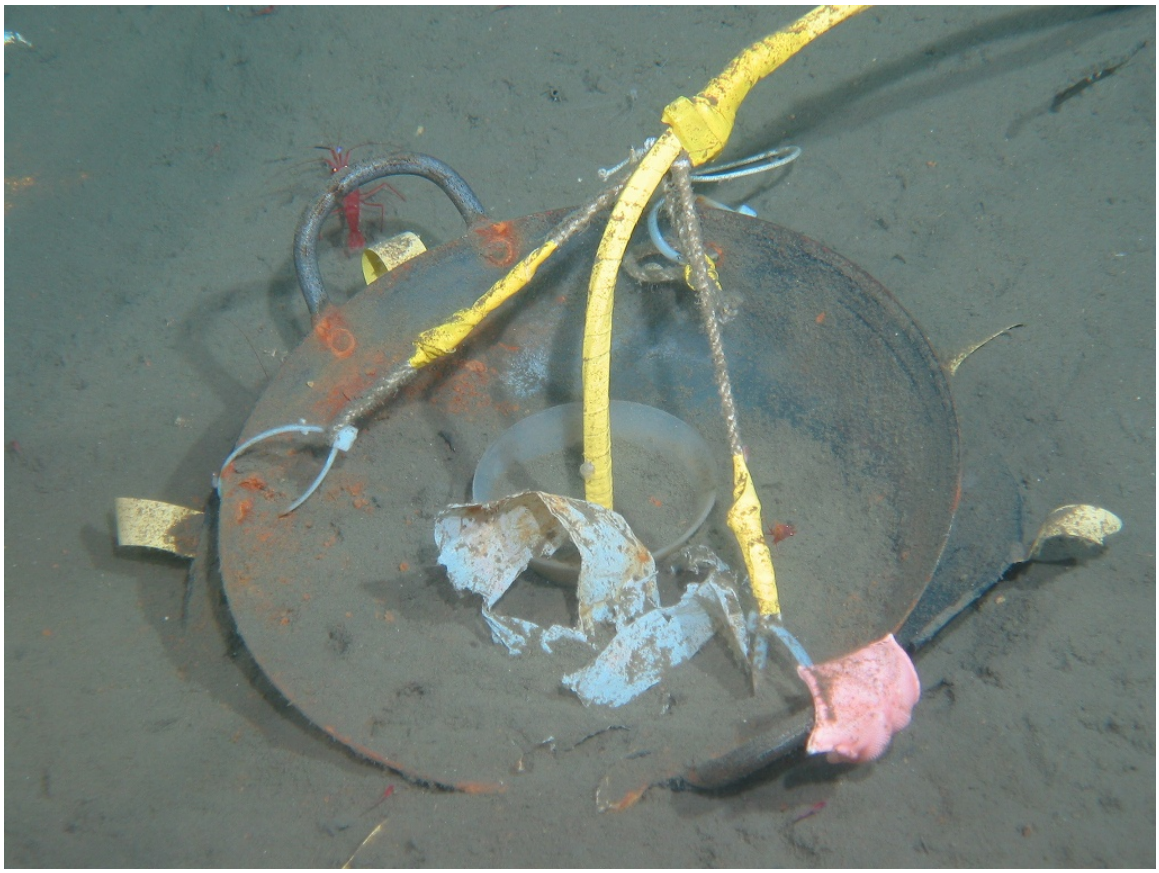


Figure 16 Close up photo of the NABE-1 on the hole.

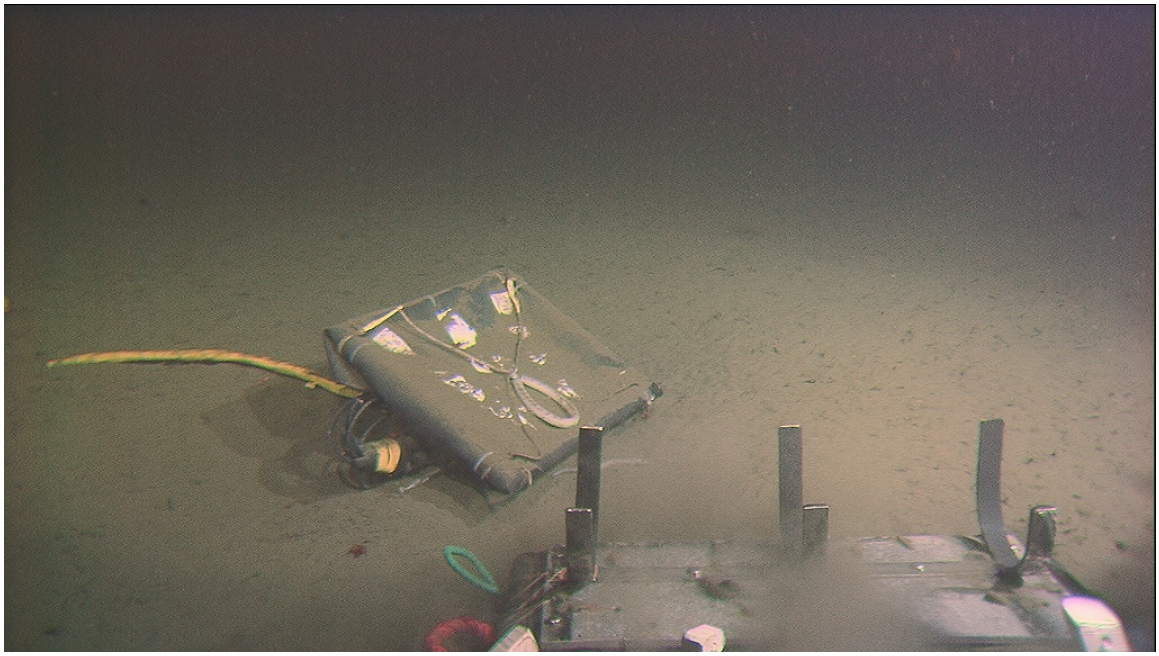


Figure 17. NABE-1 data logger approximately 4m off the benchmark hole.

