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KAIREI Cruise Report

KR10-08

Research Dives by KAIKO-7000II
In the Northwest Pacific Ocean

June 10 – 25, 2010

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

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1. Cruise Information

1.1. Cruise Number

KR10-08

1.2. Ship Name

KAIREI

1.3. Title of the Cruise

Research dives by KAIKO-7000II

1.4. Title of the Proposal

New phase of Ocean Hemisphere Project: Imaging the normal oceanic mantle by advanced ocean bottom observations

1.5. Cruise Period

June 10 - 25, 2010

1.6. Port Call

Yokosuka Shinko - Jamstec, Yokosuka

1.7. Research Area

Northwest Pacific Ocean

1.8. Research Map

Refer to Figure 1.

2. Researchers

2.1. Chief Scientist

Hisashi Utada [ERI, Univ. Tokyo]

2.2. Co-chief Sientist

Hajime Shiobara [ERI, Univ. Tokyo]

2.3. Science Party

Takehi Isse [ERI, Univ. Tokyo]

Kiyoshi Baba [ERI, Univ. Tokyo]

Hiroko Sugioka [IFREE, JAMSTEC]

Noriko Tada [IFREE, JAMSTEC]

Koji Miyakawa [ERI, Univ. Tokyo, support]

Takashi Tonegawa [ERI, Univ. Tokyo, support]

Akiko Takeo [ERI, Univ. Tokyo, support]

Koichi Sakaguchi [ERI, Univ. Tokyo, support]

Luolei Zhang [ERI, Univ. Tokyo, support]

Tsukasa Yoshida [OCC, support]

Hitoshi Okinaga [OCC, support]

Hiroaki Toh [Graduate School of Science, Kyoto Univ., support]

Tetsuya Higa [Graduate School of Science, Kyoto Univ., support]

Hitoshi Kawakatsu [ERI, Univ. Tokyo, land support]

Daisuke Suetsugu [IFREE, JAMSTEC, land support]

Yozo Hamano [IFREE, JAMSTEC, land support]

Takafumi Kasaya [IFREE, JAMSTEC, land support]

Aki Itoh [IFREE, JAMSTEC, land support]

Masanao Shinohara [ERI, Univ. Tokyo, land support]

Tadanori Goto [Graduate School of Engineering, Kyoto Univ., land support]

Aoki [NME, scientific support staff]

Tanaka [NME, scientific support staff]

2.4. Captain, crew and KAIKO operation team

2.4.1. Captain and crew of the R.V. KAIREI

Captain	RYONO SHINYA
Chief Officer	KIMURA NAOTO
2nd Officer	ADACHI TATSUO
3rd Officer	KONNO HIDEHIKO
Chief Engineer	KAJINISHI KIYONORI
1st Engineer	KANEDA KAZUHIKO
2nd Engineer	KATO KENZO
3rd Engineer	MORI TAKAHIRO
Chief Electronics Operator	TAKAHASHI MASAMOTO
2nd Electronics Operator	INOUE YOICHI
3rd Electronics Operator	MORIWAKI YUKA
Boat Swain	KYUKI YASUYOSHI
Able Seaman	KAWAMURA YOSHIAKI
Able Seaman	SHIMIZU KATSUMI
Able Seaman	ISHII YUKITO
Able Seaman	MURATA KAITO
Sailor	HANAZAWA JIRO
Sailor	NAKANISHI TORU
No.1 Oiler	NAKAI KAZUAKI
Oiler	HASHIMOTO TOMOYUKI
Oiler	HIGASHIGAWA YUJI
Assistant Oiler	UEKI FUMIHIRO
Assistant Oiler	KOZAKI MAKOTO
Chief Steward	MATSUMOTO ISAO
Steward	TAKEMURA RYUEI
Steward	FUKUMURA HIDEO
Steward	KUBOTA HIDEKI
Steward	SHIMIZU SHIHO
Trainee	TORIGOE KATSUYA
Trainee	SHINODA JUN

2.4.2. KAIKO operation team

Operation Manager	NAMBU YOSHINOBU
Chief ROV Operator	HIRATA KAZUYOSHI
1st ROV Operator	MIURA ATSUMORI

2nd ROV Operator	UEKI MITSUHIRO
2nd ROV Operator	TAKISHITA KIYOSHI
2nd ROV Operator	WAKAMATSU HOMARE
2nd ROV Operator	KONDO TOMOE
2nd ROV Operator	SHIGETAKE SEIJI
3rd ROV Operator	KATAGIRI MASAYA
3rd ROV Operator	ASAI RYU
3rd ROV Operator	IHARA SHOTA

3. Observation

3.1. Purpose and background

We proposed and funded by Grant-in-aid for specially promoted research (JSPS) to conduct a research program in 5 years toward understanding of the mantle dynamics from an <u>innovative observational approach</u> by answering two fundamental questions in Earth science:

(a) ***What is the physical condition for the lithosphere-asthenosphere boundary (LAB)?***

(b) ***Is the mantle transition zone (MTZ) a major water reservoir of the Earth?***

The “normal” ocean floor is the best window to approach these questions as it allows us to see the inside of the Earth through it without the disturbance due to the thick and heterogeneous continental crust. However, any approach, if ever attempted, has not yet been successful because of technological difficulties in obtaining high-quality geophysical data in the ocean.

