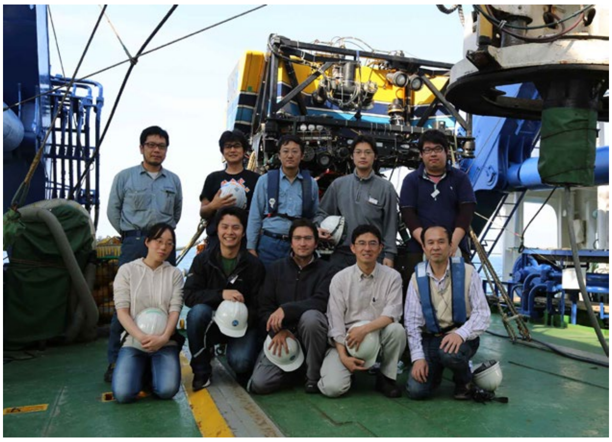
doi : 10.17596/0002915

R/V Natsushima Cruise Report

NT14-07

Geological study on intermittent methane seep, temporal variation of Rn emanation at faults and the visualization of marine species by using the cable network

Daini-Tenryu Knoll and Kumano-nada



April 22, 2014 – April 30, 2014

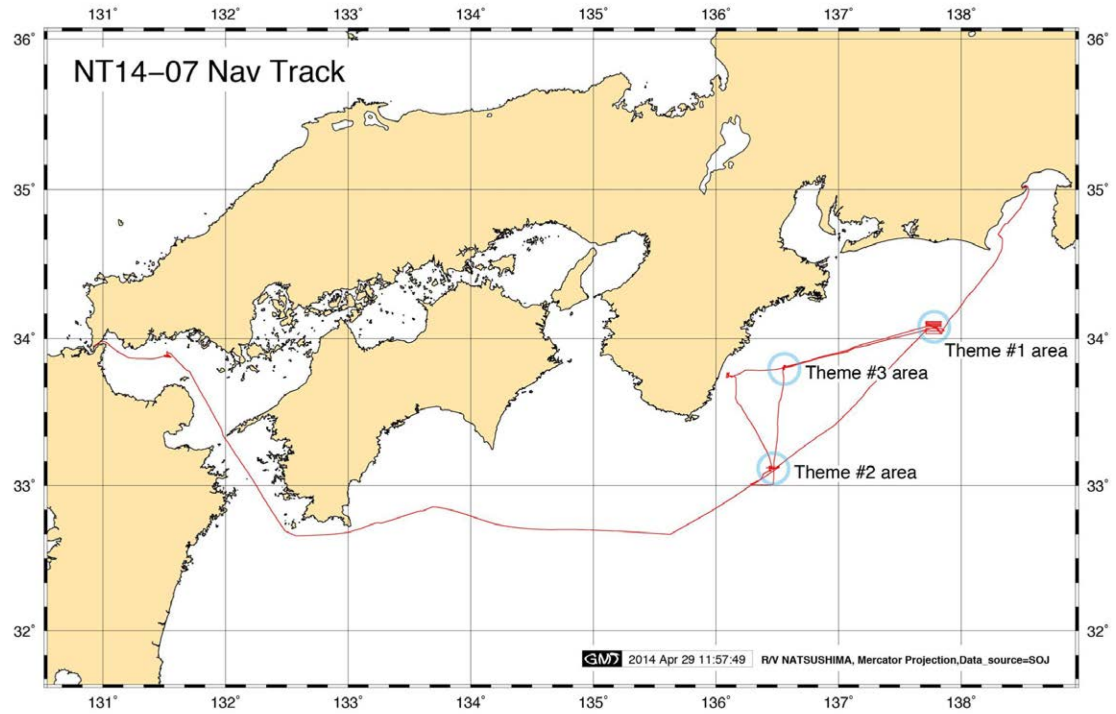
Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

●Contents

1. Cruise Information

- Cruise ID: NT14-07
- Name of vessel: R/V Natsushima
- Title of the cruise: Geological study on intermittent methane seep, temporal variation of Rn emanation at faults and the visualization of marine species by using the cable network
- Title of proposal: Verification of intermittent methane seep using radiocarbon shell age of large *Calyptogena* colony off Tokai (Proponent, PI: Juichiro ASHI), Temporal variation of Rn emanation at faults in correlation with earthquakes (Proponent, PI: Shin TOYODA), and the visualization of marine species by using the cable network hydrophones (Proponent, PI: Tomonari AKAMATSU)
- Cruise period: April 22, 2014 to April 29, 2014
- Ports of call: Shimizu (April 22, 2014), Shimonoseki (April 30, 2014)
- Research area: Daini-Tenryu Knoll and Kumano-nada
- Research Map: Ship track and survey area



2. Researchers

● Chief scientist: Juichiro ASHI [Graduate School of Frontier Sciences, Univ. Tokyo]

● Representative of the science party: Juichiro ASHI [Graduate School of Frontier Sciences, Univ. Tokyo], Shin TOYODA [Faculty of Science, Okayama University of Science] and Tomonari AKAMATSU [Fisheries Research Agency Fisheries Technology Division, National Research Institute of Fisheries Engineering]

● Science party (List) [Affiliation]

< Theme 1 Group >	
Juichiro ASHI, Associate Prof.	[Univ. Tokyo]
Kazuhiro YAGASAKI, D.C. student	[Univ. Tokyo]
Eriko SEO, D.C. student	[Univ. Tokyo]
Yama TOMONAGA, PostDoc Researcher	[Swiss Federal Institute of Aquatic Science and Technology / Univ. Tokyo]
< Theme 2 Group >	
Shin TOYODA, Prof.	[Okayama Univ. of Science]
Taisei FUJIWARA, M.C. student	[Okayama Univ. of Science]
Tomohiro OOTANI, M.C. student	[Okayama Univ. of Science]
< Theme 3 Group >	
Tomohito IMAIZUMI, Researcher	[NRIFE]
Shuhei NISHIDA, Research Scientist	[JAMSTEC]
< Marine Technician >	
Toru KODERA, Deputy General Manager	[Nippon Marine Enterprises, LTD.]

3. Theme 1: Verification of intermittent methane seep using radiocarbon shell age of large *Calyptogena* colony off Tokai

3-1. Introduction

Cold seeps are vents found on the seafloor, releasing seawater than often contain high concentrations of sulphides and methane (Lalli and Parsons, 1997). Variety of causes form cold seeps and has so far been discovered along continental margins and subduction zones, where tectonic activity is present. Cold seeps use variety of passage that are created by tectonic movements that can be along faults or cracks and fissures.

The Nankai and Tokai regions are common areas of the ocean floor where hydrogen sulphide, methane and hydrogen rich fluid occurs. Such substances encourage the growth of chemosynthetic communities, such as bivalves to flourish. This process is made possible by the symbiotic relationship held between the chemosynthetic bacteria and the bivalve, converting inorganic compounds into nutrients for growth through the process of chemosynthesis (Fujikura et al., 2008). In 1998, a large scale *Calyptogena* colony was discovered by Shin'ichi Kuramoto aboard the submersible vehicle *Shinkai* 2000 along the Daini Tenryu knoll. Unlike most bivalve communities which are found in these environments that usually consist of small "patches" of colonies of several meters, the colony discovered by Kuramoto (2002) covers an area of at least 200~300m^2. One of the most peculiar findings was the large bivalve colony being comprised mainly of dead shells with very few "patches" of living bivalves remaining. The ephemeral nature of cold seeps can be a common cause for shells dying (Gaudron et al., 2012), yet the scale of the dead colony discovered at Daini Tenryu knoll has raised suspicions over what caused something on this scale. Acid racemization dating results of the shells at this site by Misawa et al. (2004) suggested that the colony may have been a result of the local Kodaiba fault movement causing the underlying methane hydrate to become unstable and released to the seafloor via the seep vents. Past seismic reflection surveys of the Daini Tenryu knoll displays faults of the Kodaiba fault system and the Bottom Simulating Reflector (BSR) (Kuramoto and Joshima, 1998), suggesting the existence of methane hydrates below the seafloor (Ashi et al., 2002; Kuramoto, 2002; Otsuka et al., 2011). Such studies support the potential for such scale shell colony to form.

3-2. Background

The Nankai Trough is located within the southwest of Japan where the Philippine Sea Plate subducts beneath the northwest at a rate of 4~6.5cm/ year (Sano et al., 1993; Loveless and Meade, 2010). Large scale inter-plate earthquakes in this region have occurred at intervals of around 100 to 200 years (Ando, 1975). Yet there is little geological evidence proving which fault moved in relation to past earthquakes that have taken place in the area. Daini Tenryu knoll is located within the Tokai region, Eastern Nankai Trough where the Kodaiba active fault system is found. The Kodaiba active fault system is one of the five major fault systems that lie in a NE-SW direction along the Tokai region (Research

Group for Active Faults off Tokai, 1999). The fault has been recognized as a major active thrust dipping in a northward direction (Chamot-Rooke et al., 1992; Moore et al., 1990; Mazzotti et al., 1995).