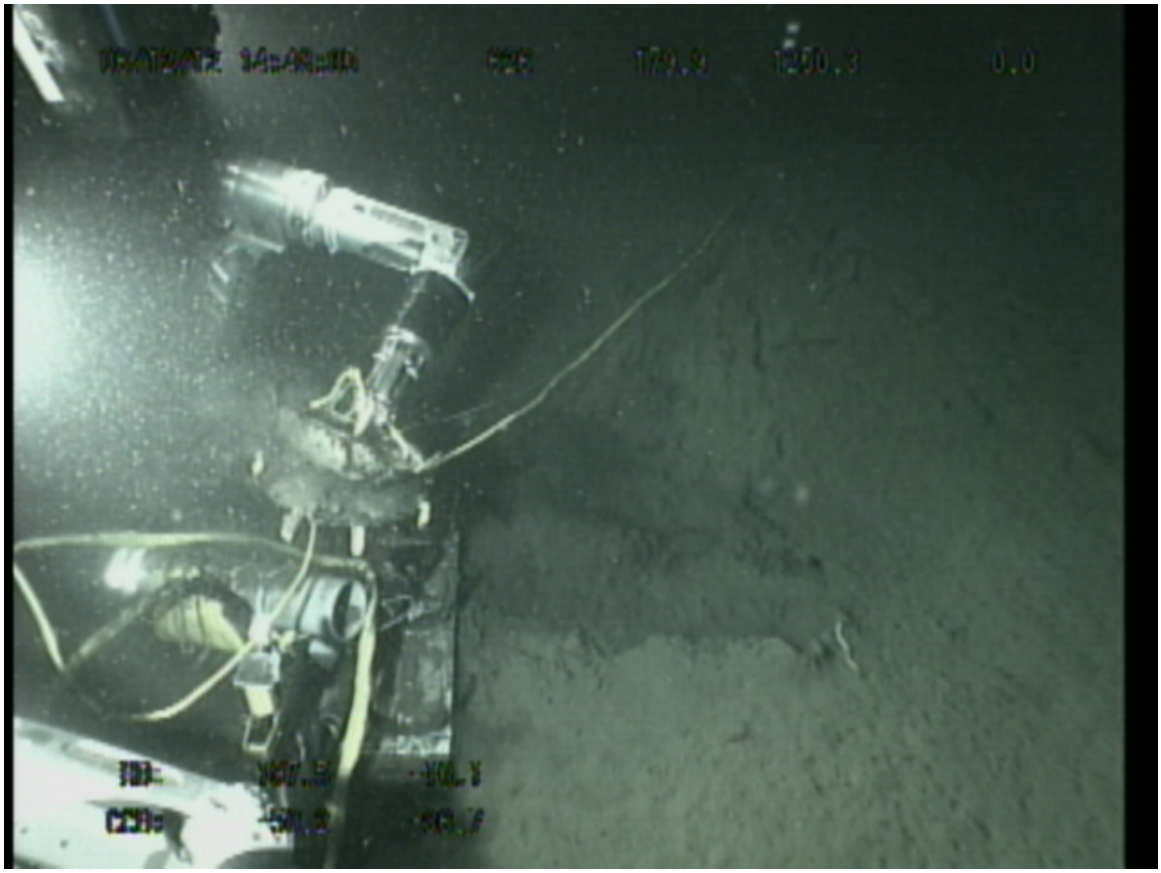


Figure 18. The cables and NABE-1 were winded to recover to the sample basket of the Hyper Dolphin.