The present investigators had led the Ocean Hemisphere network Project (OHP) in 1996-2001, in which a network of geophysical observatories was built in the western Pacific region. Data from the OHP network, especially from broadband seismographs on land and under water, precise magnetometers, submarine cables to measure electric field, successfully provided improved global images of the Earth’s interior in terms of seismic velocities and electrical conductivity (e.g., <u>Utada</u> et al., ***GRL***, 2003). During the OHP project, we had also developed a set of new portable ocean bottom instruments, broadband ocean bottom seismometers (BBOBSs) and ocean bottom electro-magnetometers (OBEMs).

These new observation technologies have been fully utilized in the 5-year Stagnant Slab Project (SSP) that succeeded the OHP since 2004. In the SSP, we have carried out a long-term (3 years in total) joint observation of BBOBSs and OBEMs in the Philippine Sea (Shiobara et al., ***EOS***, 2009) to study the MTZ where the subducted Pacific slab appears to be stagnating. We have made significant contributions to the SSP by obtaining results such as the estimation of water content in the MTZ by joint interpretation of seismic and electromagnetic tomography (Koyama, <u>Utada</u> et al., ***AGU Monograph***, 2006) and the seismic evidence for water transportation deep into the mantle by subducting slab (<u>Kawakatsu</u> & Watada, ***Science***, 2007).

Recently, we developed further innovative instruments (**BBOBS-NX**: broadband ocean bottom seismometer next generation; **EFOS**: Earth electric field observation system). By improving the mechanical coupling between the sensor housing and seafloor sediments, the **BBOBS-NX** enables us to record horizontal seismic motions, as well as vertical ones, with a typical noise level comparable to land observations. This gives us a strong advantage over other OBS’s because it allows us to apply station-based powerful seismic analysis methods commonly used on land, such as the receiver function and shear-wave splitting analyses, for ocean bottom data. The **EFOS**, on the other hand, measures the electric voltage difference at the seafloor by using a 10 km long cable. Compared to the OBEM measuring the electric field with a spacing of only 5 m, it successfully reduces the noise level to 1/10 or lower so as to provide reliable estimates of electromagnetic responses in a wide period range (1,000-500,000 s) that have high sensitivity to the electrical conductivity in the upper mantle and in the MTZ. Therefore, we are now capable of providing strong constraints to answer the two questions **(a)** and **(b)** listed above by applying our advanced observational technologies to the "**normal oceanic mantle**" (as opposed to the mantle beneath subduction zones, hot spots or mid-oceanic ridges).

This cruise is conducted in the first year of the five year project as a 'pilot experiment', in which **BBOBS-NX** and **EFOS** are deployed together for the first time in our experience, as well as BBOBS's and OBEM's of conventional type. We expect it provides a good opportunity to train ourselves for instrumentations, observations, data processing and analyses. This will be an essential step to complete the main observation phase of the project, which is planned in 2011-2014.

3.2. Research Areas

The present has three target areas in the northwest Pacific Ocean. The area 1 (northwest of the Shatsky Rise) is the main target of this cruise where the sea floor is considered as 'normal'. It consists of five sites (Fig. 2), which are named Site 1 – Site 5. The areas 2 and 3 are supplementary where we are going to retrieve instruments, OBEM and SFEMS, respectively, which are deployed in previous cruises. These instruments are supposed to have recorded electromagnetic variation data for no less than a year that will be useful for the scientific objective of the present proposal as well as for their original scientific purposes.

3.3 Type of instruments and methods for installation and recovery

3.3.1 BBOBS-NX

Two sets of BBOBS-NX (Fig. 3) are going to be installed in the cruise at Sites 2 and 3 of Area 1. Each is deployed by free-falling with the recording unit tied above the sensor unit by a rope. After confirming that the sensor unit is penetrated into the sediment deep enough, the recording unit is untied and replaced on the sediment nearby the sensor unit by ROV Kaiko-7000II. This operation enables us to make seismic noise level as low as those at normal land observatories at the period band (1-1000 sec) important for the present purpose.

3.3.2. EFOS

One set of EFOS (Electric Field Observation System) is installed for the first time by ROV Kaiko-7000II. Location is site 3. The system consists of a cable drum with 6 km long cable and a recording device (Fig. 4a). They are deployed from the ship by a mooring system (Fig. 4b). After deployment, the buoy is released by an acoustic system and retrieved. Following operations are all done by the Kaiko-7000II vehicle.

(1) Four ropes connected to the buoy are removed from the EFOS.

(2) The drum is untied from the anchor.

(3) The vehicle is docked to the drum, and then

(4) 6 km cable is installed by towing.

The electric potential difference is measured between two electrodes, one at the far end of the cable and the other near the recording device. A 3 m long silver wire is used for electrode, which is coated by silver-chloride. A weak current is programmed to flow between each electrode and a dummy electrode after the installation.

3.3.3 BBOBS

BBOBS's have been used in many of our previous projects, and are to be used in the present project. It consists of a pressure housing, hydrophone for acoustic release system, and an anchor. A broad-band sensor batteries and recording unit are contained in the pressure case (a 65 cm f sphere) made of titanium alloy (Fig. 5). It is deployed by free-falling and recovered by self pop-up system normally about one year after deployment. In this cruise, they are deployed at sites 1, 4, and 5.

3.3.4 OBEM

OBEM's have also been used in our previous projects together with BBOBS's. It consists of two grass spheres, frame made of titanium, an acoustic release system, and an anchor. A three-component fluxgate sensor and recording unit are installed in one sphere and batteries in the other (Fig. 6). It is deployed by free-falling and recovered by self pop-up system normally about one year after deployment. In this cruise, they are deployed at all five sites. Another type of OBEM installed in the Area 2 (Fig. 7) is to be recovered by Kaiko-7000II during this cruise, because its acoustic release system is not active.