3-3. Objectives

The objective of this dive was to gain a better understanding for the possible cause of a large scale *Calyptogena* colony that was initially discovered off the Daini Tenryu knoll by Kuramoto (2001). A dead bivalve colony discovered on this scale is very unusual, and is thought to have been caused by past tectonic event (s). Past records of the seismic reflection survey of the Daini Tenryu knoll displays faults of the Kodaiba fault system, as well as the Bottom Simulating Reflector (BSR) (Kuramoto and Joshima, 1998), suggesting the existence of methane hydrates below the seafloor (Ashi et al., 2002; Kuramoto, 2002; Otsuka et al., 2011). It may be possible that the underlying methane hydrate layer was disturbed by this tectonic event, temporarily releasing methane to the seafloor to create such a large scale colony. Through C^{14} dating analysis of the shells, it may be possible to identify when these bivalve colonies formed and whether this was a result of a single or a multiple event. Various samples including living *Calyptogena*, bivalve shells, MBARI sediment cores and Niskin water samples were collected for various analyses.

3-4. Study Areas

The study site at the Daini Tenryu knoll (34° 04'N-137° 47.5'E) is located above the Kodaiba Fault Thrust System the lie in a NE-SW direction (Figs. 3-1 and 3-2). It is one of the five major active fault systems that lie in the Tokai region (Research Group for Active Faults off Tokai, 1999).

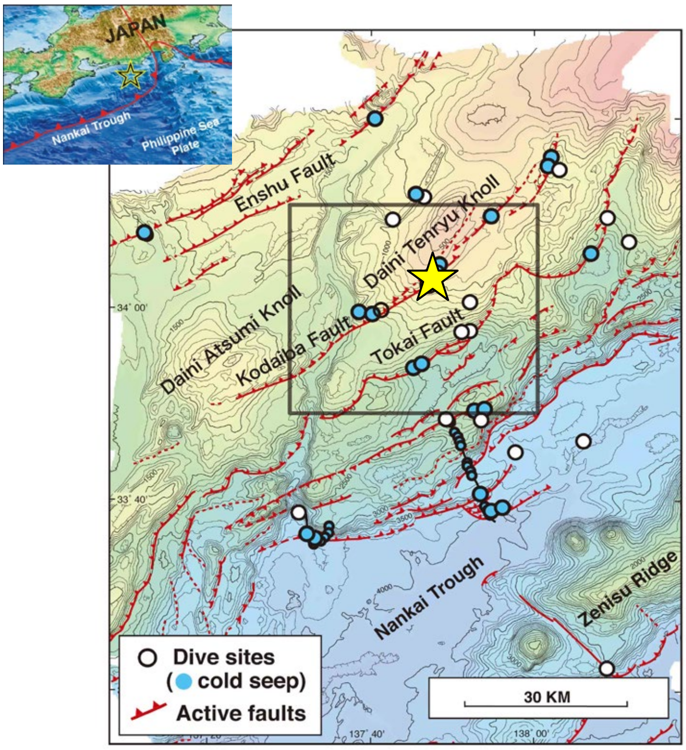


Fig. 3-1 Dive survey area map

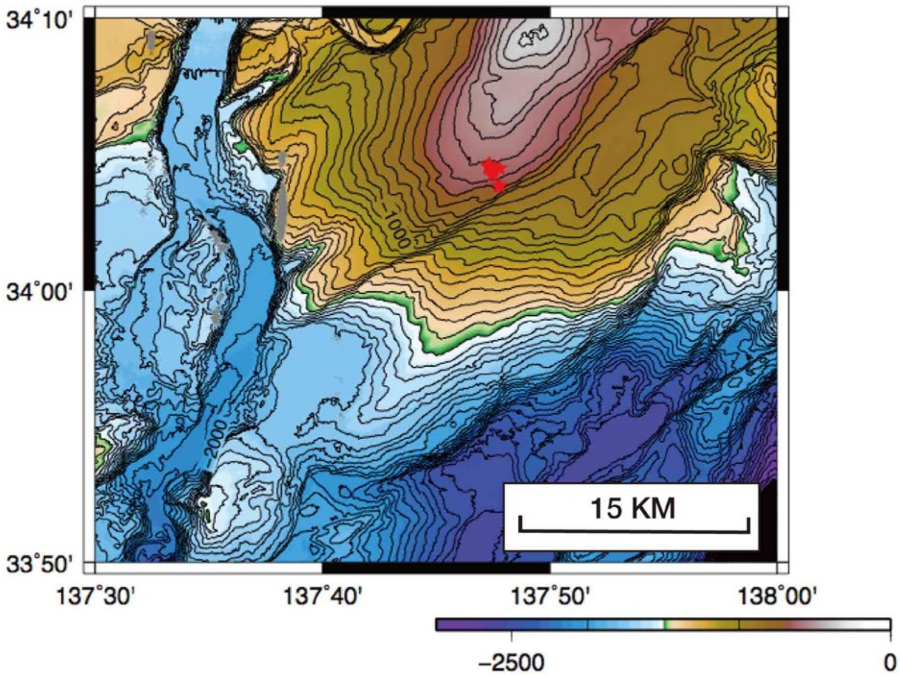


Fig. 3-2 Detailed dive survey area map

3-5. Methods and Instruments

The entire operation during this dive was carried out using the ROV Hyper Dolphin. The following tasks were undertaken: 1) Seafloor observation by high definition cameras, 2) Sampling of sediments, 3) Niskin water sampling, 4) Sediment core sampling by MBARI, 5) *Calyptogena* bivalve collection using a shovel. Payload carried onboard the research vessel by researchers: 1) MBARI corer (four MBARI cores were installed to the basket of the ROV)

3-6. Results

The purpose of this research was to establish a more in-depth understanding of this study area and to collect shell, sediment and water samples to identify the bivalve colony age in relation to past tectonic records in the region. The dive route plan involved climbing up the slope, slightly south of the large scale *Calyptogena* colony in a NW direction (Fig. 3-3). The landing site was covered mostly with large fragments of bedding planes with little sediment present (Figs. 3-4 and 3-5). As the ROV progressed further up the slope, the fragments decreased in size and quantity, revealing signs of fine sediment on the seafloor. The higher regions of the slope revealed signs of dead bivalve shells buried within the sediment with few remaining on the surface. The number of shells and the area it covered increased as the ROV travelled further up the slope. At site 2, the seafloor was fully covered in dead bivalve shells making it difficult to observe any signs of sediments. Niskin water sampling (green) was conducted alongside shell and MBARI core #1 (green) collection (Table 3-1, Fig. 3-6). Few small patches of living *Calyptogena* colony were also found and collected for sampling. At site 3, several tubeworms were identified and collected for sampling alongside dead bivalve shells nearby. An active methane seep releasing frequent bubbles of gas was discovered at the most northern region of the bivalve colony. Both living *Calyptogena* and dead bivalve shells were present and collected for analysis (Table 3-2, Fig. 3-7). Shells Niskin water sampling (red) and MBARI core #2 (yellow) were also collected to carry out noble gas analysis to evaluate the possible dead carbon effect the seeps have on the bivalve community (Table 3-1, Fig. 3-6). Overall, the seafloor pattern continued in a similar layout of dead bivalve shells and occasional small "patches" of living *Calyptogena*. A black line of dead bivalve shells was identified just before leaving the seafloor. Although the exact origin or cause is unknown, the black rusty nature of the "transect" and squashed shells suggest that it may have been the remains from old ballasts from the D.S.V. *Shinkai 2000.*

