



## YOKOSUKA Cruise Report

YK08-06

Detection of Multi-scale Slow earthquakes by using  
Ocean-bottom Seismic and Geodetic Observation

Landward slope of Japan Trench,  
Off Miyagi, Northeastern Japan.

May 7, 2008 – May 22, 2008

Japan Agency for Marine-Earth Science and Technology  
(JAMSTEC)

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### 3. Cruise Information

(1) Cruise number/ship name

YK08-06/ R/V YOKOSUKA

(2) Title of the cruise (Title of the operational plan)

Detection of Multi-scale Slow Earthquakes by using Ocean-bottom Seismic and Geodetic Observation

(3) Proposal number/Title of the proposals

S08-27/ Detection of Multi-scale Slow earthquakes by using Ocean-bottom seismic and geodetic observation

(4) Period of the cruise

May 7, 2008–May 22, 2008

(5) Port calls

Yokosuka–Kurihama

(6) Research area

Landward slope of Japan Trench, Off Miyagi, Northeastern Japan

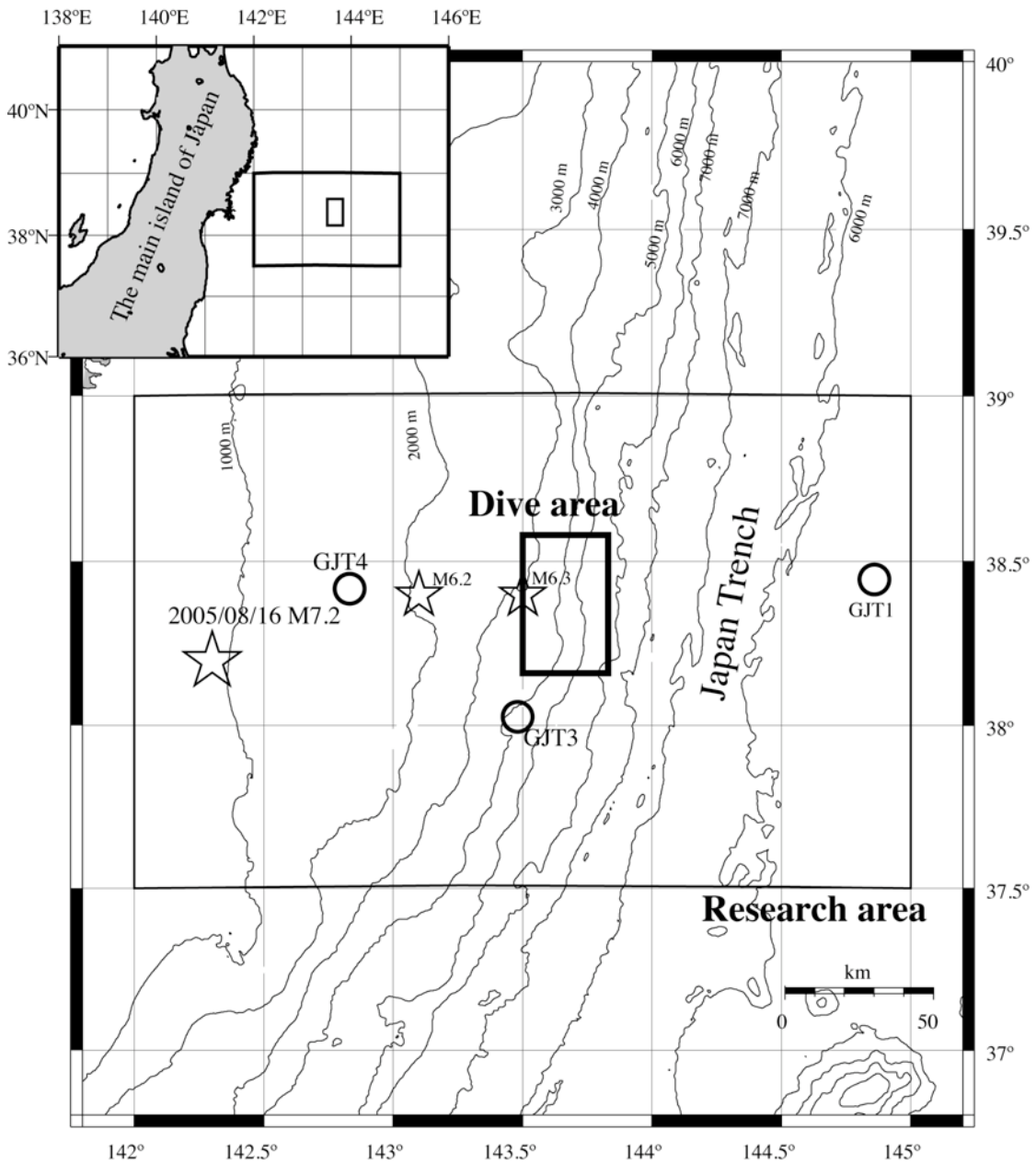


Fig 3-6-1. Research area. The open circles indicate the GPS/Acoustic stations operated by Tohoku Univ. The stars indicate large earthquakes with moment magnitudes exceeding 6.0 after August 16, 2005.

(7) Dive list (Dive numbers, Observers, Dive points, Keywords for the dives)

6K#1069, Takeshi Tsuji, Landward slope of Japan Trench, Cold seep

6K#1070, Yoshihiro Ito, Landward slope of Japan Trench, Cold seep

6K#1071, Motoyuki Kido, Landward slope of Japan Trench, Cold seep

6K#1072, Yukihiro Osada, Landward slope of Japan Trench, CAT-meter, Cold seep

6K#1073, Noriko Nakayama, Landward slope of Japan Trench, CAT-meter, Cold seep

6K#1074, Hiromi Fujimoto, Landward slope of Japan Trench, Cold seep

(8) Track line chart of the vessel.