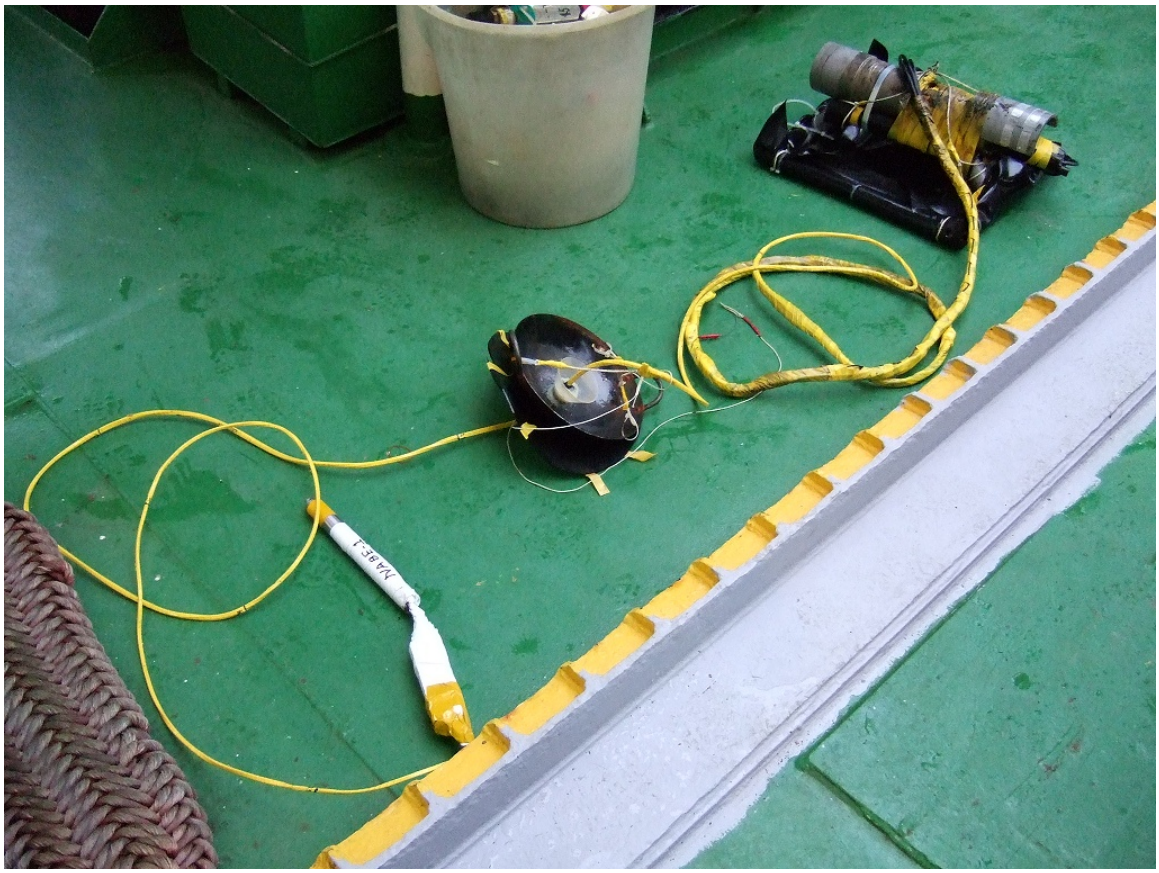


Figure 19 NABE-1 (NSS Aided Benchmark Entry-1) recovered on deck on December 12, 2006.

Time (JST)	Heading Degrees	Description
08:08		ROV operation start
08:13		ROV dive start
09:06	271.0	arrived at 1247.6m
09:07	271.0	45.5m to ROV-Homer (ID69)
09:08	305.0	38.7m to ROV-Homer (ID69)
09:09	305.2	28.3m to ROV-Homer (ID69)
09:10	304.6	18.9m to ROV-Homer (ID69)
09:11	309.7	found the Benchmark
09:12	310.5	arrived at the Benchmark
09:14	251.2	sit down in front of the Benchmark
09:26	250.4	pull out Chinese wok from the borehole
09:33	266.8	recovered thermometer string from the borehole
09:44	242.4	lifted bore hole seismometer

09:48	250.3	start installation of borehole seismometer into the borehole
10:01	242.1	finished installation of the borehole seismometer into the borehole
10:19	238.9	placed ROV-connector block on the seafloor (lie down)
10:24	239.4	extended cable and placed ROV-connector (for SAM)
11:03	117.5	fixed cable by yellow hook
11:08	117.5	fixed cable by red hook
11:10		moved to SAM
11:14	312.6	58.8m to ROV-Homer (ID45)
11:15	350.1	44.5m to ROV-Homer (ID45)
11:17	329.9	20.0m to ROV-Homer (ID45)
11:18	329.6	found SAM (lie down)
11:20	28.2	arrived at the SAM
11:25	28.7	cut rope
11:33	96.5	removed weight on the right side
11:35	97.0	got up SAM
11:39	187.5	removed weight on the left side
11:41	187.0	lifted SAM and moved to ROV-connector
11:48	255.0	44.0m to ROV-Homer (ID69)
11:50	260.1	31.7m to ROV-Homer (ID69)
11.53	259.0	found the benchmark
11:55	260.0	placed SAM near ROV-connector, sit down, waited for clear view
12:06	260.0	picked up UMC
12:12:00	259.6	connected UMC to SAM
12:14	260.6	recovered ROV-Homer(ID45) from SAM
12:20	180.5	picked up ROV-connector(for communication)
12:21:00	180.3	connected ROV-connector(for communication), started communication, 1250.8m
12:27		seismometer N/S unlock (manual)
05:06:44(UTC)		moved stage for vibration test, borehole seismometer detected vibration
14:35	179.4	removed ROV-connector from SAM, power off
14:41	179.8	picked data logger for thermometer string
14:47	179.9	picked up Chinese wok
14:50	180.1	picked up weight of thermometer string end
14:54:00		

	179.8	finished mission
14:55		ROV removed Benchmark
14:58	90.0	ROV started surfacing
1530		ROV came to the surface

Table 5 Operation log of Hyper Dolphin Dive #626 on December 12, 2006.