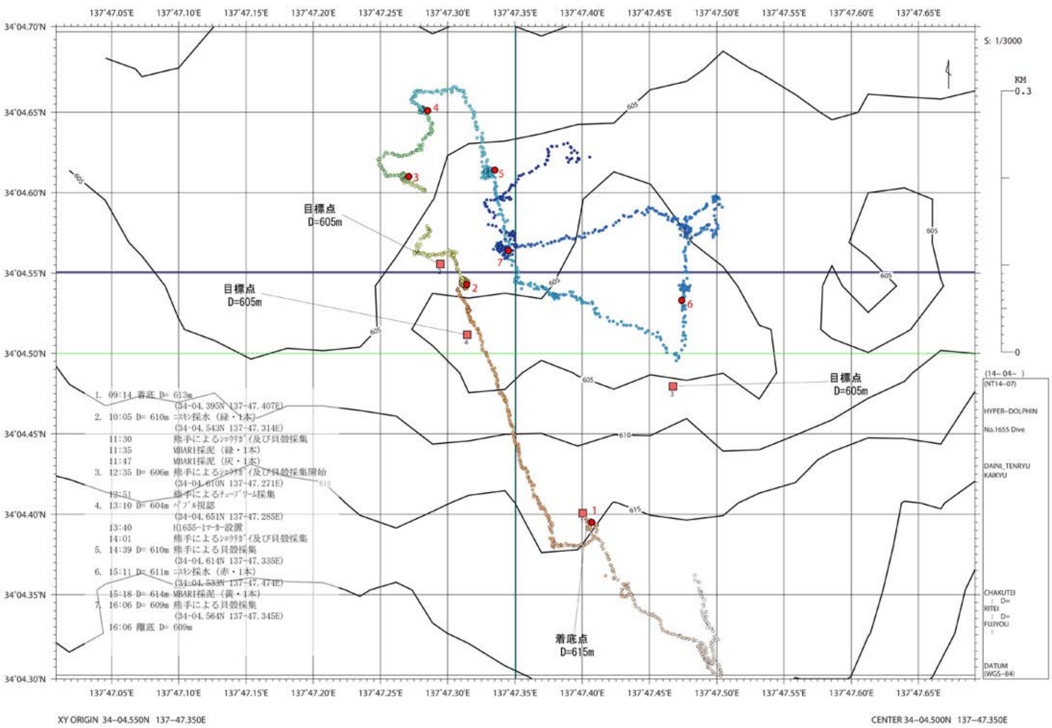


Fig. 3-3 ROV track of HPD Dive 1655

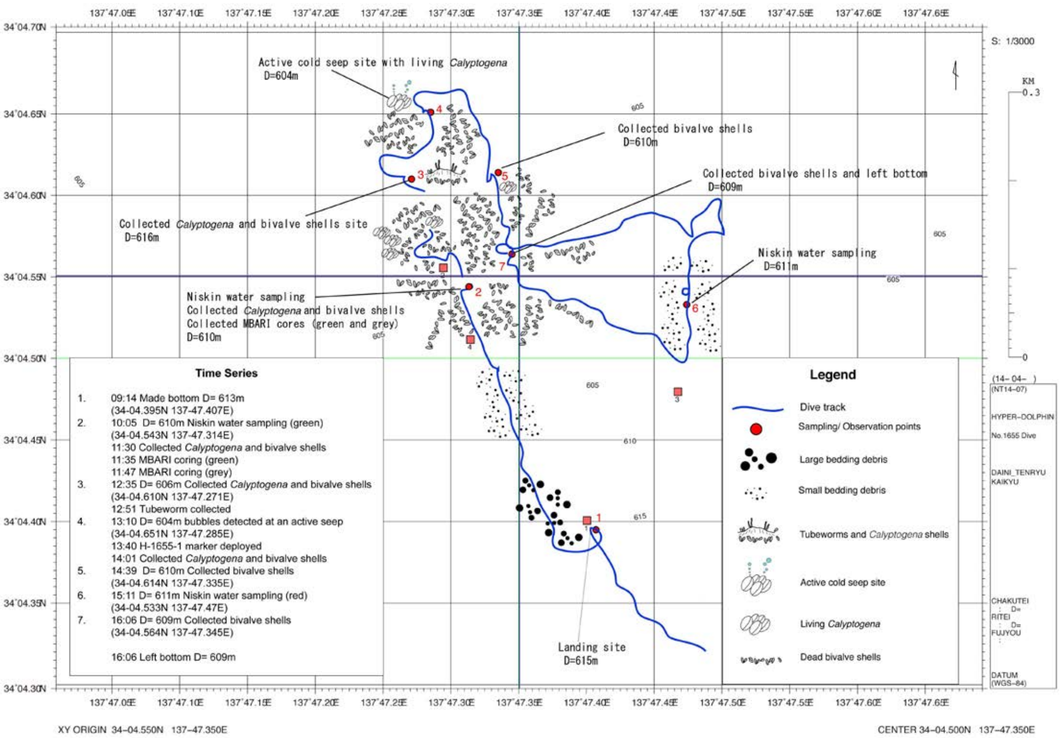
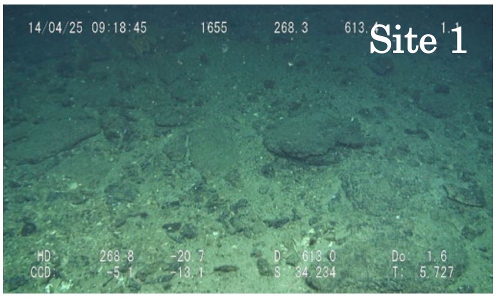
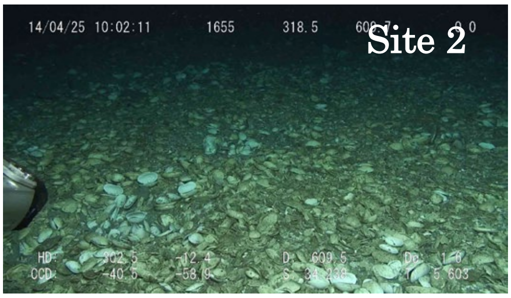


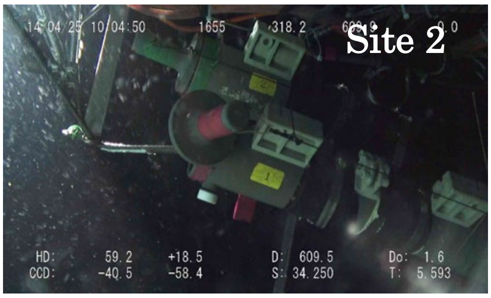
Fig. 3-4 Route map of HPD Dive 1655



Seafloor at landing point

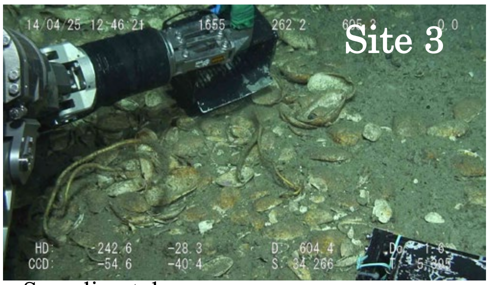


Calyptogena colony site: collected shells

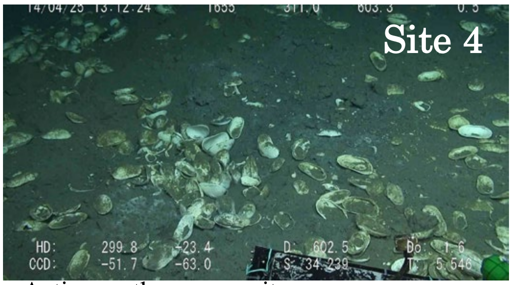


Niskin water sampling (Green)

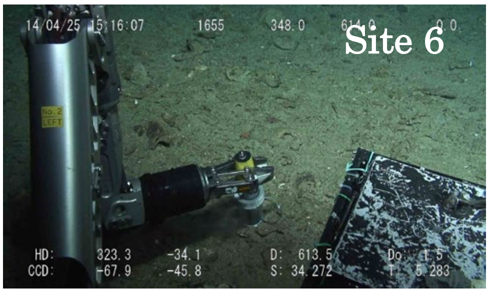
MBARI core ① (Green) collected



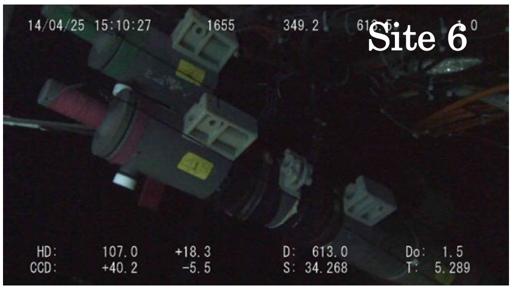
Sampling tubeworm



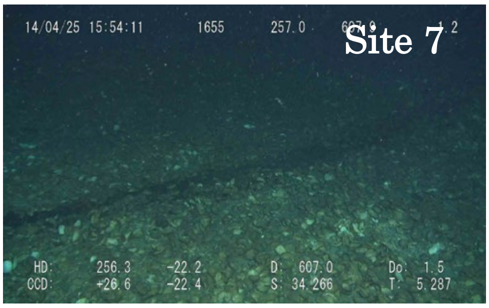
Active methane seep site



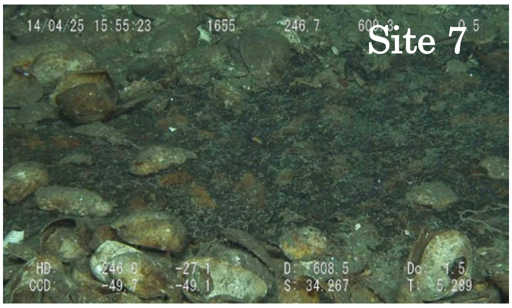
MBARI core ① (Yellow) collected



Niskin water sampling (Red)



Black transect



Black transect (zoomed up)

Fig. 3-5 Photos from R.O.V. HPD Dive #165

3-7. Data and Sample lists

3-7.1 Core sample

Dive #	Core #	Long. (+E)	Lat. (+N)	Depth (m)	Core length (cm)	MBARI Colour	Distribution
1566	C1	137°47. 314’	34°04.543’	610	19	Green	AORI
1566	C2	137°47. 470’	34°04.533’	611	27	Yellow	AORI