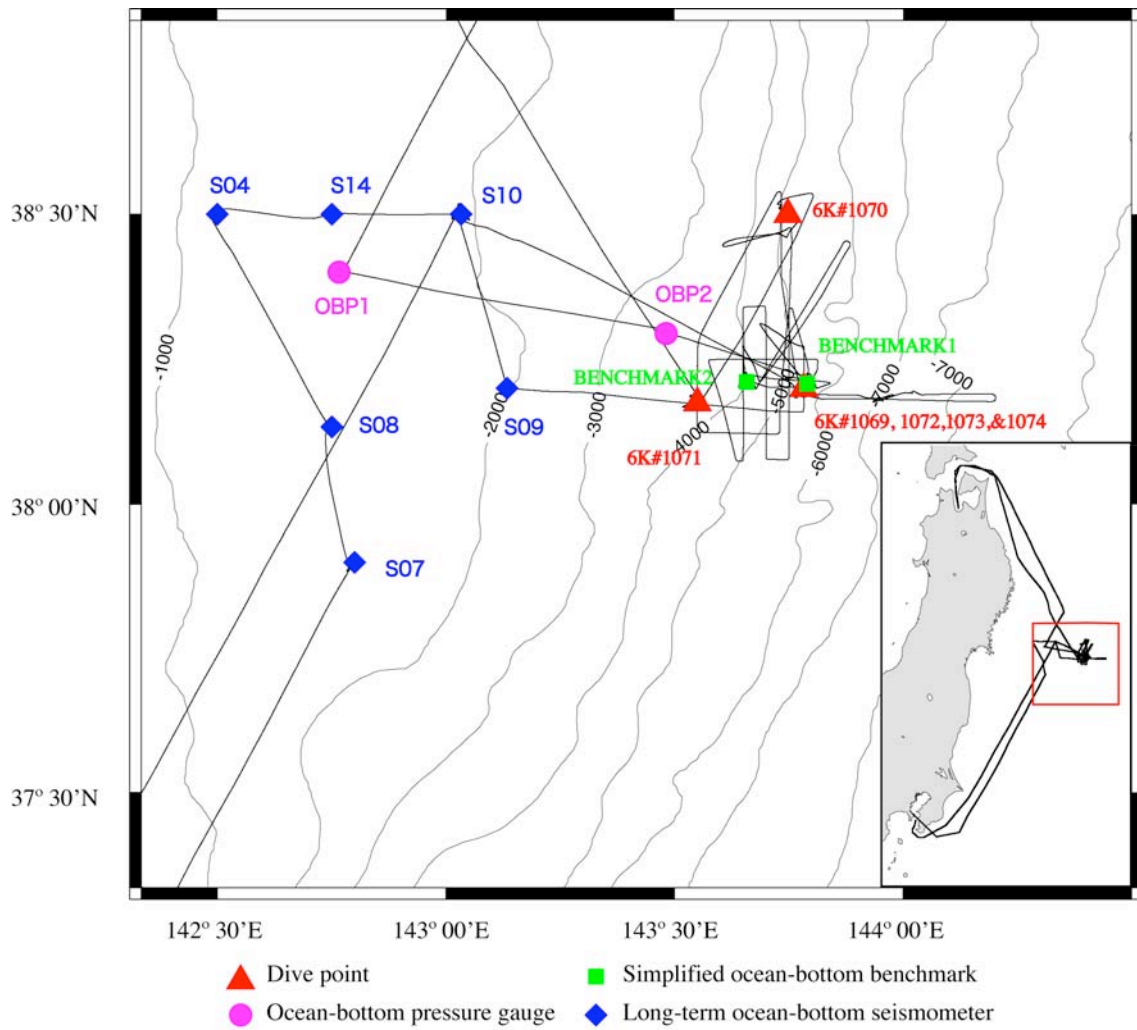


Fig. 3-8-1. Cruise track, dive points, and deployed instruments

#### 4. Researchers

(1) Chief Scientist

Yoshihiro Ito (Tohoku Univ.)

(2) Representative of the Science Party

Yoshihiro Ito (Tohoku Univ.)

(3) Science Party

Hiromi Fujimoto (Tohoku Univ.)

Yukihito Osada (Tohoku Univ.)

Motoyuki Kido (Tohoku Univ.)

Hiroaki Tsushima (Tohoku Univ.)

Ryosuke Azuma (Tohoku Univ.)

Kensuke Suzuki (Tohoku Univ.)

Takeshi Tsuji (Kyoto Univ.)

Noriko Nakayama (ORI, Univ. Tokyo)

## 5. Observation

### (1) Introduction

It is important to understand the process of stress accumulation to an asperity. Recently, several different types of slow earthquakes—non-volcanic tremor, very-low-frequency (VLF) earthquakes, or short-term slow slips—were reported in the Nankai, Cascadia, and Costa-Rica subduction zones. Slow earthquakes occur in both the downdip and updip portions of the asperity of megathrust earthquakes in the Nankai subduction zone. It is believed that slow earthquakes increase the stress on the asperity.

VLF earthquakes are only detected in the Nankai subduction zone. The periods of the seismic wave corresponding to VLF earthquakes are predominantly in the range of 10–20s [Obara and Ito, 2005]. The earthquake hypocenters are distributed at a depth of ~10 km above the upper surface of the subducting Philippine Sea Plate. The focal mechanism indicates reverse faulting. VLF earthquakes are excited by dynamic deformation on the out-of-sequence thrust or megasplay faults within the accretionary prism. The thrust faults generate a reverse-polarity reflection in the seismic reflection profiles; this may indicate the existence of an elevated fluid process within the fault zones [Shibley et al., 1994] or that the fault zones are pathways of earthquakes fluid migration [Park et al., 2002],

Hydrotectonic events coincident with some seismic signals observed by ocean-bottom-seismometers were first reported by Brown et al. (2005); they used CAT-meters in the shallow subduction system in regions of the Costa Rica subduction zone. Their results suggested that anomalously rapid flow events coincide with bursts of seismic noise.

The Pacific plate subducts beneath Tohoku, northeastern (NE) Japan, along the Japan Trench. The seismicity along the plate boundary is the highest in the world. The regional seismicity varies from north to south along the Japan Trench. From off Sanriku to off Miyagi, the northern part of the subduction zone, there exist asperities of large earthquakes, that is, earthquakes whose magnitudes exceed 7, and some clusters of small or intermediate earthquakes around the asperities. An aseismic slip has been observed as a post-seismic slip after large events. Tsunami earthquakes, a type of slow earthquakes, have also occurred near the Japan Trench.



(2) Scientific objectives

The question that arises is whether there occur any non-volcanic tremors, VLF earthquakes, or short-term slow slips in NE Japan. There three events have not been observed in NE Japan; this may be attributed to low detectability for long-period events near the trench. Here we make temporal ocean-bottom seismic, geodetic and hydraulics station in order to detect multi-scale slow earthquakes in NE Japan (Fig. 5-2-1)

There arises another question: what is the interrelationship between slow earthquakes and hydrodynamics on the fault plane? Recent seismic results indicate the existence of fluid around the source regions of various slow earthquakes. Fluid migration would occur during a sequence of slow earthquakes. In order to provide an answer to the above question, we investigate the relationships among slow earthquakes, fluid migration along a fault, and deformation of the seafloor using ocean-bottom broadband seismometers, ocean-bottom pressure meters, GPS and acoustic measurements, and CAT-meters near a cold seep or thrust fault branching from the upper surface of the subducting Pacific plate. We also investigate the chemical composition of and isotopes in pore fluid at a cold seep as a step toward revealing the origin of the fluid.

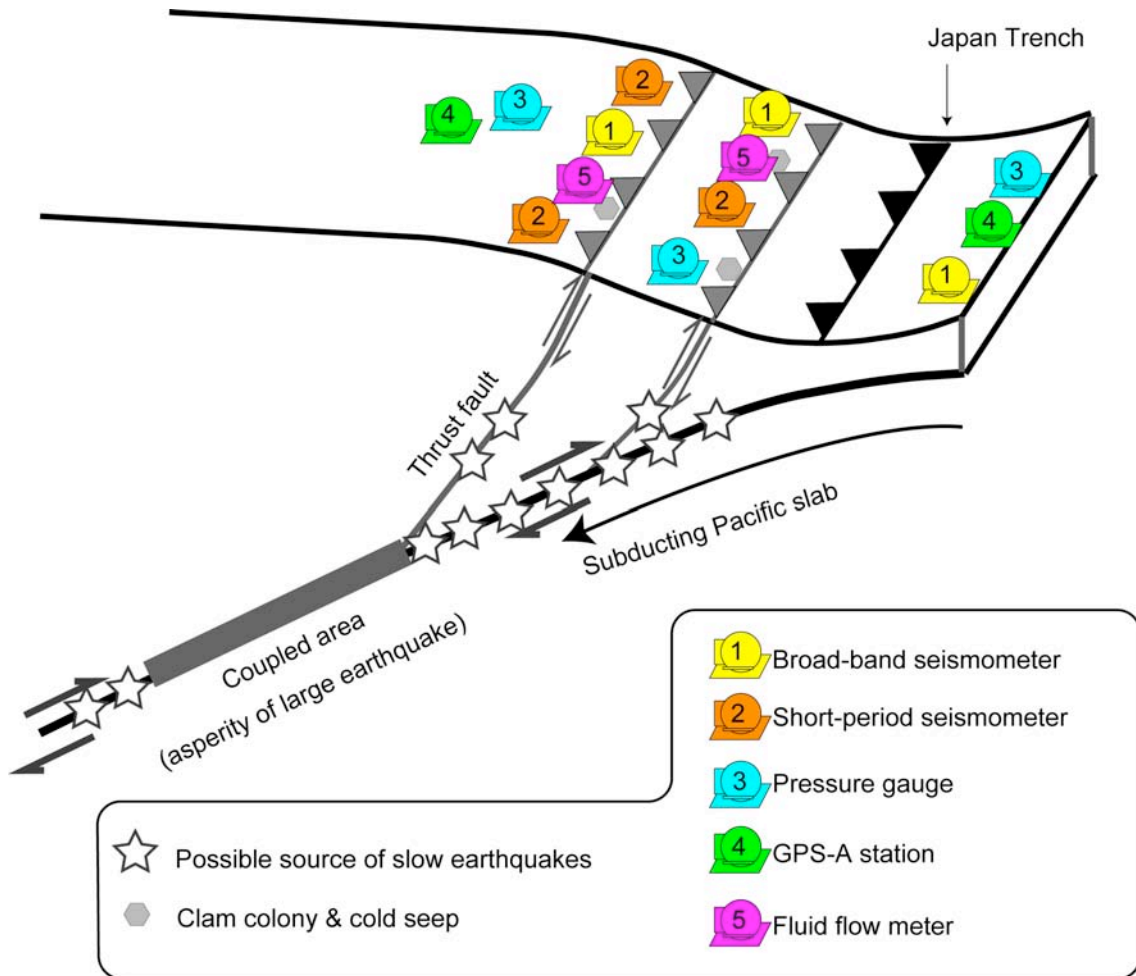


Fig. 5-2-1. Schematic representation of the distribution of slow earthquakes, fluid path, and ocean-bottom stations for seismic, geodetic, and hydraulics studies.