4-6-4. Preliminary Scientific Results

4-6-4.1 Seafloor benchmark borehole seismometer

During the installation of the borehole seismometer, we monitored initial data from the seismometer for approximately two hours. Figure 20 shows three components (two horizontal and one vertical) records from the seismometer. The vertical component data in the low frequency range appears quieter than horizontals. Especially above 1Hz, the seismometer receives noises from the Hyper Dolphin. There was abrupt noise increase at 03:28 UT and decrease at 05:31 UT of the short period noise, which may be associated with the mechanical status of ROV system. The noise level does not seem to correlate with connection of UMC between ROV and SAM.

From visual inspection of the seismometer on the seafloor benchmark, the E component of the seismometer points to approximately 45 degrees anti-clockwise from the mini-acoustic transponder (170 degrees from the north). Therefore, the E component corresponds to approximately 125 degrees from the north. The E component also corresponds to the direction of the cable from the seismometer. Two wings of bow spring spread opposite side of the E component. So the E component may be better coupled to the benchmark borehole than N component.

The temperature inside the seismometer went up by 3.7 degrees during 2.3 hours after running.

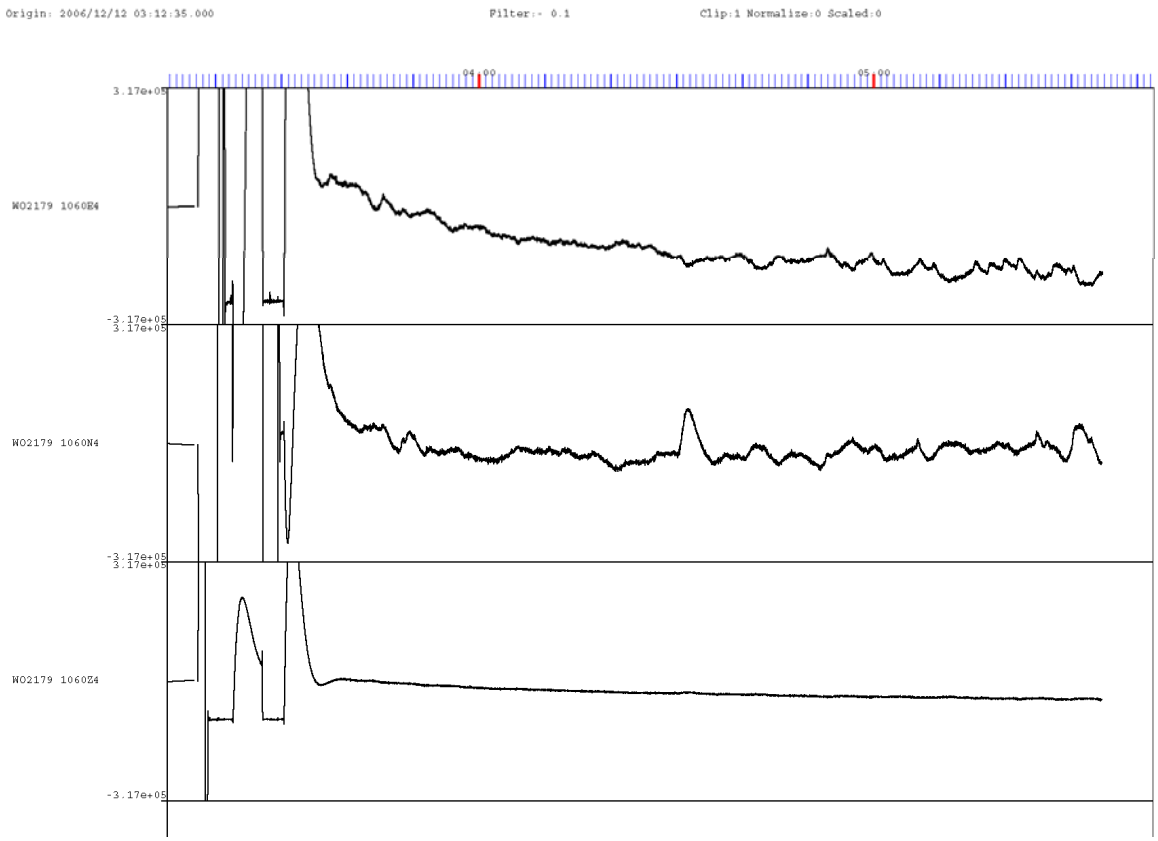


Figure 20 Initial data from seafloor benchmark borehole seismometer on December 12, 2006. Traces are E/W, N/S, vertical components from the top. Low-pass filtered below 0.1Hz.

4-6-5. Proposal for Future Studies

4-6-5.1 Maintenance of the seafloor benchmark observatory

During the next year, we propose to recover SAM and replace with another SAM to continue observation at the seafloor benchmark observatory. We expect to obtain a long-term broadband seismic data in the Sagami-bay of as long as 300 days for the first time. With the long-term data, we will be able to evaluate the advantage of installation of a seismometer in the seafloor benchmark borehole compared to installation on the seafloor. After evaluating the performance of the installation, we start continuous long-term observation for years at this site.

We also plan to install a set of seismic and pressure sensors as a part of the off Hatsushima submarine cable observatory. The sensors consist of a strong-motion accelerometer, a quartz pressure gauge, and a differential pressure gauge. The data from the differential pressure gauge is useful to correct broadband seismometer data for

effects from ocean gravity wave noise. Combining these multi parameter observables, we construct complete observatory for seafloor geodynamics in off Hatsushima site. Our plan is to install such a complete station in several locations around the Japanese coast such sites as off Toyohasi submarine cable site, off Sanriku deep borehole site, and those sites as DONET (off Kii-peninsula). These distributed observatories of complete seismic observation will also function as a large scale array of seafloor seismic station looking into activities of global scale in the oceans.