Table 3-1　Core sample list

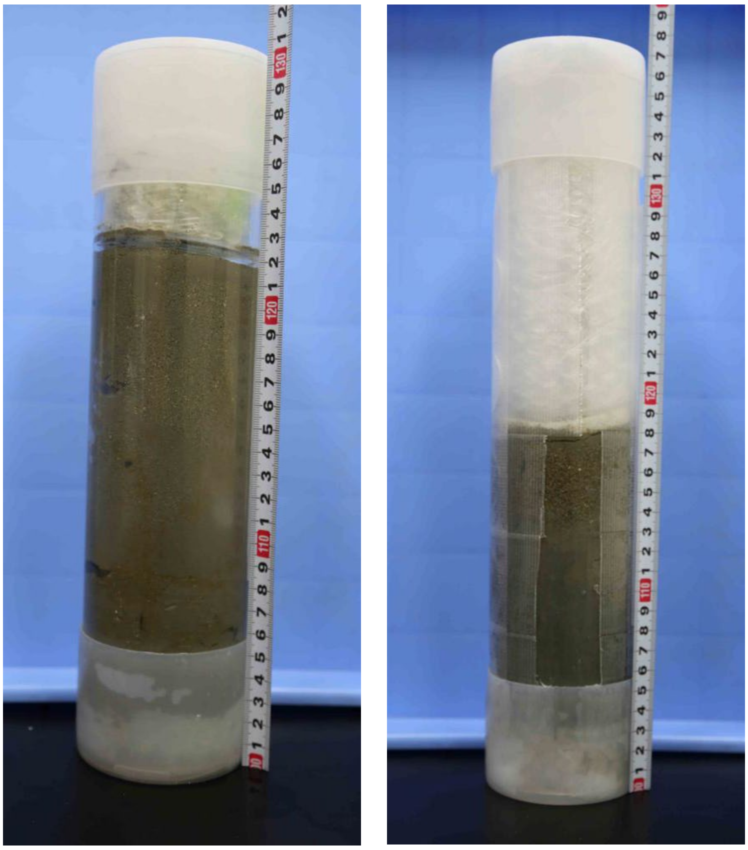


Fig. 3-6　Photos of Core 1 (left) and Core 2 (right)

3-7.2 *Calyptogena* and Bivalve Shells

Fig. 3-7 Photo of *Calyptogena* (left) and bivalve shells (right)

Onbord No.	Serial No.	Species Name	Lat.		Long.		depth	Dive#
HPD#1655-B01-01	#1655-B01-01	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B01-02	#1655-B01-02	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B01-03	#1655-B01-03	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B01-04	#1655-B01-04	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B01-05	#1655-B01-05	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B01-06	#1655-B01-06	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B01-07	#1655-B01-07	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B01-08	#1655-B01-08	Calyptogena sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B02-01	#1655-B02-01	Calyptogena sp.	34°	04.610N	137°	47.271E	606	#1655
HPD#1655-B02-02	#1655-B02-02	Calyptogena sp.	34°	04.610N	137°	47.271E	606	#1655
HPD#1655-B02-03	#1655-B02-03	Calyptogena sp.	34°	04.610N	137°	47.271E	606	#1655
HPD#1655-B02-04	#1655-B02-04	Calyptogena sp.	34°	04.610N	137°	47.271E	606	#1655
HPD#1655-B02-05	#1655-B02-05	Calyptogena sp.	34°	04.610N	137°	47.271E	606	#1655
HPD#1655-B02-06	#1655-B02-06	Calyptogena sp.	34°	04.610N	137°	47.271E	606	#1655
HPD#1655-B03-01	#1655-B03-01	Calyptogena sp.	34°	04.651N	137°	47.285E	604	#1655
HPD#1655-B03-02	#1655-B03-02	Calyptogena sp.	34°	04.651N	137°	47.285E	604	#1655
HPD#1655-B03-03	#1655-B03-03	Calyptogena sp.	34°	04.651N	137°	47.285E	604	#1655
HPD#1655-B01-10	#1655-B01-10	Conchocele sp.	34°	04.543N	137°	47.314E	610	#1655
HPD#1655-B03-05	#1655-B03-05	Conchocele sp.	34°	04.651N	137°	47.285E	604	#1655

Table 3-2 *Calyptogena* sample list

References

Ando, M., (1975): Source mechanisms and tectonic significance of historical earthquakes along the Nankai trough, *Tectonophysics*, 27: 119-140.

Ashi, J., Tokuyama, H. and Taira, A. (2002): Distribution of methane hydrate BSRs and its implication for the prism growth in the Nankai Trough. Marine *Geology*, 187: 177-191.

Chamot-Rooke, N., Lallemant, S. J., Le Pichon, X., Henry, P., Sibuet, M., Boulègue, J., Foucher, J. -P., Furuta,, T., Gamo, T., Glaçon, G., Kobayashi, K., Kuramoto, S., Ogawa, Y., Schultheiss, P., Segawa, J., Takeuchi, A., Tarits, P. and Tokuyama, H. (1992): Tectonic context of fluid venting at the toe of the eastern Nankai accretionary prism: Evidence for a shallow detachment fault. *Earth and Planetary Science Letters*, 109: 319-332.

Fujikura, K., Okutani, T. and Maruyama, T. (2008): Deep-sea life: biological observations using research submersibles. Tokai University Press, 20-21.

Gaudron, S. M., Demoyencourt, E. and Duperron, S. (2012): Reproductive Traits of the Cold-Seep Symbiotic Mussel *Idas modiolaeformis*: Gametogenesis and Larval Biology. *The Biological Bulletin*, 222: 6-16.

Kuramoto, S. and Joshima, M. (1998): Precise Gravity measurement for Gas Hydrate Layer. *JAMSTEC Journal of Deep Sea Research*, 14, 371-378.

Kuramoto, S. (2001): Possibility of intermittent emission of methane gas, *Chikyu Monthly*, 32: 130-135. (in Japanese)

Kuramoto, S. (2002): Report of submersible *Shinkai 2000* Dive1377. In *R/V Natsushima NT02-08 Cruise Report*. (ed. Kuramoto S.) Japan Marine Science and Technology Center, pp. 63-73. (in Japanese)

Lalli, C. M. and Parsons, T. R. (1997). Biological Oceanography An Introduction Second Edition. Elsevier Butterworth-Heinemann, 241-242pp.

Loveless, J. P. and Meade, B. J. (2010): Geodetic imaging of plate motions, slip rates, and portioning of deformation in Japan. *Journal of Geophysical Research*, 115: B02410.

Mazzotti, S., Le Pichon, X. and Lallemant, S. (1996): Tectonics of the eastern Nankai accretionary prism, in situ study of the Kodaiba Fault central scarp (October 1995, "Shinkai 2000" Dive report). *JAMSTEC Journal of Deep Sea Research*, 12, 167-173.

Moore, G.F., Shipley, T.H., Stoffa, P.L., Karig, D.E., Taira, A., Kuramoto, S., Tokuyama, H. and Syehiro, K. (1990): Structure of the Nankai trough accretionary zone from multichannel seismic reflection data. *Journal of Geophysical Research*, 95: 8753-8766.

Otsuka, H., Morita, S., Tanahashi, M., Nagakubo, S. and Ashi, J. (2011): Possible migration front of gas-related fluid inferred from 3D reflection seismic survey in the eastern Nankai Trough. *Journal of the Japanese Association for Petroleum Technology*, 76: 39-42.

Research Group for Active Faults off Tokai (1999): Active Submarine Faults Off Tokai- Results from the Japan- France KAIKO-Tokai Project., University of Tokyo press, ISBN4-13-066704.

Seno, T., Stein, S. and Gripp, A. E. (1993): A model for the motion of the Philippine Sea Plate consistent with Nuvel I and geological data. *Journal of Geophysical Research*, 98: 941-948.

4. Theme 2: Temporal variation of Rn emanation at faults in correlation with earthquakes

4-1. Introduction

The mechanism of inter-plate earthquakes and the physico-chemical processes associated with those earthquakes are the critical scientific issues in Japan where large and fierce earthquakes are expected in Tokai and Tonankai within several ten years. The temporal variation in Rn in cold seeps, indicating the variation in the formation fluid emanating from the sea floor, may be a key to investigate such processes associated with the crustal deformations.

4-2. Background

The increase of Rn concentrations in air and in well water samples was once observed at the time of the Southern Hyogo prefecture earthquake in 1995. This phenomenon has been interpreted so that Rn, produced by decay of U (and Th) and accumulated in the crust, was released from the minerals, and through the fissures created by the foreshock and main shock, emanated to the air and water in the wells. Unlike Rn in the air, which will soon diffuse away, Rn emanated into the sea water would more easily be detected when the emanation of formation fluid is appropriately detected.