3.3.5 SFEMS

SFEMS (Sea Floor ElectroMagnetic Station, Fig. 8) has been repeatedly installed at WP2 in the Area 3 since 1998. The instrument to be recovered in this cruise is the one deployed about three years ago, which is almost the same as the duration time of batteries of the acoustic release system.

3.4. Results (also refer to 3.5 for details)

Although recovery of OBEM by Kaiko-7000II at Area 2 was planned on the way to Area 1, it was postponed because of the rough weather. We arrived at Site 2 of Area 1 on June 13, 2010, and carried out a topographic survey by SEABEAM around the site 2 till 6 h. At this site, we deployed OBEM, BBOBS-NX and buoyed EFOS. The descending speed of EFOS was found to be only 30 m/min or so. After confirming EFOS's landing on to the bottom, we carried out positioning three instruments by LBL (Fig. 9). The relative distance between BBOBS-NX and EFOS was about 200 m, and that between EFOS and OBEM was only about 80 m. It was also found that the sensor of BBOBS-NX was tilted by about 10 degrees, which is out of controllable range.

On June 14, 2010, we performed the first Kaiko-7000II dive in this cruise, which is the dive #478. We tried to move the recording unit beside the sensor, and to correct the tilt of BBOBS sensor. The whole operation took about two hours. Then we tried to install cable for EFOS. Four mooring ropes we removed from a top of EFOS, cable drum was untied to the anchor, and then the cable drum was unlocked by the manipulator of Kaiko-7000II. All these operations were successful. Then the vehicle tried to dock to the cable drum for installation. It attempted three times. Finally the vehicle carried the drum with the safety system locked, and dropped the drum on to the sea floor. We tried to observe the situation of the drum and the cable, but found that a serious trouble occurred in the thruster system of Kaiko-7000II. The Kaiko-7000II was immediately retrieved on board.

In the morning and evening of June 15, we deployed BBOBS and OBEM by a free fall at Sites 1 and 4, respectively. The position of each instrument was calibrated by LBL (Figs. 10 and 11). Inspection on the thruster trouble conducted by the Kaiko team clarified that it is due to the trouble in communication circuits. After a correspondence with the maker, we decided to go to the Hachinohe port to receive spare parts. It took 3 days. By replacing all circuit boards in trouble, the Kaiko team successfully repaired the thruster system, which enabled us to carry out further dive operations.

We returned to the site 2 of the Area 1 in the morning of June 19. Here the second dive of Kaiko-7000II in this cruise was attempted, following the deployment of BBOBS-NX. The recording device was untied from the sensor, and replaced on the seafloor. From visual inspection, it was noted that the penetrating depth of the sensor ‘U’ is not enough, and so we corrected it by pushing the sensor head by the Kaiko-7000II’s front basket. The operation was completed. After the retrieval of Kaiko-7000II, we deployed OBEM. Locations of instruments are shown in Fig. 12.

On June 20, we shifted to Site 5, where BBOBS and OBEM were deployed. Locations are shown in Fig. 13.

On June 21 and 22, we tried to install EFOS cable by Kaiko-7000II. The first trial on June 21 was terminated by a trouble of the cable drum. Installation distance was about 450 m. At the second trial on June 22, we successfully recovered the trouble of previous attempt, and installation became stable at a speed of 0.4 – 0.5 kt. However, we could not complete this operation due to the rough weather. We terminated installing cable at the distance slightly exceeding 3 km. The cable drum with remaining distance was left at the termination point. Although the installation itself was incomplete, we have obtained useful information for further development of EFOS from the experience of this cruise.

In summary, all operations planed for Area 1 were successfully completed, except the cable installation at Site 3. Operations planed for Area 2 an Area 3 were not conducted because the given ship time was limited.

3.5. KR10-08 Cruise Log

2010/06/10(Yokosuka-shin-kou)-2010/06/25(JAMSTEC)

Time: JST =UTC+9:00

06/10 (Noon report: 34-58.5’N, 139-38.7’E/ weather: bc/ wind direction: NNE/ wind speed index: 5/ wave: 3m/ swell: 2m/ visibility: 8 nautical miles)

10:00 departure, transit

11:00-11:40 briefing about onboard life and safety

13:00-13:35 meeting

13:45-14:10 briefing about KAIKO7K-II operation

18:00-18:10 science meeting

06/11 (Noon report: 35-50.6’N, 145-21.0’E/ bc/ North/ 5/ 4/ 4/ 10)

transit

18:00-18:10 science meeting

06/12 (Noon report: 37-26.8’N, 150-43.6’E/ c/ NNW/ 5/ 3/ 4/ 8)

transit

preparing OBEM, BBOBS-NX, EFOS and mooring system

18:00-18:20 science meeting

06/13 (Noon report: 38-45.7’N, 155-54.3’E/ bc/ NNW/ 4/ 3/ 2/ 8)

06:50 arrive at the site-3 in area-1

06:56 XBT

07:21-08:45 MBES survey

09:32 let go the OBEM

09:58 let go the BBOBS-NX

10:37 let go the EFOS mooring

11:01 BBOBS-NX landing

12:16 OBEM landing

13:57 EFOS landing

13:59-15:33 calibration

16:04 release the EFOS mooring

17:08 mooring at the surface

17:30 recover mooring system

18:05-18:25 science meeting

19:42 start MBES survey

06/14 (Noon report: 38-45.8’N, 155-54.6’E/ c/ ENE/ 1/ 1/ 1/ 8)