Appendix 1. Sample List

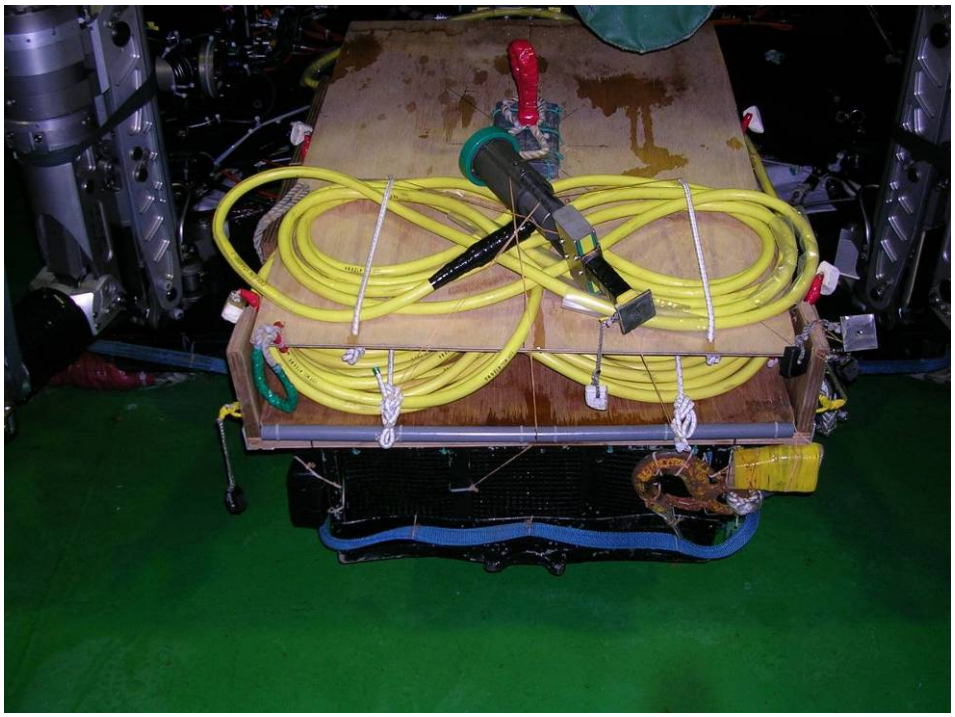
Appendix_1_Samplelist.xls exists in the folder.

Appendix 2. Videotape List

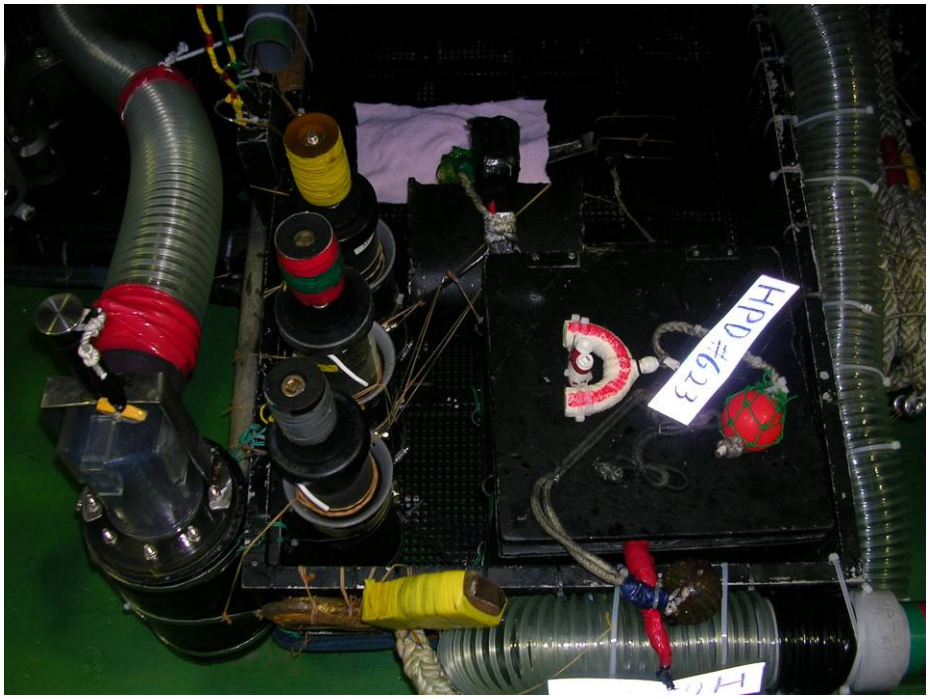
Institution	IFREE4		Denmark		XBR		DONET	
media	(mini-DV, 60min)		(mini-DV)		(DV)		(mini-DV)	
Dive No. (Date)	HTV	CCD	HTV	CCD	HTV	CCD	HTV	CCD
#622 (20061209)	4	4	4	4	0	0	0	0
#623 (20061210)	6	6	6	6	5	0	0	0
#624 (20061211)	2	2	2	2	0	0	0	0
#625 (20061211)	2	3	2	2	0	0	0	0
#626 (20061212)	0	0	0	0	0	0	5	5
#627 (20061213)	2	2	2	1	0	0	0	0
#628 (20061213)	1	1	1	1	0	0	0	0
#629 (20061214)	4	4	4	4	3	0	0	0