Kumanonada is a seismic source region for the expected Tonankai earthquake where cold seeps have been observed. This region would be appropriate for investigating the temporal change of Rn concentration in emanating formation fluid in correlation with small earthquakes in this region.

4-3. Objectives

The group of present researchers has developed a stand-alone automatic recording gamma ray spectrometer to which the electricity is supplied from another pressure proof vessel containing batteries. With also a newly developed software which enables episodic measurements, instead of continuous measurements, it is possible that the measurements of gamma ray spectrometry are done up to several months. The aim of the present proposal of the cruise was to measure the radioactivity in sea water during the dives and to install this newly developed gamma ray measurement system at the sea bottom in the cold seeps at the floor of Nankai Trough off Kumano after finding the most appropriate installation site.

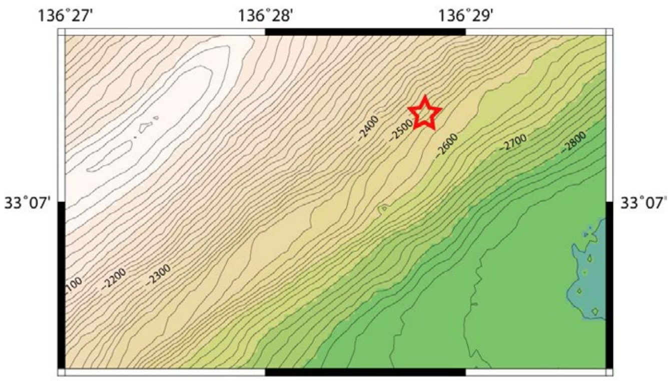


Fig. 4.1 Location of the site in Kumanonada at which the automatic gamma ray measurement system was placed on the sea floor.

4-4. Study Area

The automatic gamma ray measurement system was placed in Kumanonada at the location shown in Fig. 4-1.

4-5. Methods and Instruments

The gamma ray spectra were measured every minute using another NaI gamma ray spectrometer connected to the Hyperdolphin. Monitoring the counts on board, the location with elevated gamma ray dose was searched, considering the bacteria mats as the indicator of cold seeps.

Fig. 4-2 The automatic gamma ray spectrometry system developed for the present study.

The automatic gamma ray spectrometry system as shown in Fig. 4-2 was installed at one of the bacteria mats with higher gamma ray dose. A stand-alone heat flow meter (SAHF) and a sea floor thermometer were also settled at the same place. Sediment samples were also taken from the location by a MBARI type corer with 30 cm in length.

4-6. Results and Future plan

Gamma ray measurements were performed at three locations of bacteria mats with another NaI gamma ray spectrometer connected to the Hyperdolphin. The automatic gamma ray spectrometry system was placed at the location (33°7.3584'N, 136°28.8014'E) with the highest gamma ray counts of the three as shown in Fig. 4-3. The detector is about 30 cm from the sea floor. The temporal variation observed by the two stand-alone heat flow meter (SAHF) and a sea floor thermometer will be analyzed in correlation with those in Rn concentration. A sediment sample was also taken from the site and another from a control area.

The gamma ray spectra were also obtained during the dive. The temporal changes of the counts during the Dive #1654 and #1657 are shown in Fig. 4-4. The gamma ray counts are much higher when the detector touched or close to the sea floor surface because of the gamma rays from the radioactive nuclei (U, Th, and K) contained in the sea floor sediment. Due to the attenuation by the sea water, the counts are smaller when elevating the detector from the sea floor.

The gamma ray counts above these bacteria mats were about 30% higher than the usual sea water most probably the Rn contained in the emanating water from the sea floor of the bacteria mats. Sulfide minerals were found in the sediments in the core taken at this place, which confirms the continuous water emanation at this place.

Another research cruise is planned in August to retrieve the automatic gamma ray spectrometry system, the two stand-alone heat flow meter (SAHF) and a sea floor thermometer. The temporal change for three months in gamma ray spectrum and in thermal currents will be obtained and analyzed examining the correlation with micro earthquakes in the region off Kumano.

The temporal variation in the gamma ray spectra during the dive #1654 and #1657 will also be analyzed to examine how the positions of the detector and the locations correspond to the intensity of the gamma rays. The high resolution gamma ray spectra will also be obtained for the sulfide minerals and the sediments underneath in order to investigate quantitatively the Rn and daughter radioactive nuclei and their radioactive disequilibrium in the those samples.

Quantitative measurements and analysis of shielding of the gamma rays by the sea water is another issue to investigate in future to determine quantitatively the contributions of the gamma rays from the sea floor sediment and the sea floor to the total gamma ray intensities observed.

4-7. Data and Sample lists

Gamma ray spectra: every minute during

Dive #1654 (April 24, 2014)

Dive #1657 (April 27, 2014)

Sediment samples

HD#1654Green

HD#1654Grey

5. Theme 3: The visualization of marine species by using the cable network hydrophones

5-1. Background and purpose

Our long term goal of the study is to identify species and count the number of individuals using their vocalization produced by marine organisms. The distribution and movement of each species will be visualized using the submarine cable system as the passive acoustic monitoring network. As the first step to reach this goal, we conducted high quality calibrated measurement at the cable network system. It is known that some fish produce sounds, and the acoustic feature depend on species. It is expected tha the distribution, seasonal trend and resources will be estimated by using the cable network hydrophone system (DONET1 hydrophone). However, the band limited hydrophone installed in the deep sea, has not been tested yet its performance of sound bearing estimation. Therefore we install the a calibrated stereo automatic recording device (hereafter; the hydrophone array system) nearby the DONET1 hydrophone and measured the sound source direction acoustically for further comparison with DONET1 system.

5-2. Objective （date）

1) Installation of the hydrophone array system (23 April. 2014)

2) Measurement of the article sound for calibration (23 and 26 April. 2014)

3) Recovery of the hydrophone array system (26 April. 2014)

5-3. Survey area

We conducted acoustic monitoring at St. A-1 of DONET1.

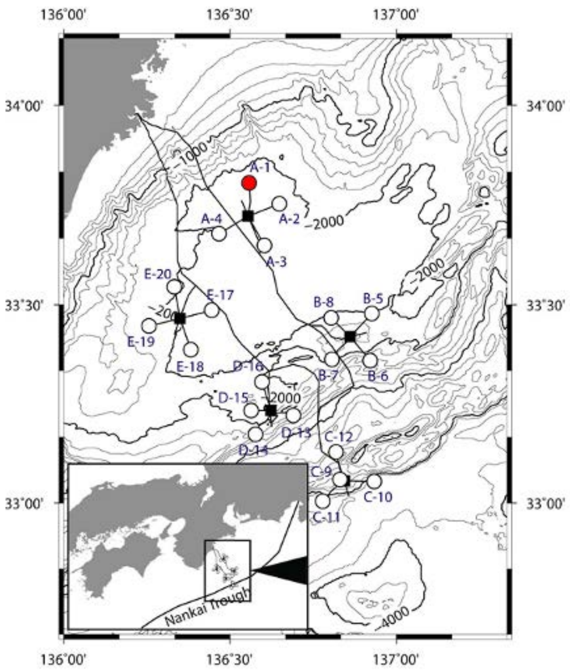


Fig. 5-1. The observation and survey area

5-4. Hydrophone array system and experimental procedure

5-4-1. Hydrophone array syste,

Figure 5-2 shows the hydrophone array system for acoustic observation. This system was composed of two calibrated hydrophones for deep sea (SH-20D, Aqua sound inc.) and recorder (AUSOMS-D, Aqua sound inc.). The distance between the hydrophones was 80cm. We fixed the recorder and hydrophones to the rack (0.9m *0.95m). In addition, the transponder (SONARDYNE) was fixed together for easy discovery in the water during retrieval operation. The total weight of this system was 42.1 kgf (in sea water), and 86.7 kgf (in air). The sampling frequency of this system was 192 kHz and the measurable frequency band was from 1 Hz to 96 kHz.

Figure 5-3 shows the low frequency sound transmitter for calibration of the hydrophone array system. This device consists of a control unit and the transmitting drum (sound source). The transmitting drum weighs 12.6 kgf (in sea water), and 17.5 kgf (in air). The sound transmission pattern is directive. The maximum sound pressure level was 214 dB re 1μPa. It produces sequence of pulses whose frequency spectrum ranged from 0.5 to 5.2 kHz.

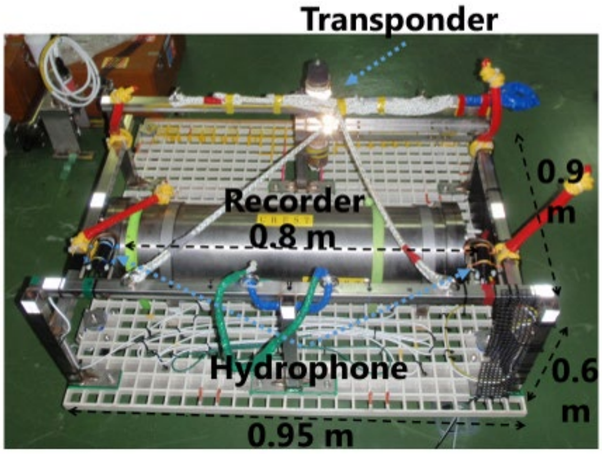


Fig. 5-2. The photograph of the Hydrophone array system. The system were consist of two calibrated hydrophones, the recorder, and a transponder. The distance between hydrophones was 0.8 m. The total weight was 86.7 kgf (in air), and 42.1 kgf (in sea water).