05:58 finish MBES survey

07:36 start dive #478 (site-3/area-1)

10:00 KAIKO on bottom (depth=5,762m)

16:35 KAIKO off bottom (depth=5,763m)

18:00-18:15 science meeting

19:29 KAIKO on deck
21:17 start MBES survey

6/15 (Noon report: 39-11.6'N, 154-46.9'E/ r/ SSE/ 4/ 3/ 1/ 8)
01:44 finish MBES survey
10:32 let go the OBEM at site 1
10:51 let go the BBOBS at site 1
11:59 BBOBS landing
13:19-14:30 calibration
18:00-18:10 science meeting
19:07 let go the OBEM at site-4
19:28 let go the BBOBS at site-4
20:39 BBOBS landing
21:53 OBEM landing
21:53-23:14 calibration

06/16 (Noon report: 38-46.0'N, 150.50.0'E/ f/ SSW/ 4/ 3/ 1/ 0.2)
transit to Hachinohe port
18:00-18:05 science meeting

06/17 (Noon report: 40-09.0'N, 143-04.0'E/ bc/ SSW/ 5/ 3/ 1/ 8)
17:00 anchor at off Hachinohe port
18:00 weigh anchor
18:00-18:15 science meeting

06/18 (Noon report: 40-07.0'N, 147-42.0'E/ bc/ SSW/ 4/ 2/ 1/ 4)
transit to the site-2, area-1
18:00-18:15 science meeting

06/19 (Noon report: 39-42.0'N, 153-21.4'E'E/ bc/ SSE/ 3/ 1/ 1/ 0.3)
03:44-05:30 MBES survey
05:20 XBT
06:16-06:40 MBES survey
07:02 let go the BBOBS-NX at site-2
08:20 BBOBS-NX landing
08:36 finish calibration
08:57 start dive #479 (site-2/area-1)
11:08 KAIKO on bottom (depth=5,730m)
12:43 KAIKO off bottom (depth=5,728m)
15:07 KAIKO on deck
16:15 let go the OBEM at site-2
18:13-18:25 science meeting
19:01 OBEM landing
20:05 start MBES survey

06/20 (Noon report: 40-16.2'N, 155-26.4'E/ c/ North/ 5/ 3/ 3/ 6)

01:04 finish MBES survey
05:49- MBES survey
08:53 let go the OBEM at site-5
09:13 let go the BBOBS at site-5
10:18 BBOBS landing
11:33 OBEM landing
11:33-11:36 calibration
11:48-20:34 MBES survey
22:42 start MBES

06/21 (Noon report: 38-45.8'N, 155-54.7'E/ r/ SSE/ 4/ 3/ 2/ 7)
05:05 finish MBES
10:27 start dive 7K#480 (site-3/area-1)
13:01 KAIKO on bottom (depth=5,764m)
17:44 KAIKO off bottom (depth=5,761m)
19:47 KAIKO on deck
18:00- meeting
22:35 start MBES survey

06/22 (Noon report: 38-45.8'N, 155-55.1'E/ o/ NW/ 5/ 4/ 3/ 6)
04:20 finish MBES survey
07:36 start dive 7K#481 (site-3/area-1)
09:45 KAIKO on bottom (depth=5,762m)
16:06 KAIKO off bottom (depth=5,767m)
18:06 KAIKO on deck
18:06-18:15 science meeting
21:20 start MBES survey

06/23 (Noon report: 37-50.0'N, 152-04.0'E/ bc/ East/ 1/ 1/ 1/ 8)
05:18 finish MBES survey, transit to JAMSTEC
13:00-14:00 ship tour
14:00-14:45 rope work
15:00-16:30 seminar

06/24 (Noon report: 36-07.0'N, 145-05.0'E/ SW/ o/ 6/ 5/ 4/ 7)
transit
15:00-16:30 seminar

06/25
14:00 arrive at the JAMSTEC

weather: bc=fine but cloudy, c=cloudy, o=overcast, r=rain, f=fog

wind speed index:

0 = 0 - 0.2 m/sec., 1 = 0.3 - 1.5m/sec., 2 = 1.6 - 3.3m/sec.,
3 = 3.4 - 5.4m/sec.,4 = 5.5 - 7.9m/sec., 5 = 8.0 - 10.7m/sec.,
6 = 10.8 - 13.8m/sec., 7 = 13.9 - 17.1m/sec., 8 = 17.2 - 20.7m/sec.,
9 = 20.8 - 24.4m/sec., 10 = 24.5 - 28.4m/sec., 11 = 28.5 - 32.6m/sec.,
12 = more than 32.7 m/sec.

4. Acknowledgements

We thank for the captain and crew of R.V. KAIREI, the KAIKO operation team and a scientific support staff of NME in their correct work and warm support during this cruise. This study is partially supported by the JSPS Grant-in-aid for specially promoted research (22000003).

5. Notice on using Data

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.