Appendix 3. Payload Pictures

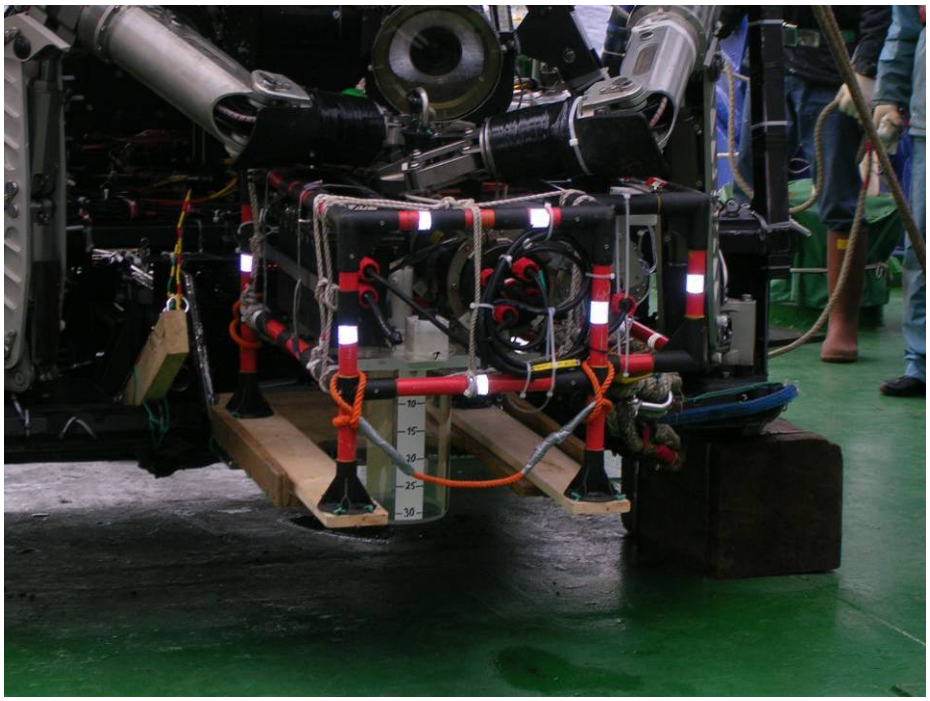
Dive#622 (off Hatsushima, 20061209)



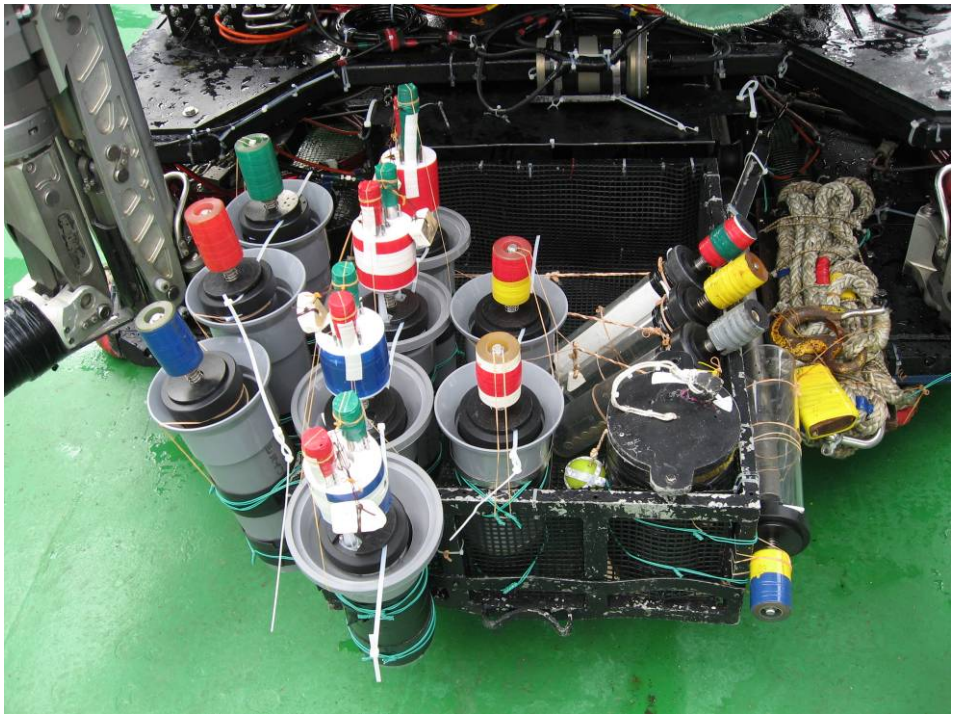
Dive#623 (off Hatsushima, 20061210)