## (3) Actual schedule

Shipboard Log & Ship Track(YK08-06 08/05/07 - 08/05/23)			Landward slope of Japan Trench	Position/Weather/Wind/Sea condition (Noon)
Date	Time	Description	Remark	
07,May,08	9:00	Boarding on R/V YOKOSUKA	Port YOKOSUKA-SHI N-KO	12:00(UTC+9)
	11:00	Onboard seminar	For safety YOKOSUKA life	34-57.7N, 139-39.1E
	13:00	Meeting for research dive	With 6K operation team	Fine but cloudy
	16:40	Pray for safety of cruise to KONPIRASAN		Gentle Breeze,W
				Smooth
08,May,08	5:30	Arrive at research area		12:00(UTC+9)
	6:58	BBOBS S07		38-30.0N, 142-37.5E
	8:48	BBOBS S08		Overcast
	11:06	BBOBS S04		Gentle Breeze,NW
	12:33	BBOBS S14		Smooth
	14:05	BBOBS S10		
	16:01	BBOBS S09		
	18:05	XBT		
	18:46-19:29	MBES mapping survey		
	19:00-20:00	Scientific meeting		
09,May,08	9:04	Started 6K#1069 dive		12:00(UTC+9)
	11:31	Arrived at bottom (5796m)		38-12.4N, 143-47.2E
	14:57	Leave the bottom (5731m)		Fine but cloudy
	16:56	Surfaced 6K		Moderate Breeze,NNE
	17:22	6K on-decked		Slight
	18:57-19:38	MBES mapping survey		
	20:00-	Scientific meeting		

	21:00			
	21:10- 21:55	MBES mapping survey		
10,May,08	9:06	Started 6K#1070 dive		12:00(UTC+9)
	11:23	Arrived at bottom (5545m)		38-29.5N, 143-45.1E
	15:11	Leave the bottom (5213m)		Cloudy
	17:08	Surfaced 6K		Fresh Breeze,NE
	17:33	6K on-decked		Moderate
	20:00- 21:00	Scientific meeting		
11,May,08	10:03	Started 6K#1071 dive		12:00(UTC+9)
	11:34	Arrived at bottom (3466m)		38-11.3N, 143-33.1E
	15:46	Leave the bottom (3370m)		Overcast
	17:04	Surfaced 6K		Fresh Breeze, ENE
	17:31	6K on-decked		Modreate
	19:30- 20:30	Scientific meeting		
12,May,08	9:00 - 11:30	Scientific meeting	Escape from typhoon #2	12:00(UTC+9)
	14:10	Arrive at AOMORI		41-18.8N, 140-42.0E
				Fine but cloudy
				Light Breeze,WSW
				Calm
13,May,08	9:00 - 10:00	Seminor for crews		12:00(UTC+9)
				40-52.9N, 140-45.9E
				Fine but cloudy
				Moderate Breeze,ENE
				Slight
14,May,08	12:50	Departure from AOMORI		12:00(UTC+9)

				40-52.9N, 140-45.9E
				Rain
				Light air,NW
				Calm
15,May,08	10:27	OBP(GJT4)		12:00(UTC+9)
	11:04	Release OBP		38-24.0N, 142-46.0E
	11:43	Recover OBP		Fine but cloudy
	14:30	OBP(GJT3)		Fresh Breeze,ENE
	14:43	Release OBP		Moderate
	16:21	Recover OBP		
	18:03	Deployment of Benchmark, BENCHMARK 1		
	20:00- 21:50	Estimation of position using the travel times of an acoustic wave		
16,May,08	5:40	Send command for release to releaser		12:00(UTC+9)
	7:31	Recovery of releaser		38-11.8N, 143-47.1E
		Started 6K#1072 dive		Fine but cloudy
	11:52	Arrived at bottom (m)		Light Breeze,S
	15:06	Leave the bottom (m)		Calm
		Surfaced 6K		
	17:26	6K on-decked		
	18:42	Deployment of Benchmark, BENCHMARK 1		
	20:05- 21:08	Estimation of position using the travel times of an acoustic wave		
17,May,08	5:40	Send command for release to releaser		12:00(UTC+9)
	7:02	Recovery of releaser		38-12.4N, 143-46.9E
	9:00	Started 6K#1073 dive		Rain

	11:27	Arrived at bottom (5741m)		Moderate Breeze,ESE
	15:01	Leave the bottom (5865m)		Slight
	16:56	Surfaced 6K		
	17:23	6K on-decked		
		Scientific meeting		
18,May,08	9:02	Started 6K#1074 dive		12:00(UTC+9)
	11:29	Arrived at bottom (5866m)		38-11.5N, 143-47.1E
	14:51	Leave the bottom (5854m)		Blue sky
	17:00	Surfaced 6K		Gentle Breeze,NW
	17:30	6K on-decked		Slight
	20:29- 21:35	OBS(S10) Estimation of position using the travel times of an acoustic wave		
		Scientific meeting		
19,May,08		Transit to Tokyo Bay	Escape from the typhoon #4	12:00(UTC+9)
				35-18.1N, 140-43.4E
				Cloudy
				Fresh Breeze,SE
				Moderate
20,May,08		Anchorage in Tokyo Bay		12:00(UTC+9)
				35-35.2N, 139-55.9E
				Overcast
				Near gale,SSW
				Moderate
21,May,08		Anchorage in Tokyo Bay		12:00(UTC+9)
				35-19.8N, 139-40.8E
				Fine but cloudy
				Light Breeze,ESE
				Calm
22,May,08	9:30	Arrival in port	Port Kurihama	
	11:30	Leave the YOKOSUKA		

- (4) Research activities
- (4)-1 Investigation of cold seeps and installation of CAT meters  
Yoshihiro Ito, Takeshi Tsuji, Hiromi Fujimoto, Yukihito Osada,  
Motoyuki Kido, and Noriko Nakayama

### Introduction

The pore fluid in a fault zone is important for understanding the mechanisms of slow earthquakes because some seismological and geological studies have revealed the existence of pore fluid around the source region of slow earthquakes. Shallow VLF earthquakes in the Nankai subduction zone occur on the thrust faults within the accretionary prism along the Nankai Trough. The out-of-sequence thrusts or megasplay faults within the accretionary prism generate a reverse-polarity reflection in the seismic reflection profiles; this may indicate the existence of elevated fluid pressures within the fault zones or that the fault zones are pathways of fluid migration. Moreover, some chemosynthetic benthic colonies, which indicate the presence of cold seeps, are found out on the seafloor around the outer ridge, where megasplay faults that branch out from the decollement reach the seafloor.

Recently, a significant transience in fluid flow accompanied by an increase in the amplitudes of ground velocity was observed using osmotically-driven fluid flow meters and short-period seismometers. This result suggests that the poro-elastic strain filed around a series of slow or creep slip simultaneously forces fluid through fluid-pathway networks.

### Method

In order to observe the transience of fluid flow due to some slow earthquakes, we used an osmotically-driven fluid flow meter (CAT-meter) (Fig. 5-4-1-1). Since data showing the existence of cold seeps in the research area were unavailable, we first investigated about the distribution of chemosynthetic benthic colonies by diving surveys using the SHINKAI 6500, following which we installed CAT-meters on cold seeps.