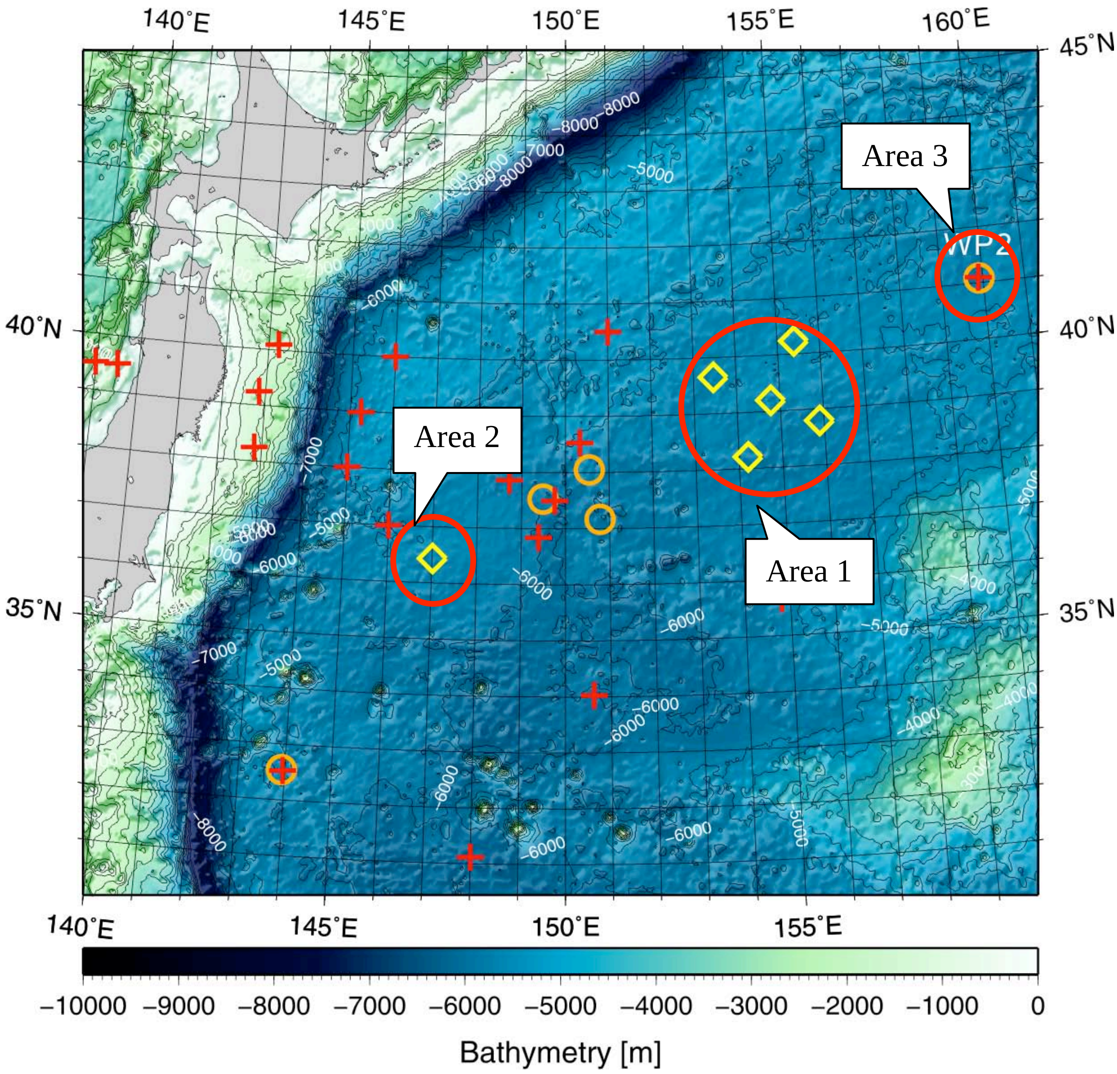

Figure 1. Map of research areas. Site locations of previous projects are shown by circle (BBOBS site) and plus (OBEM site).

Area 1: Main area of the present research which includes fives seafloor observation sites to be installed by the present cruise.

Area 2: Research area of second priority with s site where an OBEM is to be recovered by Kaiko-7000II.

Area 3: Research area of third priority with a site (WP-2) where a SFEMS is to be recovered.