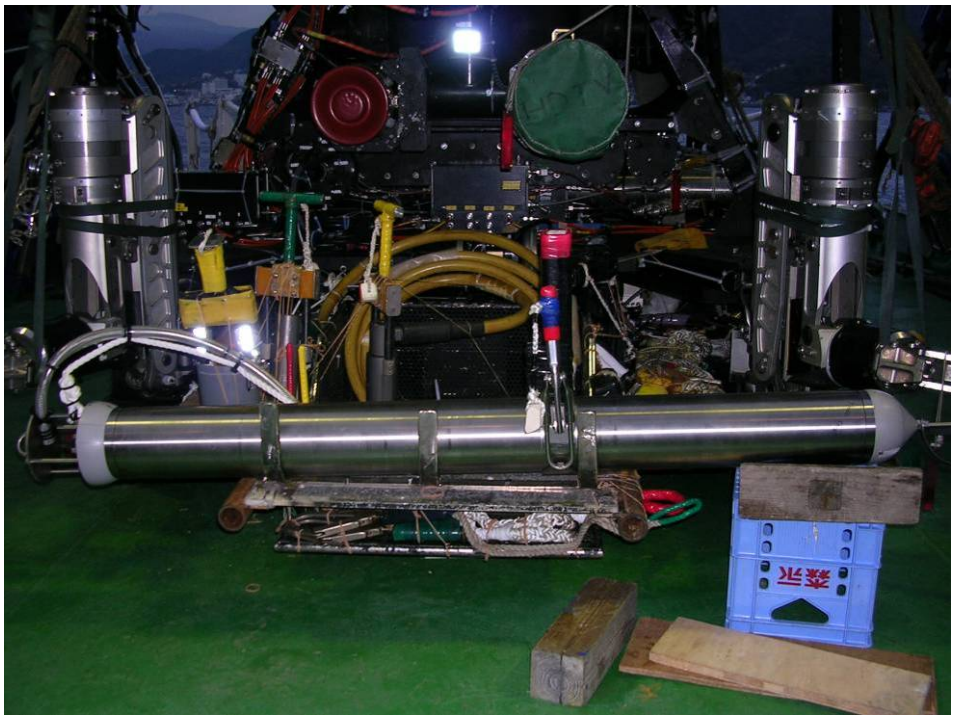
Dive#624 (OBB2, 20061211)



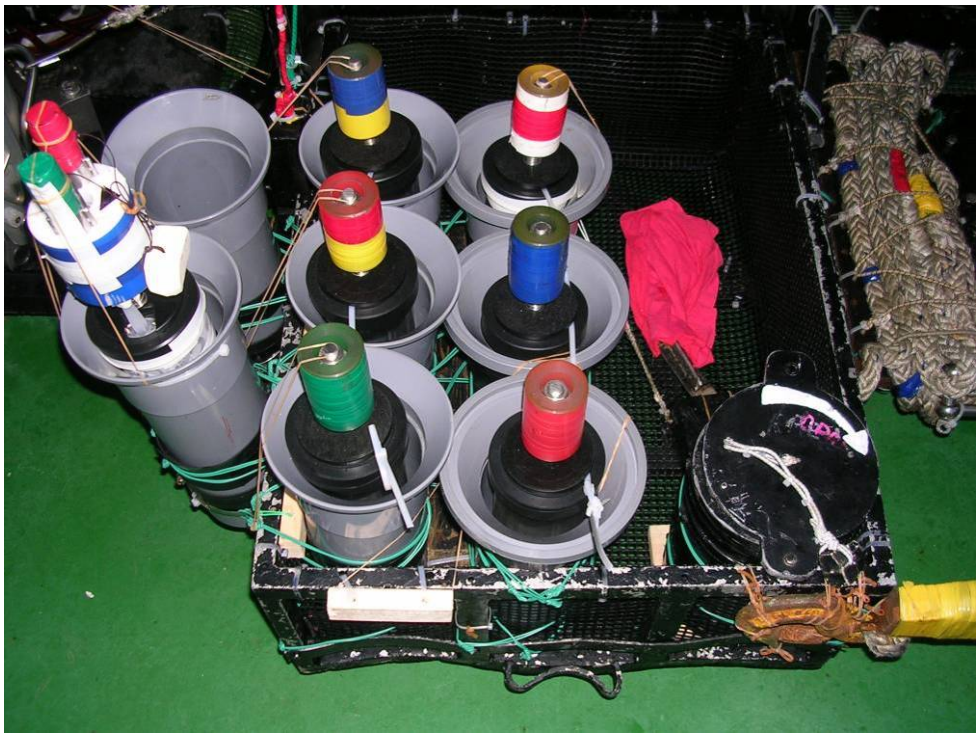
Dive#625 (OBB2, 20061211)



Dive#626 (Benchmark Site, 20061212)