### Preliminary results and future works

We carried out six dives with the SHINKAI 6500 to look for chemosynthetic benthic colonies, which suggest the existence of a cold seep, and to deploy two CAT

meters. In order to find a distribution of chemosynthetic benthic colonies, we first dived in three regions, for where a steep slope was observed in the corresponding bathymetric data (contour map) obtained using a multi-narrow-beam system (SEABEAM2112.004). We also used a map of backscatter intensity obtained by using the bathymetric system.

The dive #1069 started a depth of 5796 m, at 38°12.2662'N latitude, and 143°47.1599'E longitude, and ended at a depth of 5731m, at 38°12.6365'N latitude, and 143°47.0665'E longitude (Fig. 5-4-1-2). Two calyptogena colonies were found at depths of 5702 m and 5736 m along the foot of the steep slope (Fig. 5-4-1-3). Dive #1070 started at a depth of 5545 m, at 38°29.4832'N latitude, and 143°45.0422'E longitude, and ended at a depth of 5213m, 38°30.7496'N latitude, and 143°44.4098'E longitude (Fig. 5-4-1-4). On this dive, no chemosynthetic benthic colonies were found. Dive #1071 started at a depth of 3466 m, at 38°11.3693'N latitude, and 143°33.1297'E longitude, and ended at a depth of 3370m, at 38°10.1093'N latitude, and 143°33.0342'E longitude (Fig. 5-4-1-5). Although two calyptogena shells were found at a depth of 3474 m, no colonies were observed.

Considering the results of these three dives, we decided the target region, that is, the region in which two calyptogena colonies were found on dive #1069, for the deployment of the CAT meters. We deployed two CAT meters during two dives. Dive #1072 started at a depth of 5779 m, at 38°11.8360'N latitude, and 143°46.6817'E longitude, and ended at a depth of 5693 m, at 38°12.5954'N latitude, and 143°47.0607'E longitude. One of the CAT meters was deployed at a depth 5742 m, at 38°12.6217'N latitude, and 143° 47.0214'E longitude (Fig. 5-4-1-2). During the dive, some calyptogena colonies were found along the strike of the slope on the bathymetric contour map. Dive #1073 started at a depth of 5741 m, at 38°12.2332'N latitude, and 143°46.8255'E longitude, and ended at a depth of 5865 m, at 38°11.5279'N latitude, and 143°47.0827'E longitude (Fig. 5-4-1-2). The other CAT meter was deployed at a depth of 5703 m, at 38°12.3806'N latitude, and 143°46.8790'E longitude. At the end of this dive, we investigated a terrace-like region for which a strong backscatter, which is not indicative of a steep slope, was observed. In this region, we found several calyptogena colonies at a depth of 5780 m, at 38°11.6519'N latitude, and 143° 47.0918'E longitude.

Dive #1074 started at a depth of 5866 m, at 38°11.3502'N latitude, and 143°47.1900'E longitude, and ended at a depth of 5854 m, at 38°11.4886'N latitude,



and 143°46.9555'E longitude (Fig. 5-4-1-2). The aim of this dive was to investigate the distributions of the calyptogena colonies found toward the end of dive #1073. We mainly investigated the region that had high acoustic reflection intensity. We found 12 calyptogena colonies in four regions at depths ranging from 5830 m to 5861m.

The plan is to recover all the CAT meters after one year by using an ROV or a DSRV.

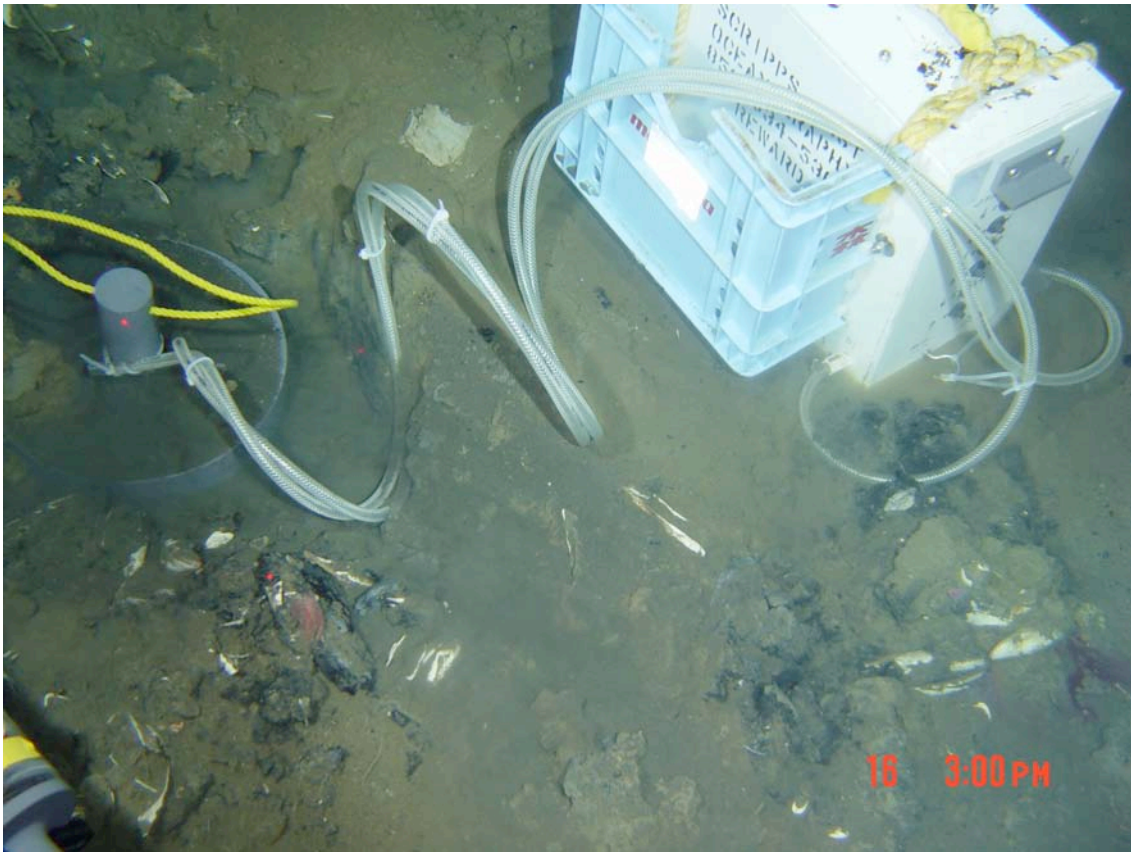


Fig. 5-4-1-1. The CAT meter deployed on the cold seep.