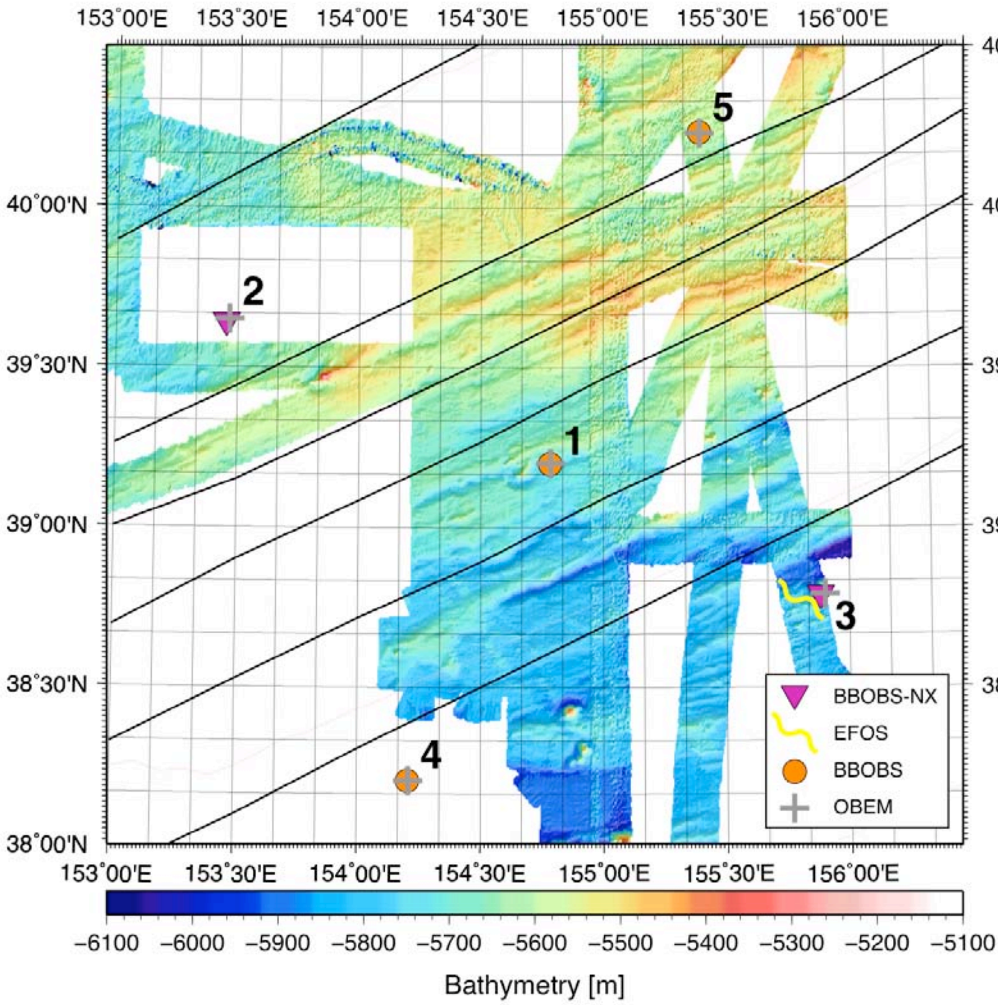

Figure 2. Site location map of the Area 1.

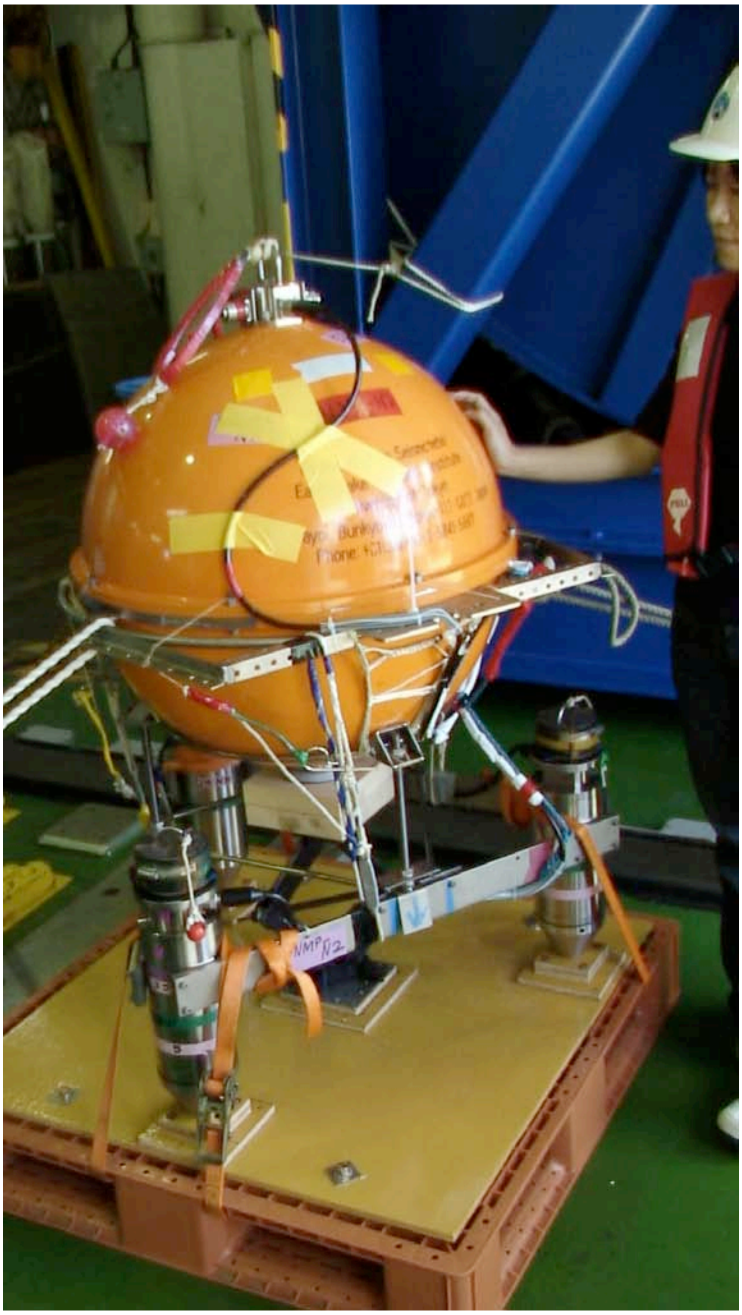

Figure 3. BBOBS-NX deployed at Site 2. The recording unit and batteries are contained in the titanium sphere (65 cm ϕ). Each of 3 component sensors are contained in the bullet shaped container held by a triangular frame.