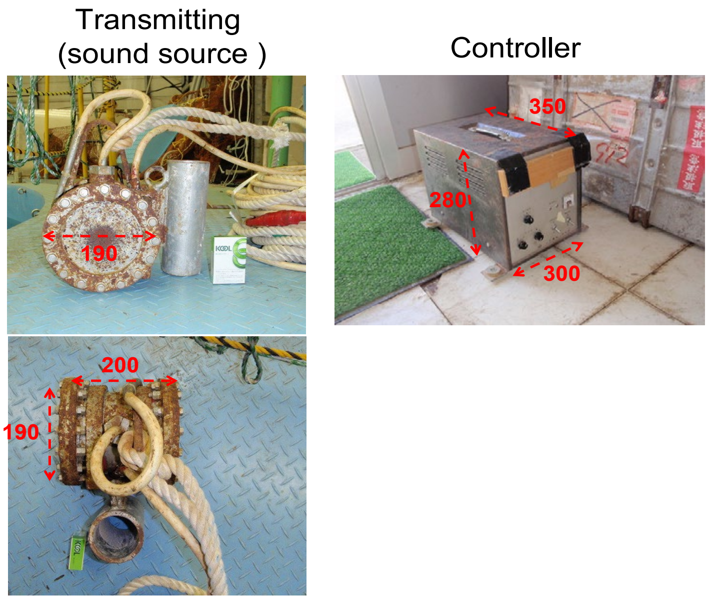


Fig. 5-3. The low frequency sound transmitter.

5-4-2. Experimental method

5-4-2-1. Installation of the hydrophone array system

We installed the hydrophone array system near DONET1's hydrophone（St. A-1 : 33°48.287N, 136°33.421E) using ROV Hyper dolphin (HPD). Figure 5-4 shows the position of installation, which was within 30 m from the DONET hydrophone. The direction of the two hydrophones of the hydrophone array system were fixed toward north to south direction (33°48.297N, 136°33.446E , depth 2040 m). Figure 5-5 shows the device positions around DONET1 systems. We confirmed that the distance between DONET1 hydrophone and our hydrophone array system was about 10 m using HPD's sonar.

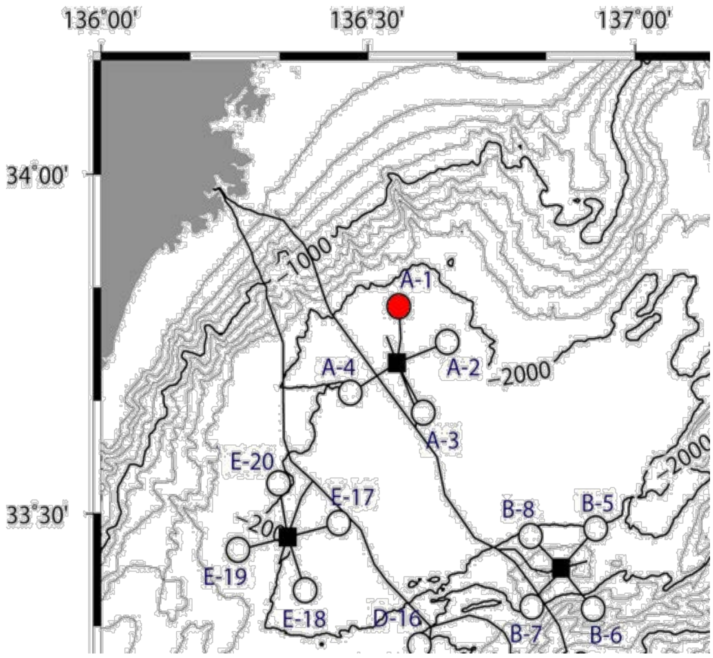


Fig. 5-4. The position of installation of the hydrophone array system. The hydrophone array system was placed near St. A-1 of DONET1 system.

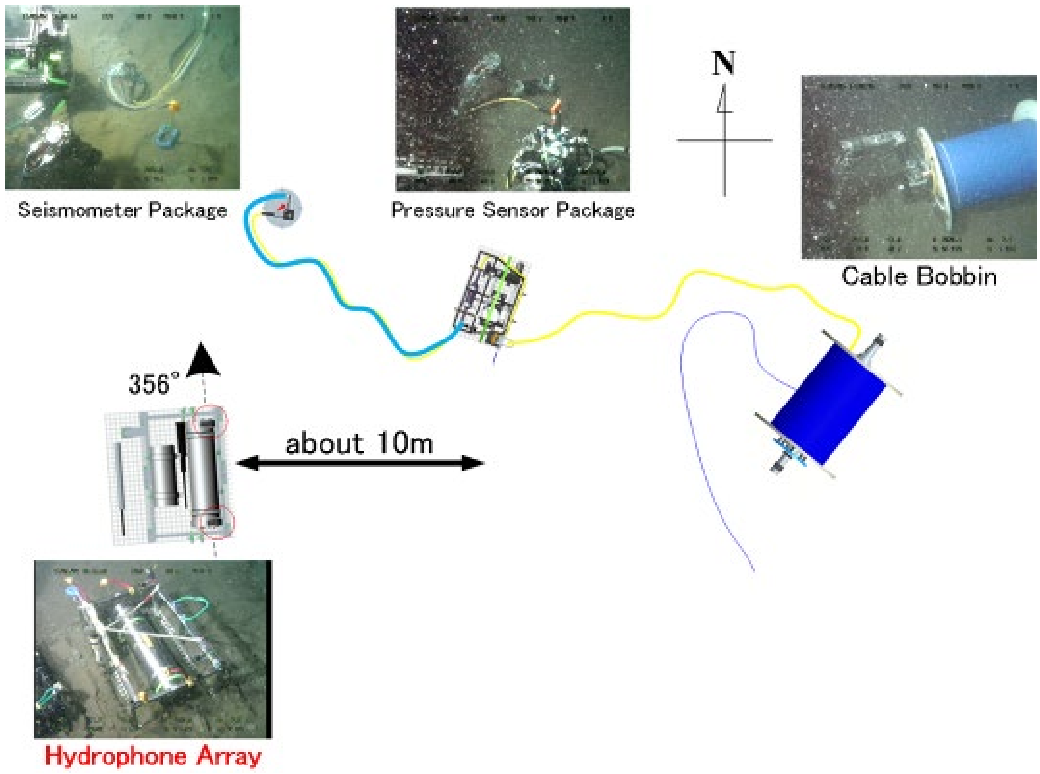


Fig. 5-5. Positions of the devices around DONET systems. The hydrophone array system was fixed about 10 m from the DONET1 hydrophone.

5-4-2-2. Measuring and transmitting the sound for calibration

The sounds for calibration were (1) thruster noise of the HPD, (2) vessel cruise noise, and (3) pulse sound produced by the low frequency sound transmitter. In those experiments, distance between the hydrophone of DONET1 and the hydrophone system was shorter enough than the distance from the sound source. We supposed that the same projected sound arrived simultaneously at the hydrophone array system and DONET1 hydrophone.

Figure 5-6 shows an experimental method when HPD's thruster noise of full power down force was projected for calibration. HPD's thruster noise was transmitted every 200 m from 1800 m in depth to the surface above both hydrophone systems.

Figure 5-7 shows an experimental method when the vessel (Natsushima) cruising noise was projected for calibration. Four speed patterns (3, 6, 8, 10 knot) were employed to change noise. At each speed, the vessel cruised 1 km along north to south direction including the point just above both hydrophone systems. We operated the vessel round trip everytime to cancel the current of th esea. In addition, we produced high frequency signal of the scientific echo sounder (EK-60, Simrad, 38 kHz). In total, 16 patterns of noise projection was conducted.

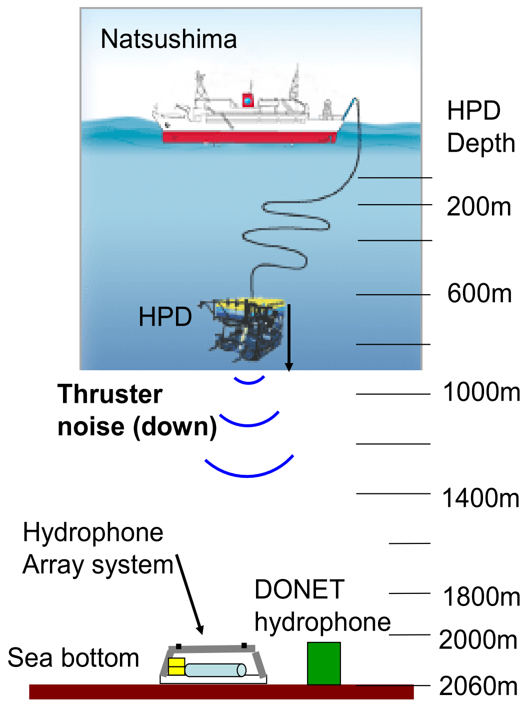


Fig. 5-6. Noise measurement experiment no.1. The thruster noise were measured by both the hydrophone array system and the DONET hydrophone. HPD depth changed every 200 m and kept the depth for making thruster noise.