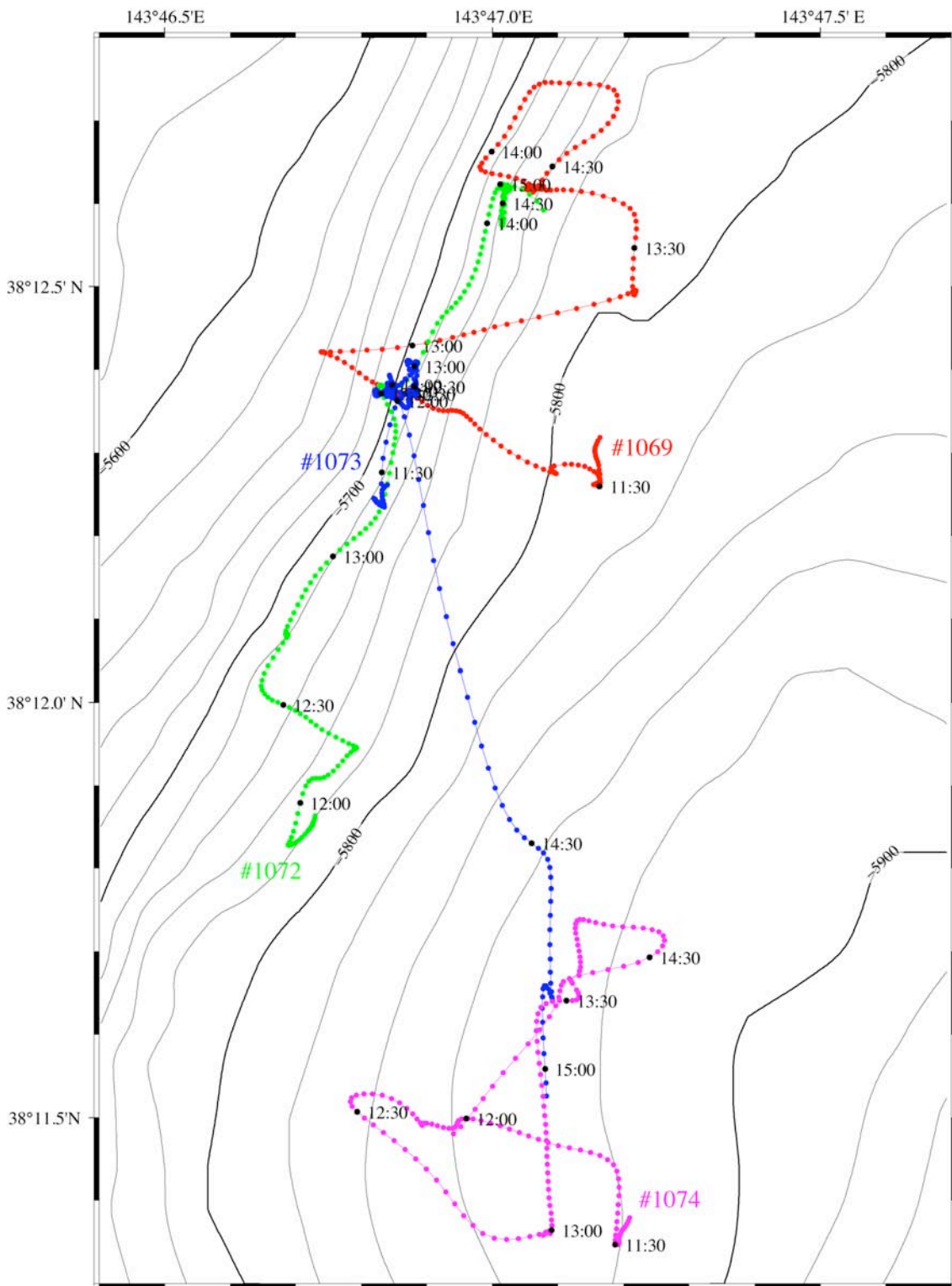


Fig. 5-4-1-2. Track line charts of dives #1069, #1072, #1073, and #1074 with the SHINKAI 6500



Fig. 5-4-1-3. Calyptogenia colony found on dive #1069.

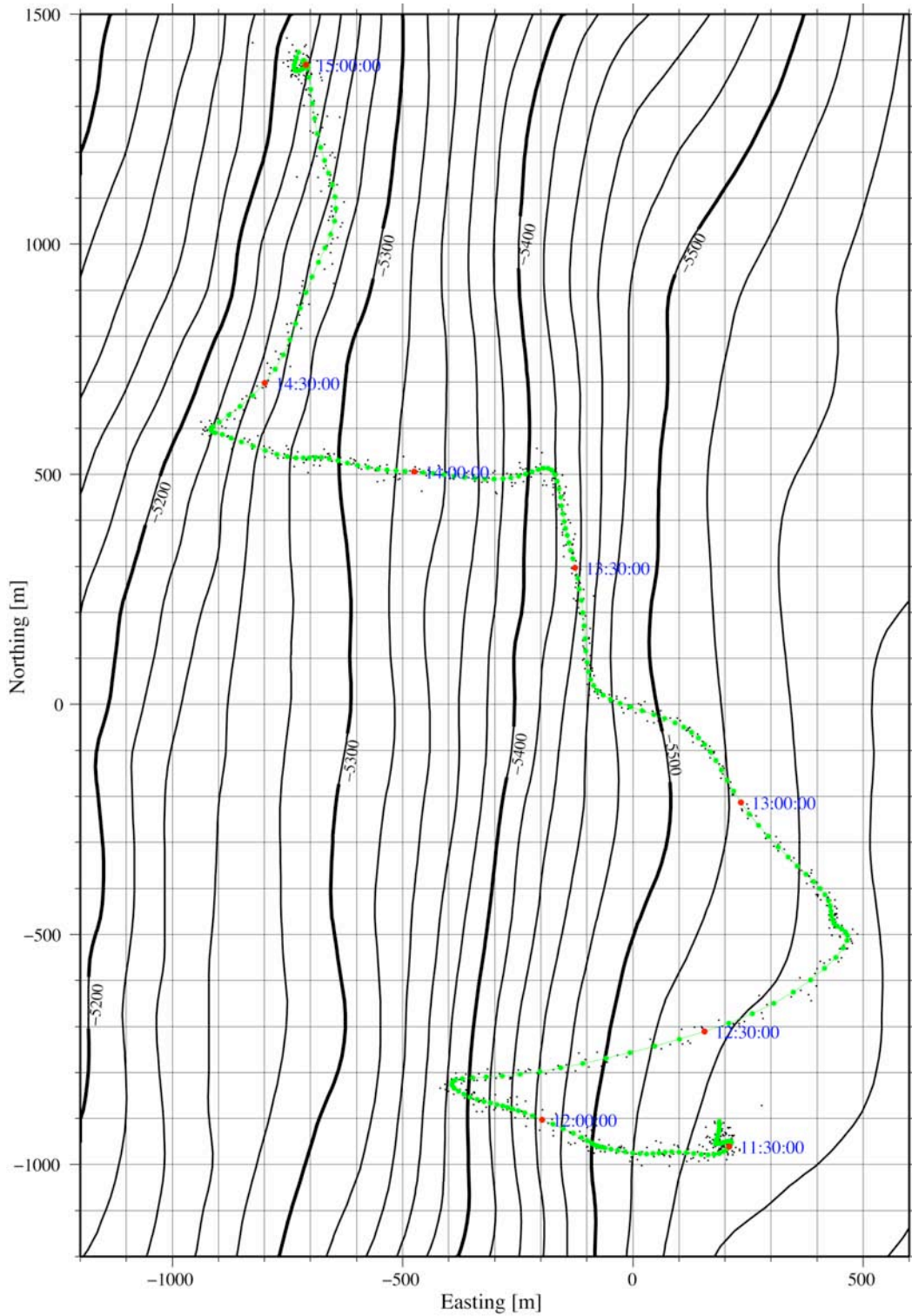


Fig. 5-4-1-4 Track line charts of dive #1070. The origin of the coordinate axes is at position 38°30.0'N latitude and 143°44.9'E longitude