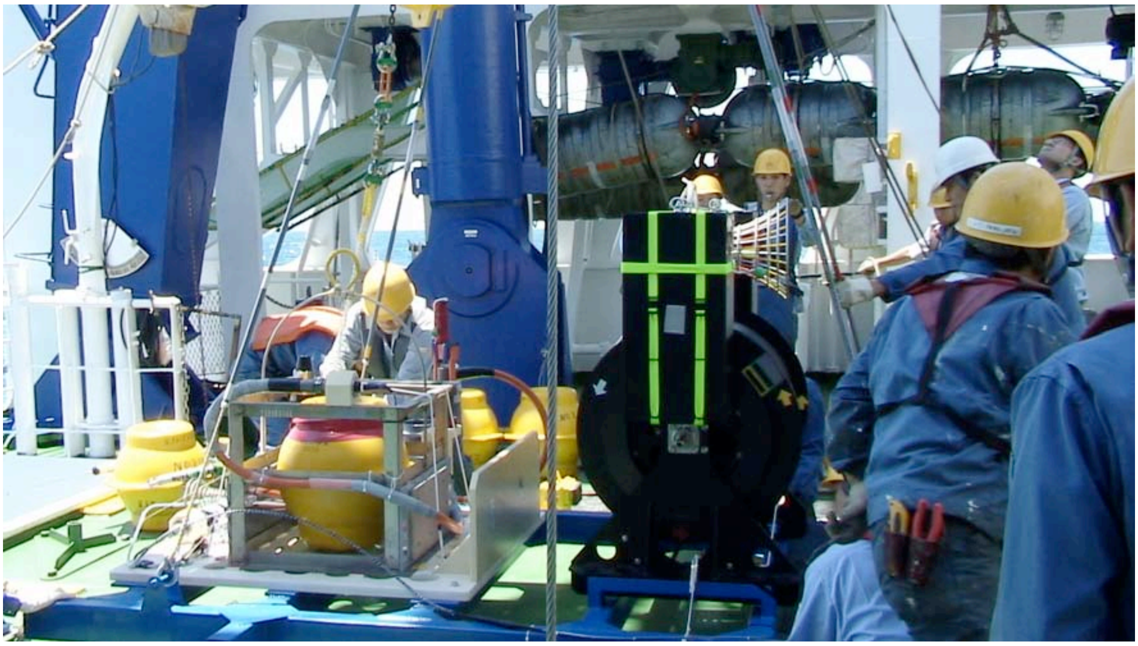

Figure 4a. Deployment of EFOS at Site 3.

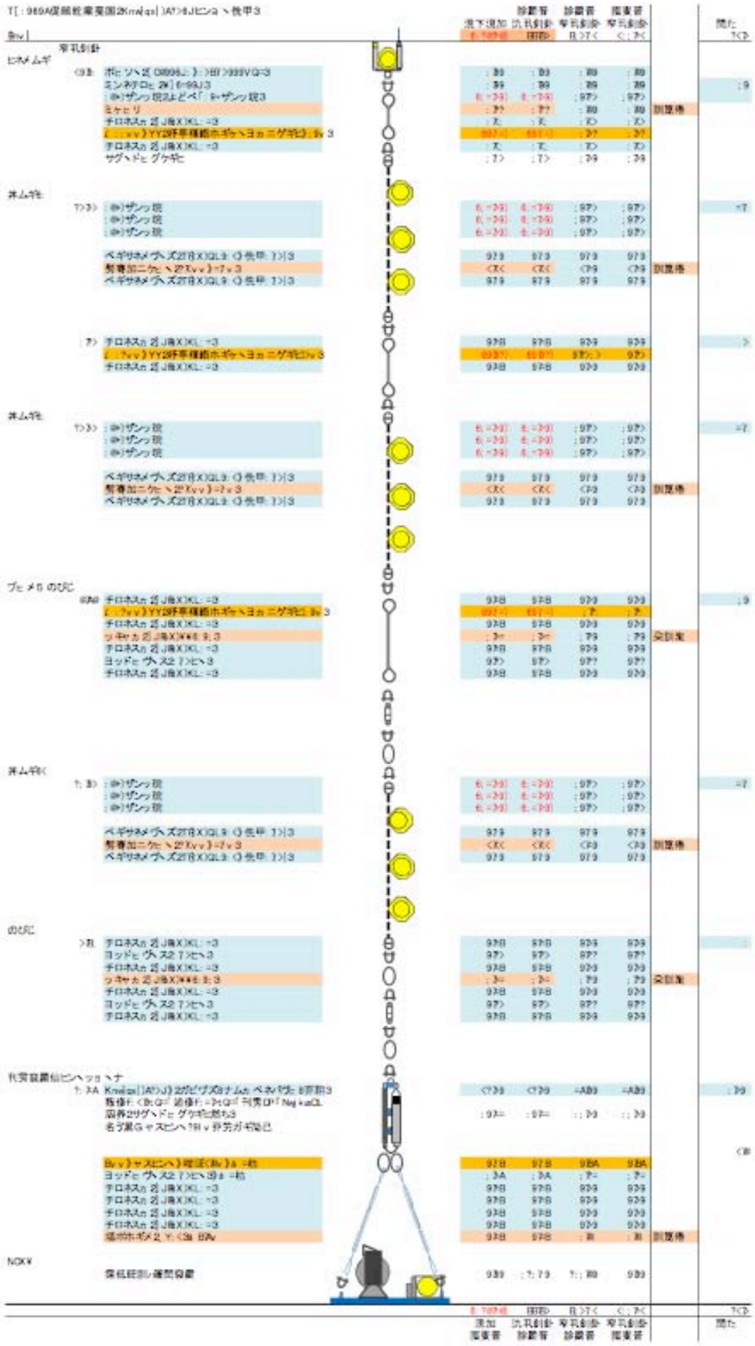

Figure 4b. A mooring system for EFOS installation. EFOS consists of a cable drum and a recording device placed on a steel anchor. For stability and safety, it is deployed with a buoy system with 10 glass spheres, which is released and recovered after deployment.