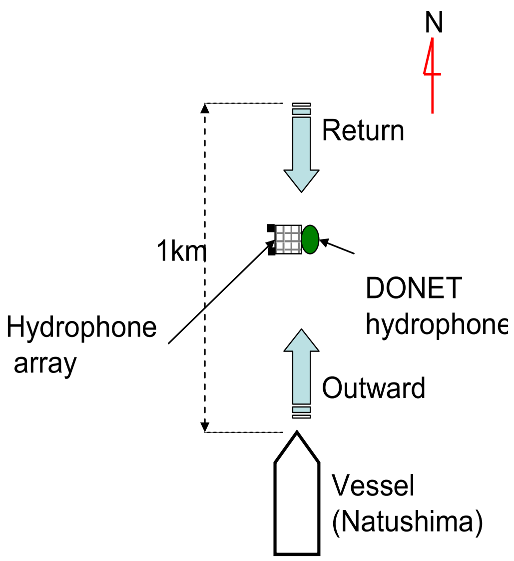


Fig. 5-7. Noise measurement experiment no.2. The vessel noise were measured by both the hydrophone array system and the DONET1 hydrophone. The vessel was operated round trip (outward and return ways) including just above both hydrophone systems.

Figure 5-8 shows an experimental method when of the low frequency sound transmitter operated for calibration. The low frequency sound transmitter was suspended at 5 m in depth and projected 1 ms pulse every several seconds.

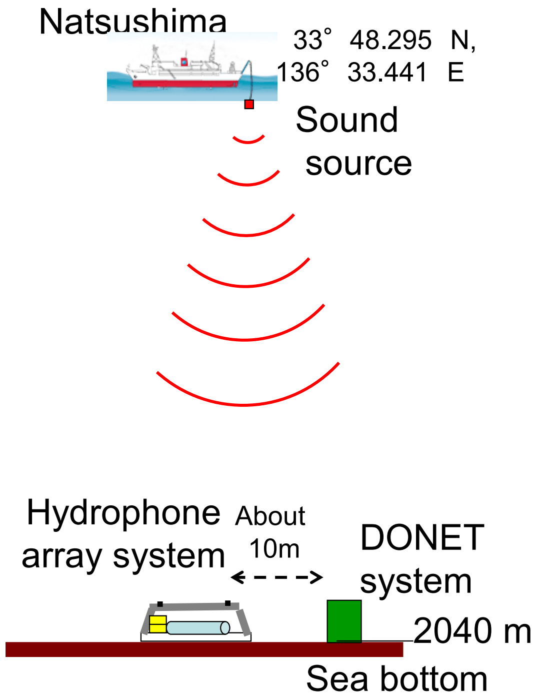


Fig. 5-8. Noise measurement experiment no.3. The low frequency sounds were measured by both the hydrophone array system and the DONET1 hydrophone. The low frequency sound transmitter was suspended from the vessel. The vessel kept the position above both hydrophone systems.

5-4-2-3. Recovery the hydrophone array system

We retrieved the hydrophone array system by using HPD. Figure 5-9 shows underwater and in-air operation. The system was retrieved on 26th April. 2014. We were able to record sound four days long with high sampling frequency.

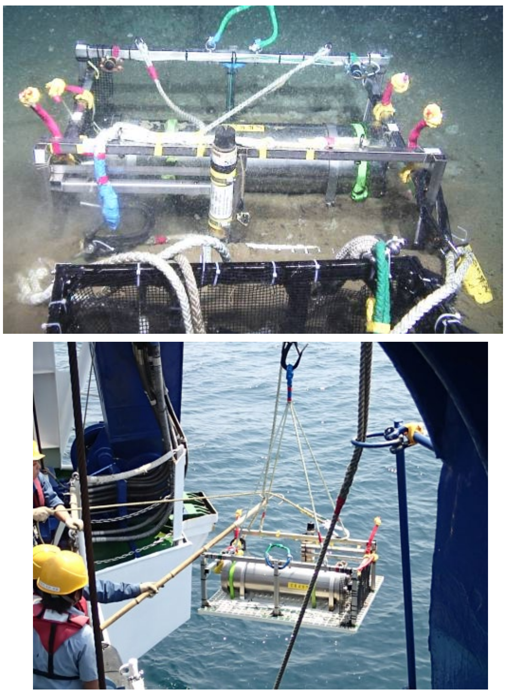


Fig. 5-9. Retrieval operation of the hydrophone array system. Top photo shows in sea water at 2080 m taken by HPD's camera, and lower photo was

taken a picture from the vessel.

5-5. Result

Figure 5-10 shows an example of an waveform and spectrogram of HPD noise for calibration measured by the hydrophone array system. When HPD arrived and stopped at measurement depth (1800m), noise components under 10 kHz reduced. This noise caused by the winding of the cable. The intensity of the winding cable sound exceeded the intensity of the HPD's thruster noise level. When HPD's was getting shallower, the distance between HPD and the hydrophone array system increased. So The influence such as the transponder sounds installed in the cable of HPD, we could use the thruster sound for calibration.

Figure 5-11 shows an example of waveforms and spectrograms of vessel cruising noise for calibration when the vessel (Natsushima) speed was 6 knot. We could see that the strong noise level at 10 kHz at the time ship came close to the hydrophone array system.

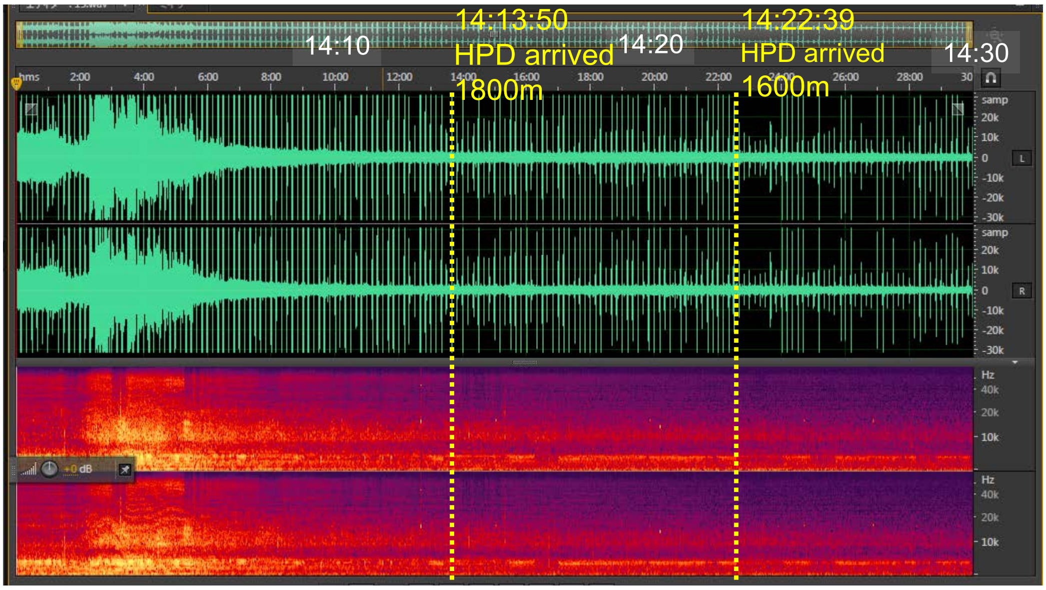


Fig. 5-10. Waveforms and spectrograms of HPD noise measured by the hydrophone array system. The waveforms received at the left channel and the right channel was depicted at the top inset. The y axis shows amplitude. Bottom inset shows spectrogram each channel. The y axis shows frequency form 1Hz to 96 kHz. Light colors show high intensity. Yellow dotted lines show the arrival time of HPD for target depth.