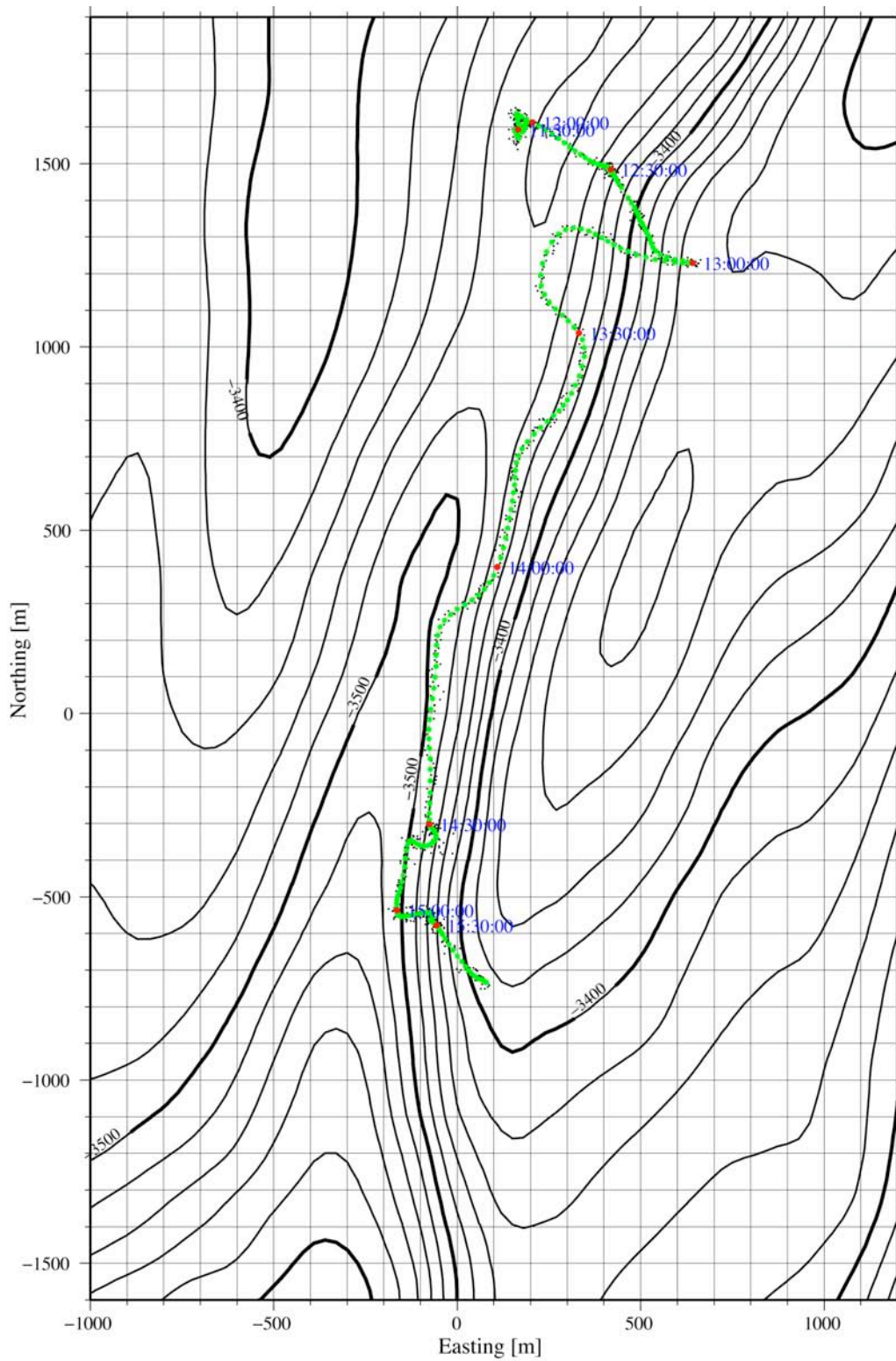


Fig. 5-4-1-5 Track line charts of dive #1071. The origin of the coordinate axes is at position 38°10.5'N latitude and 143°33.0'E longitude

- (4)-2 Deployment of benchmarks for seismological and geodetic observation  
Yoshihiro Ito, Yukihiro Osada, Motoyuki Kido, Hiromi Fujimoto,  
Hiroaki Tsushima, Ryosuke Azuma, and Kensuke Suzuki

### Introduction

It is important to observe both seismic and geodetic ground motions at the same station continuously. In order to observe multiscale slow earthquakes, it is necessary to deploy seismic and geodetic sensors at the same position because the frequency components of multiscale slow earthquakes are different. An ocean-bottom benchmark is useful for continuous seismic and geodetic observations at the same position.

### Method

We have developed a simplified ocean-bottom benchmark (SOBB), which is composed of three types of sensors: a short-period seismometer, a broadband seismometer, and a pressure gauge (Fig. 5-4-2-1). It is possible to throw the SOBB down from a vessel using floats with an acoustic releaser.

A short-period seismometer with an eigen-frequency of 4.5 Hz is used to measure ordinary micro earthquakes, and low-frequency tremors. The sensor, data logger, and batteries are packed into a glass sphere. It is possible to record continuous data related to the vertical and two horizontal components for a period of six months with a sampling rate of 100 Hz.

In order to observe VLF earthquakes and long-period seismic signals, a broadband seismometer produced by PMD Inc. is used. The sensor is packed into a glass sphere, in the same manner as described above. It is possible to observe continuous data related to the vertical and two horizontal components for six months with a sampling rate of 100 Hz.

A pressure gauge produced by Paroscientific Inc. is used to measure the vertical static crustal deformations due to creep on the plate boundary and ultra-low-frequency earthquakes. The sensor is placed outside the glass sphere. The control unit of the sensor and the batteries are installed within the glass sphere. It is possible to observe continuous data for a year with a logging interval of 10 s.

### Preliminary results and future works

We deployed two SOBBs on May 15 and 16 (Fig. 5-4-2-3). As observed from the deck of the vessel, the SOBBs were sunk with a speed of 50 m/min and were suspended in seawater by floats attached to an acoustic releaser. The SOBBs landed within 200–300 m from the targets points and were unaffected by sea current. The floats with the acoustic releaser were recovered successfully (Fig. 5-4-2-3). It rose to the surface with a speed of 65 m/min.

One SOBB, BENCHMARK-1, was deployed on the footwall near the possible faults estimated by traces of calyptogena colonies, which were observed on dives #1069, #1072, #1073, and #1074 with SHINKAI 6500. The other, BENCHMARK-2, was deployed on the hanging wall of a possible fault along the calyptogena colonies. It was located seaward of the possible fault discovered during dive #1071.

Short-period and broadband seismometers will be recovered by a pop-up system. We plan to deploy short-period and broadband seismometers for replacement by using the KAIKO 7000II ROV. The pressure gauge shall be recovered and replaced by the KAIKO 7000II ROV. We expect that these operations will be continued for several years for the observation of different types of slow earthquakes.

The locations of the two SOBBs are listed in Table 5-4-2-1 and are shown in Fig 5-4-2-3. The benchmark locations were calculated from the travel times of an acoustic wave, which were observed on the surface around the benchmarks.



Table 5-4-2-1. Locations of benchmarks

Station	Latitude	Longitude	Depth
BENCHMARK1	38°12.5519'N	143°47.3328'E	5815 m
BENCHMARK2	38°12.6107'N	143°39.4199'E	4122 m