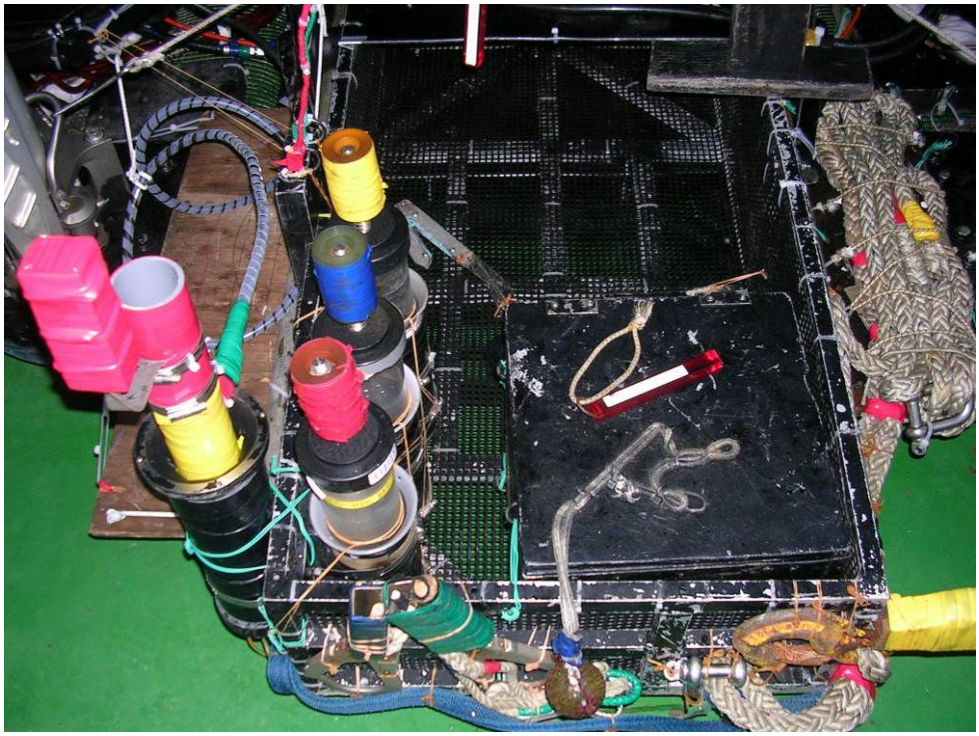


Dive#627 (OBB2, 20061213)



Dive#628 (OBB2, 20061213)

Dive#629 (off Hatsushima, 20061214)



Appendix 4. Shipboard log

Shipboard Log & Ship Track(NT06-22)			**Sagami-Bay**	Position/Weather/Wind/ Sea condition (Noon)
Date	Time	Comment.1	dive position	
08,Dec,06	10:00	Scientists on board		12/8 12:00(JST)
	11:00-12:00	Meeting with HPD team		o(Overcast)
	12:30-13:00	Briefing for life and safety		NNE-5(Fresh breeze)
	R	Arrive at research area		Sea Slight
	14:08	XBT		
	19:00-20:00	Scientific meeting		
09,Dec,06	6:15	Leave Ito port		12/9 12:00(JST)
	7:00	Arrive at research area (Hatsushima)		r(Rain)
	7:09	Throw the Copenhagen lander		NNE-5(Fresh breeze)
	7:22	Throw the JAMSTEC lander		Sea Slight
	8:24:00-13:34	Dive HPD#622 (Hatsushima)	35-00.146N,139-13.648,D=1218m	
	14:31	Throw the SAM		
	15:30	Leave research area		
	16:15	Arrive at Ito port		
10,Dec,06	6:45	Kitazato leave the ship		12/10 12:00(JST)
	7:00	Leave Ito port		c(Cloudy)
	7:30	Arrive at research area (Hatsushima)		North-2(Light breeze)
	08:23-15:06	Dive HPD#623 (Hatsushima)	35-00.180N,139-13.550,D=1195m	Sea rippled calm
	15:33	Recover the Copenhagen lander		
	15:40	Leave research area		
	16:30	Arrive at Ito port		
11,Dec,06	6:15	Leave Ito port		12/11 12:00(JST)
	7:15	Arrive at research area (OBB2)		bc(Fine but Cloudy)
	7:42	Throw the Copenhagen lander		NNE-5(Fresh breeze)
	9:09-11:19	Dive HPD#624 (OBB2)	35-00.850N,139-21.700,D=1442	Sea Slight
	12:52-16:15	Dive HPD#625 (OBB2)	35-00.850N,139-21.700,D=1454	
	16:35	Leave research area		

	17:45	Arrive at Ito port		
12,Dec,06	6:45	Leave Ito port		12/12 12:00(JST)
	7:30	Arrive at research area (Hatsushima)		o(Overcast)
	08:22-15:28	Dive HPD#626	31-52.450N,139-57.000E D=999m	NNE-5(Fresh breeze)
	15:50	Leave research area		Sea Slight
	16:30	Arrive at Ito port		
13,Dec,06	6:15	Leave Ito port		12/13 12:00(JST)
	7:30	Arrive at research area (OBB2)		bc(Fine but Cloudy)
	8:22-10:58	Dive HPD#627 (OBB2)	35-00.828N,139-21,706,D=1450	SW-1(Lighr air)
	13:22-15:27	Dive HPD#628 (OBB2)	35-00.828N,139-21,706,D=1450	Sea rippled calm
	15:55	Recover the Copenhagen lander		
	16:05	Leave research area		
	17:30	Arrive at Ito port		
14,Dec,06	6:45	Leave Ito port		12/14 12:00(JST)
	7:30	Arrive at research area (Hatsushima)		o(Overcast)
	8:23-13:35	Dive HPD#629 (Hatsushima)	35-00.180N,139-13.550E,D=1195m	North-3(Gentle breeze)
	14:00	Recover the JAMSTEC lander		Sea Slight
	14:05	Leave research area		
	18:15	Arrive at Yokosuka port		
15,Dec,06	9:00	Arrive at JAMSTEC		
		Scientists leave the Natsushima		