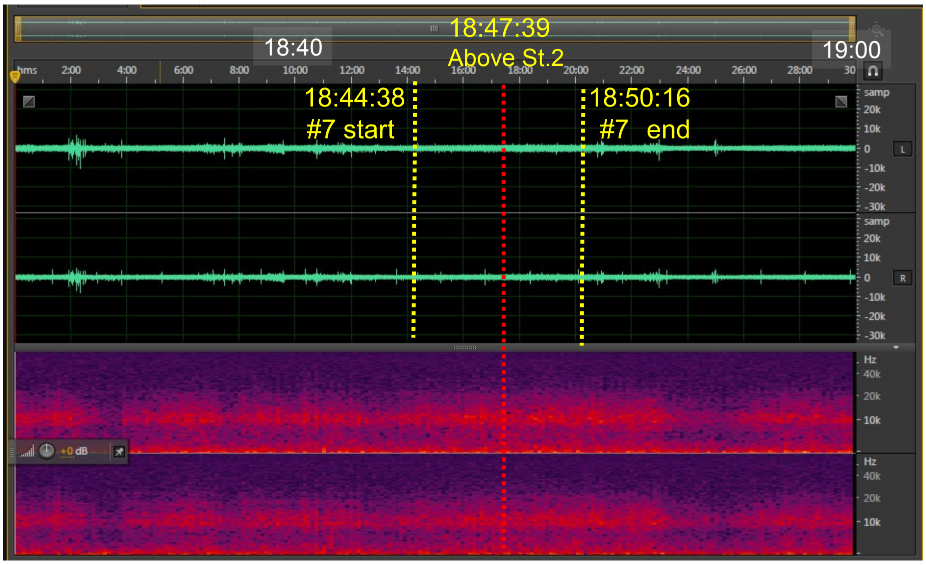


Fig. 5-11. Waveforms and spectrograms of vessel cruising noise were measured by hydrophone array system when the vessel speed was 6 knots. The dotted red line indicates the time at the nearest distance between the vessel and the hydrophone array system.

Figure 5-12 shows result of waveforms and spectrograms using low frequency sound transmitter for calibration. Because the sound source produce a sequence of pulses which have broadband frequency contains up to 5 kHz, we could see those sound fits for broadband calibration in low frequency range.

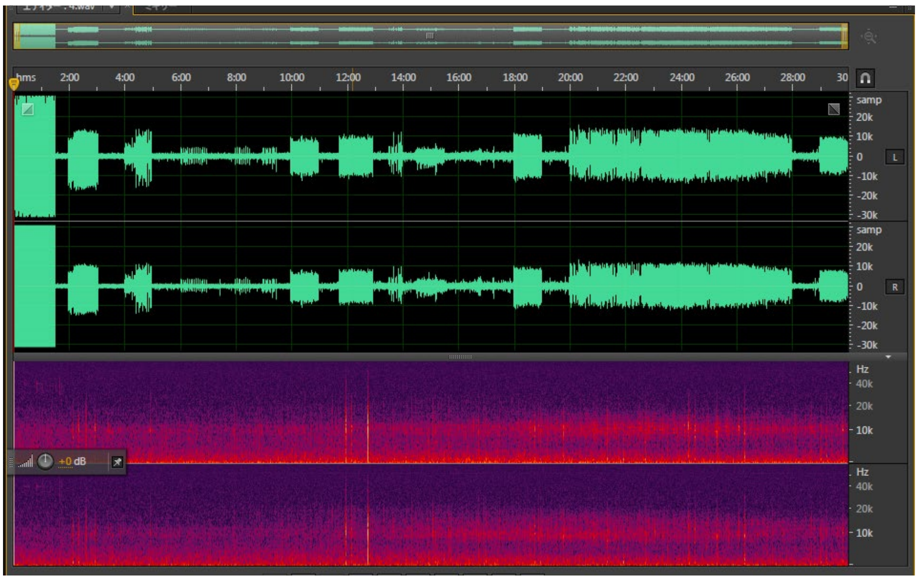


Fig. 5-12. Waveforms and spectrograms of low frequency sound were measured by the hydrophone array system.

Figure 5-13 shows the waveforms of the sound signals for the transponder from HPD, and responder signal. We calculated a sound source direction using the sound arrival time difference between two channels. The calculated absolute direction of sound source was 275.7 degree referring to the north as 0 degree, and HPD head direction was 86.5 degree. In other words, HPD head direction almost coincide with the acoustically calculated measurement value.

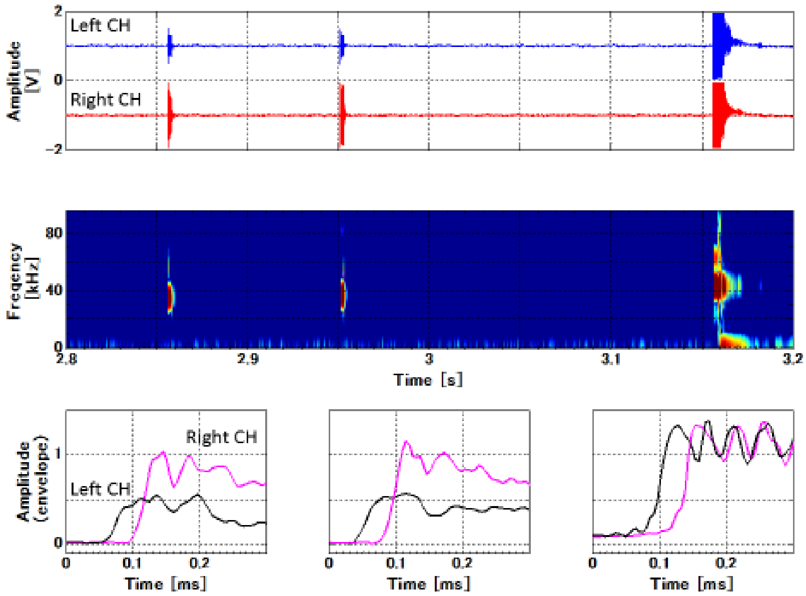


Fig. 5-13. Waveforms of the transponder signals were measured by the hydrophone array system. Top figure shows three waveforms of the transponder sounds in 0.4 second. The blue and red lines show the amplitudes of left and right channel, respectively. Middle figure shows spectrogram of top figure. Bottom figures shows the sound arrival time differences of each signals between two channels. The black and pink lines show envelops of signal amplitudes measured by left and right channelsone. The estimated directions of each signals were 85.7 degree (left), 85.8 (center), and 85.4 degrees (right). Acoustic measurement of the sound source direction was quite accurate.

5-6. Future works

We are going to calibrate the compare the recordings by the present hydrophone array system and the DONET1's hydrophone, and clarify the absolute receiving sensitivity and the frequency response. In addition, we are going to investigate possible recordings of the vocalization of marine life and compare them with the collected sounds by the DONET1's hydrophone system.

6. Sampling of water and sediments for noble-gas analysis (Project NoGOS)

The collection of water and sediment samples for noble-gas analysis on RV Natsushima cruise NT14-07 aims to complement and extend the data set acquired during the previous expedition NT13-08 within the frame of the project NoGOS (NOble Gases in Ocean Sediments as proxies for fluid transport at subduction zones and past climate conditions; Marie Curie International Outgoing Fellowship, Contract No. PIOF-GA-2012-332404; http://tomonaga.ch/nogos).

The project NoGOS aims to systematically apply the analytical state-of-the-art to ocean sediments. One of the major goals of the project is to study the fluid transport in forearc regions off shore Japan. The He isotopes should allow studying the release dynamics of deep fluids from solid earth close to these tectonically active regions and the relation of such a fluid emission to seismic activity. Moreover, the investigation of the noble-gas signature in the pore water will set a first data basis to interpret noble-gas anomalies in regions where major earthquakes occurred or are expected. NoGOS represents a further step towards a potential use noble gases in terrestrial fluids as indicator of seismic activity.
During the Hyper-Dolphin dive operations on RV Natsushima cruise NT14-07 the following water and sediment samples have been collected:

23.04.2014	Dive #1653	Hydrophone (2040 m): 1 water sample (ID: NoGOS 101)
24.04.2014	Dive #1654	γ-ray (2560 m): 1 water sample (ID: NoGOS 100) 1 sediment sample(ID: NoGOS 102)
25.04.2014	Dive #1655	Colony, Inactive seep (610 m) 1 water sample (ID: NoGOS 103) 3 sediment samples (ID: NoGOS 016, NoGOS 012, NoGOS 019) Colony, Reference (612 m) 1 water sample (ID: NoGOS 104)
26.04.2014	Dive #1656	Hydrophone (2042 m) 1 water sample (ID: NoGOS 105)
27.04.2014	Dive #1657	γ-ray (2560 m): 1 water sample (ID: NoGOS 106) 1 sediment sample (ID: NoGOS 001)

The the data obtained from the previous expedition reveal that water samples are very similar to each other in terms of elemental and isotope signature. In contrast, the analysis of noble gases in the sediment pore water allows distinct characterization of the terrigenic fluid emission at the respective sites. Therefore, particular effort has been made to collect at least one bulk sediment sample for noble-gas analysis from each core acquired during cruise NT14-07. (Yama TOMONAGA)

Acknowledgments

We would like to thank the crew of the research vessel “Natsushima” and the operation team of the ROV “Hyper Dolphin 3000” for their assistance during NT14-07.

Notice on Using

This cruise report is a preliminary documentation as of the end of the cruise.
This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.
Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.