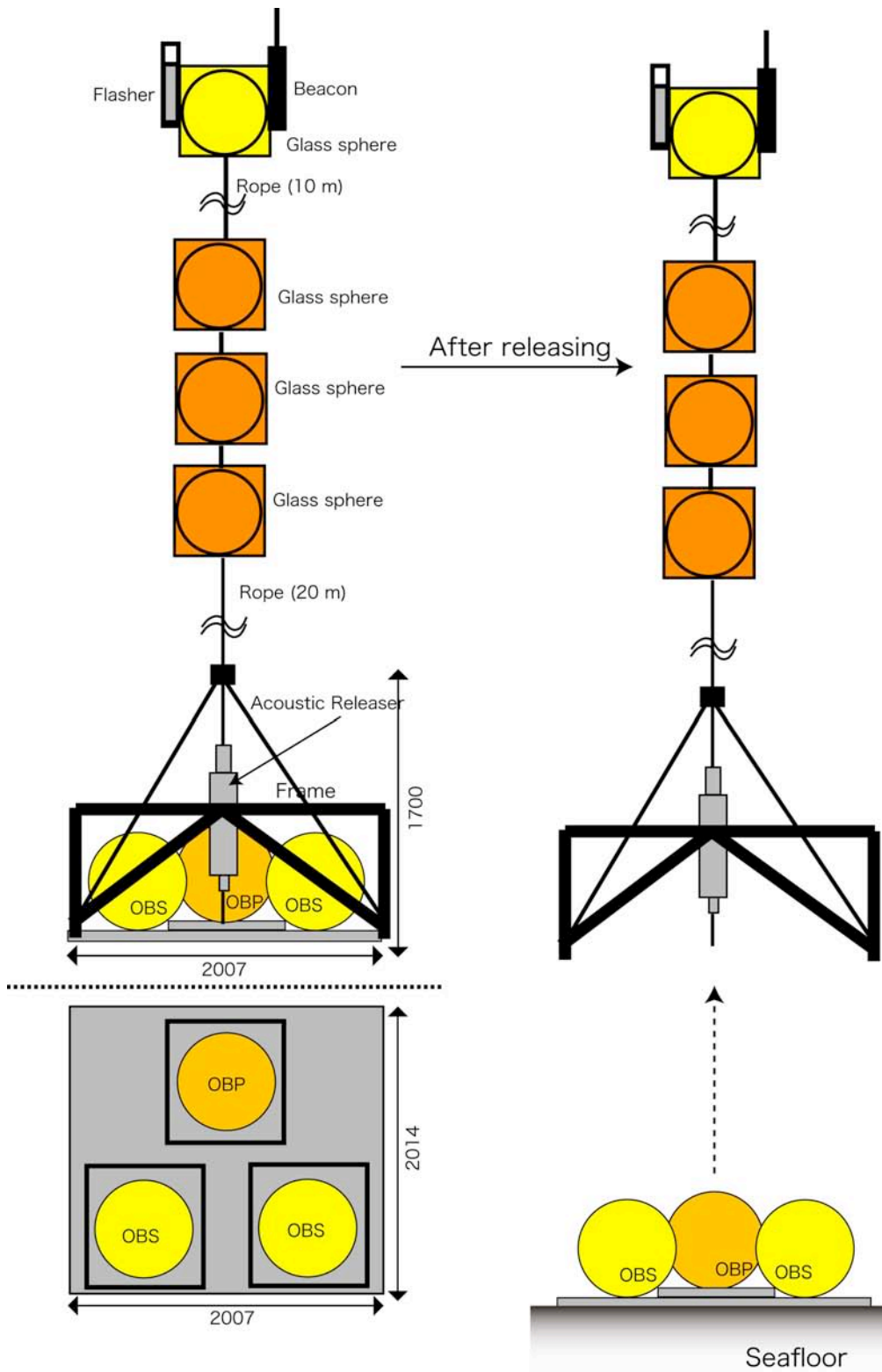


Fig. 5-4-2-1. Schematic representations of a simplified ocean-bottom benchmark and floats with an acoustic releaser.



Fig. 5-4-2-2. A simplified ocean-bottom benchmark

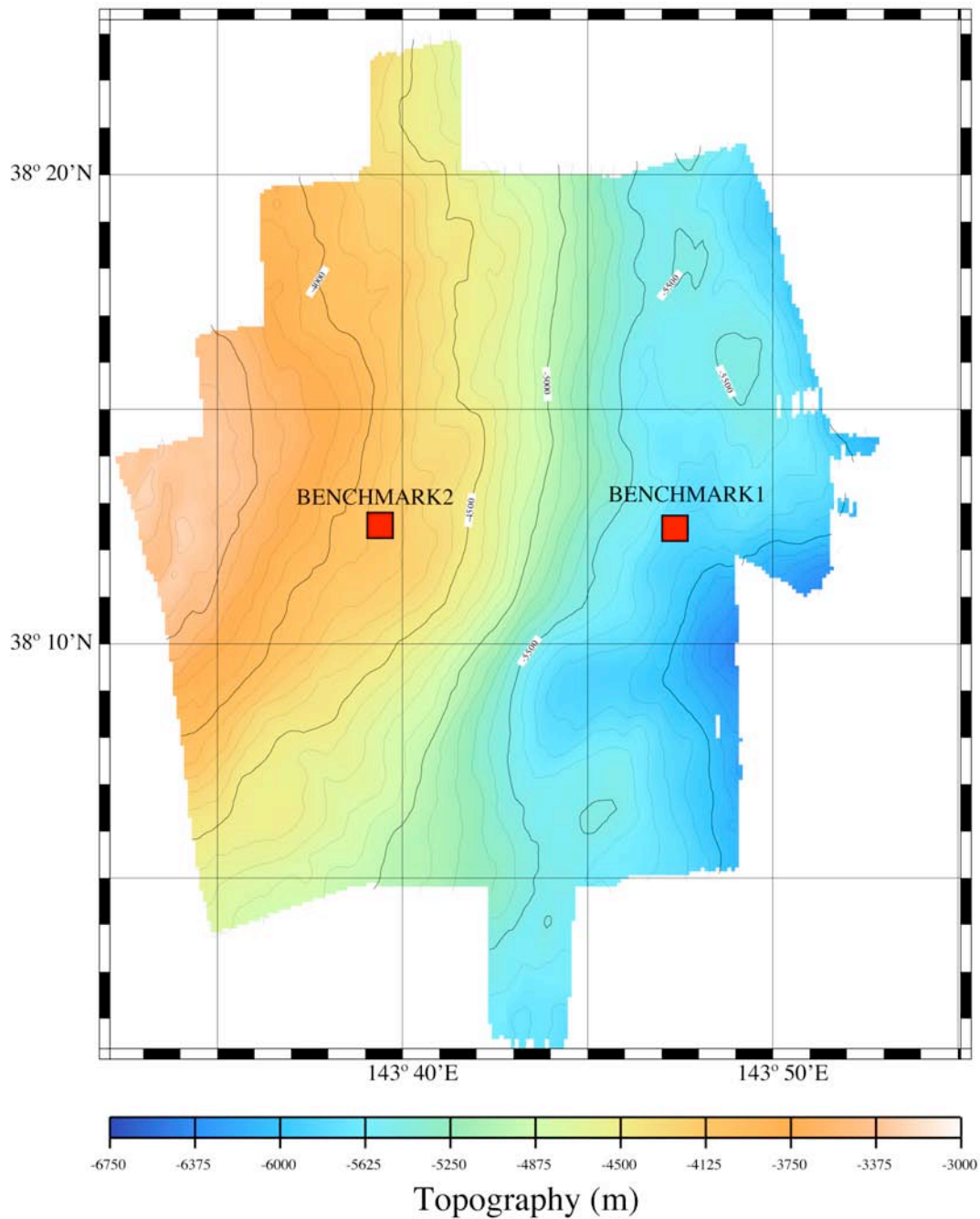


Fig. 5-4-2-3. Locations of simplified ocean-bottom benchmarks and bathymetry by the SEABEAM2112.004

4-(3) Recovery and deployment of an instrument to observe the vertical movement

Yukihito Osada, Hiroaki Tsushima, Motoyuki Kido, and Hiromi Fujimoto

We have been investigating the source region of Miyagi-Oki earthquake since 2006. We deployed an OBP and an IES to monitor the vertical movement in this region. An OBP measures the variation of water pressure. An IES measures the variation of the pressure and the two-way travel time of an acoustic wave between the sea surface and the seafloor. The acoustic wave is either phase modulated or frequency modulated. We recovered two OBPs (Fig. 5-4-3-1) and deployed two IESs between the SHINKAI 6500 diving surveys. The recovered OBP had recorded the pressure variation for six months (the total data comprises approximately 250000 samples) with a sampling interval of 1 min (Fig. 5-4-3-2). The deployed IESs are sampled every 10 min; the sampling frequency is 10 times the frequency of the transmitted signal.



Fig. 5-4-3-1 Photograph of the recovered OBP.

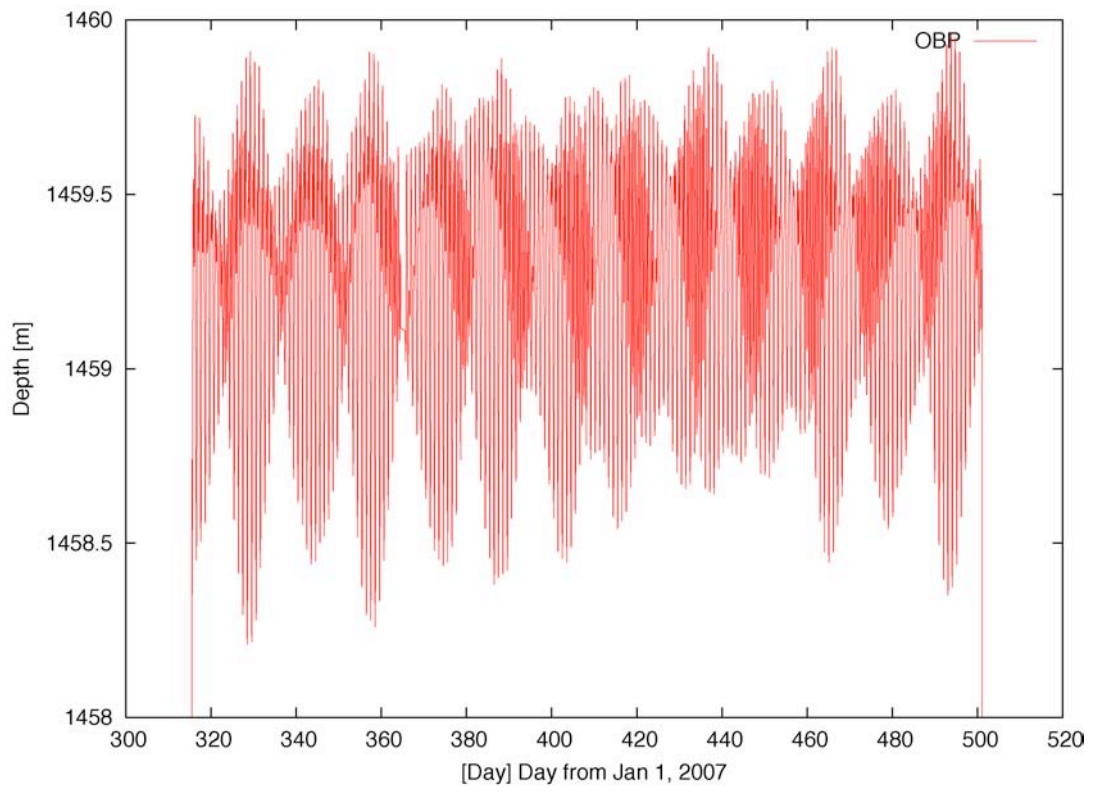


Fig. 5-4-3-2 Time series of depth calculated from OBP data.

#### 4-(4) Geochemical study of pore fluid on cold seeps

Noriko Nakayama

##### Objective

“Cold seepage” on the seafloor in connection with deep-sea biological communities has been found in tectonically active subduction zones. It is considered that the activities of biological communities associated with cold seep are supported by microbial chemosynthesis, which involves the oxidation of dissolved compounds. This suggests that chemical transport from the sedimentary layers could be important with regard to the fluid migration from the deep subsurface to the seafloor. In this study, we present geochemical features of the fluids for sediments on the Japan Trench to imply the origin of the fluids, which is necessary for a complete understanding of the relationships among the active faults, colonies and cold seepages.

##### Samples

During the R/V Yokosuka (JAMSTEC) cruise YK08-06, the following samples were collected at the Japan Trench: 13 successful near-surface sediment push cores (5–20 cm long) from within and outside the seafloor clam colonies and the two bottom seawater samples just above the clam colonies collected using Niskin bottles were taken at the Japan Trench (Table 5-4-4-1).

The pore water samples used in this study were extracted from the sampled sediment cores in an on-board laboratory. Intervals of around 5 cm were extruded from each core. After extraction, the fluid was filtered through 0.45- $\mu\text{m}$  Millipore filters, following which it was placed in a polypropylene bottle in order to measure the major cations (Na, K, Mg, Ca, Sr, and Ba) and anions (Cl and  $\text{SO}_4$ ) analysis.

Two milliliters of pore water was used for determining the  $\delta^{13}\text{C}$  values and the concentrations of light hydrocarbons measurements, (mainly  $\text{CH}_4$ ). The samples of pore water were placed in glass vials and an  $\text{HgCl}_2$  saturated solution was added to the samples. The vials were then sealed with butyl gum septum and crimp-sealed with aluminum caps for analysis on land. Seawater samples from the Niskin bottles were placed in 100-ml glass vials to which 20  $\mu\text{l}$  of saturated  $\text{HgCl}_2$  solution was added; these samples were then examined to obtain the  $\delta^{13}\text{C}$  values and the concentrations of light hydrocarbons (mainly  $\text{CH}_4$ ). All samples were stored in a refrigerator till they could be



analysed on land.

The concentrations and stable carbon isotope compositions of light hydrocarbons in pore water will be measured by using a previously described method [Tsunogai *et al.*, 2000, 2002], with an isotope ratio monitoring gas chromatography/mass spectrometry system. The concentrations of the major components concentrations of pore water will be measured using an ion chromatograph.

Table 5-4-4-1. Descriptions of sediment and seawater samples.

Sediment		sample	length(cm)	description
38° 13 N, 143° 47 E	1	6K#1069_C01	5	5737m, close to the clam colony
38° 13 N, 143° 47 E	2	6K#1069_C02	5	5732m, close to the clam colony
38° 13 N, 143° 47 E	3	6K#1069_C03	10	5732m, outside of the clam colony
38° 12.3N, 143° 46.8 E	4	6K#1072_C01	5	5703m, marker #66, close to the clam colony
38° 12.3N, 143° 46.8 E	5	6K#1072_C02	9	5742m, set up the CATmeter, close to the clam colony
38° 12.3N, 143° 46.8 E	6	6K#1072_C03	10	5742m, set up the CATmeter, close to the clam colony
38° 12.3N, 143° 46.8 E	7	6K#1072_C04	6	5742m, set up the CATmeter, close to the clam colony
38° 12.3N, 143° 46.8 E	8	6K#1072_C05	15	5742m, set up the CATmeter, outside of the clam colony
38° 12N, 143° 46.9 E	9	6K#1073_C01	-	-
38° 12N, 143° 46.9 E	10	6K#1073_C02	-	-
38° 11.5 N, 143° 47 E	11	6K#1074_C01	20	5861 m, a controll sediment
38° 11.5 N, 143° 47 E	12	6K#1074_C02	20	5860m, close to the clam colony
38° 11.5 N, 143° 47 E	13	6K#1074_C03	10	5860m, close to the clam colony
38° 11.5 N, 143° 47 E	14	6K#1074_C04	20	5860m, close to the clam colony
38° 11.5 N, 143° 47 E	15	6K#1074_C05	10	5860m, close to the clam colony
Seawater		sample		description
38° 12.3N, 143° 46.8 E	1	6K#1072_WO2		Bottom-5m, the clam colony site
38° 11.5 N, 143° 47 E	2	6K#1074_WO2		5860m, just above the clam colony

(4)-5 Deployment of long-term ocean-bottom seismometers

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In order to investigate the ordinary seismicity in the downdip portion of the research area, we deployed six long-term ocean-bottom-seismometers off Miyagi, northeastern Japan; this region has witnessed large earthquakes that have occurred at intervals of 30–40 years.

A short-period seismometer with an eigenfrequency of 1 Hz is used. The sensor, data logger, and batteries are packed into a titanium sphere. It is possible to record continuous data related to the vertical and two horizontal components for a year with a sampling rate of 100 Hz.

We deployed six OBSs from the deck to the seafloor. The locations of the OBSs are listed in Table 5-4-4-1 and are shown in Fig. 3-8-1. They will be recovered by a pop-up system after six months or one year.

Table 5-4-2-1. Location of OBSs

Station	Latitude	Longitude	Depth
S07	38°35.9973'N	142°47.9940'E	1359 m
S08	38°07.9952'N	142°44.9973'E	1530 m
S04	38°30.0017'N	142°29.9970'E	1130 m
S14	38°30.0046'N	142°44.9995'E	1471 m
S09	38°12.0001'N	143°08.0148'E	2071 m
S10 <sup>†</sup>	38°30.0348'N	143°01.9363'E	1985 m

† The location of S10 is calculated from the travel times of acoustic waves. The others show the point where the OBSs were thrown down from the surface.

6. Notice on using

This cruise report is a preliminary documentation as of the end of the cruise. It may not be corrected even if changes on content (i.e. taxonomic classifications) are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the Chief Scientist for the latest information before using.

Users of data or results of this cruise are requested to submit their results to Data Integration and Analysis Group (DIAG), JAMSTEC.