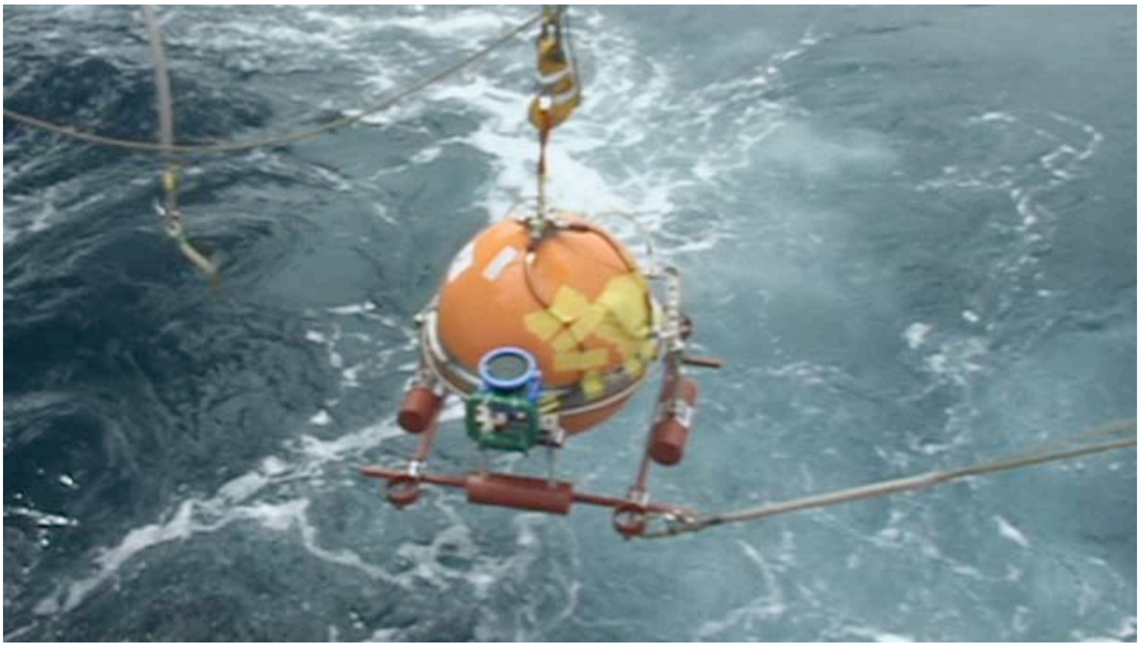

Figure 5. BBOBS deployment at Site 05.

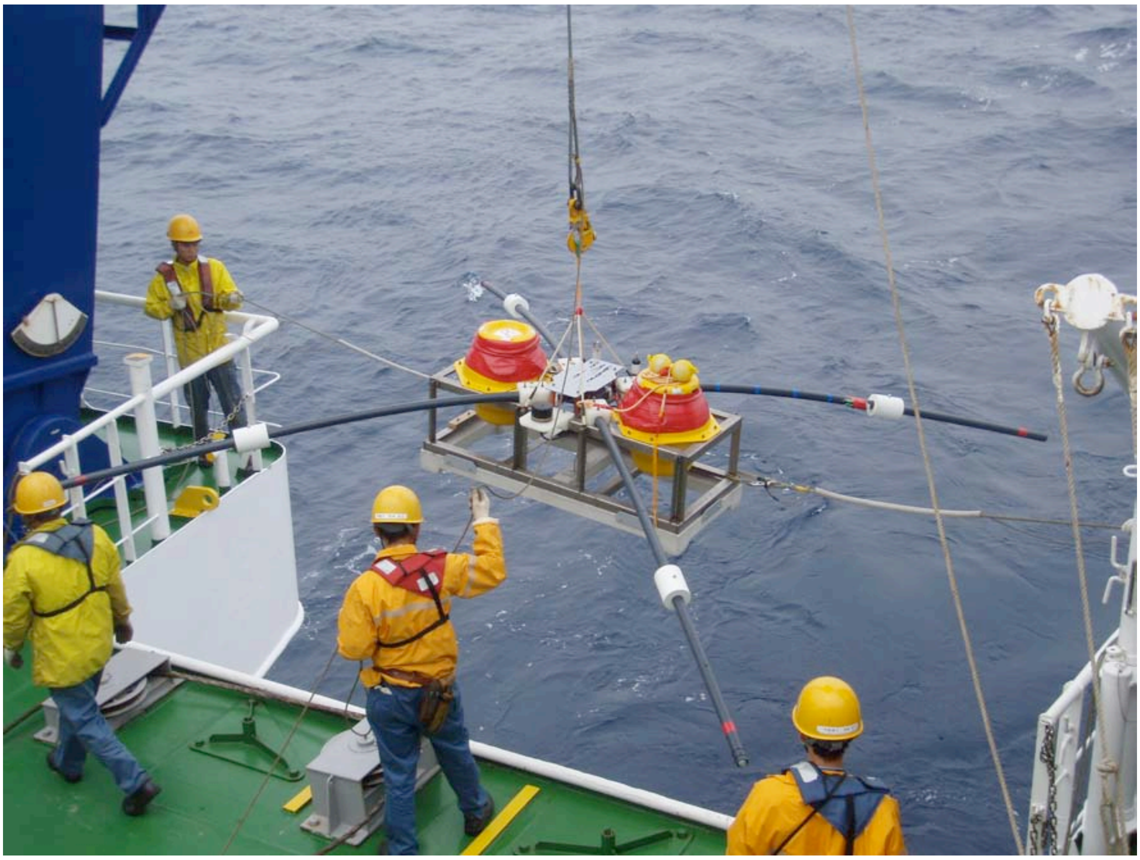

Figure 6. OBEM deployment at Site 04.

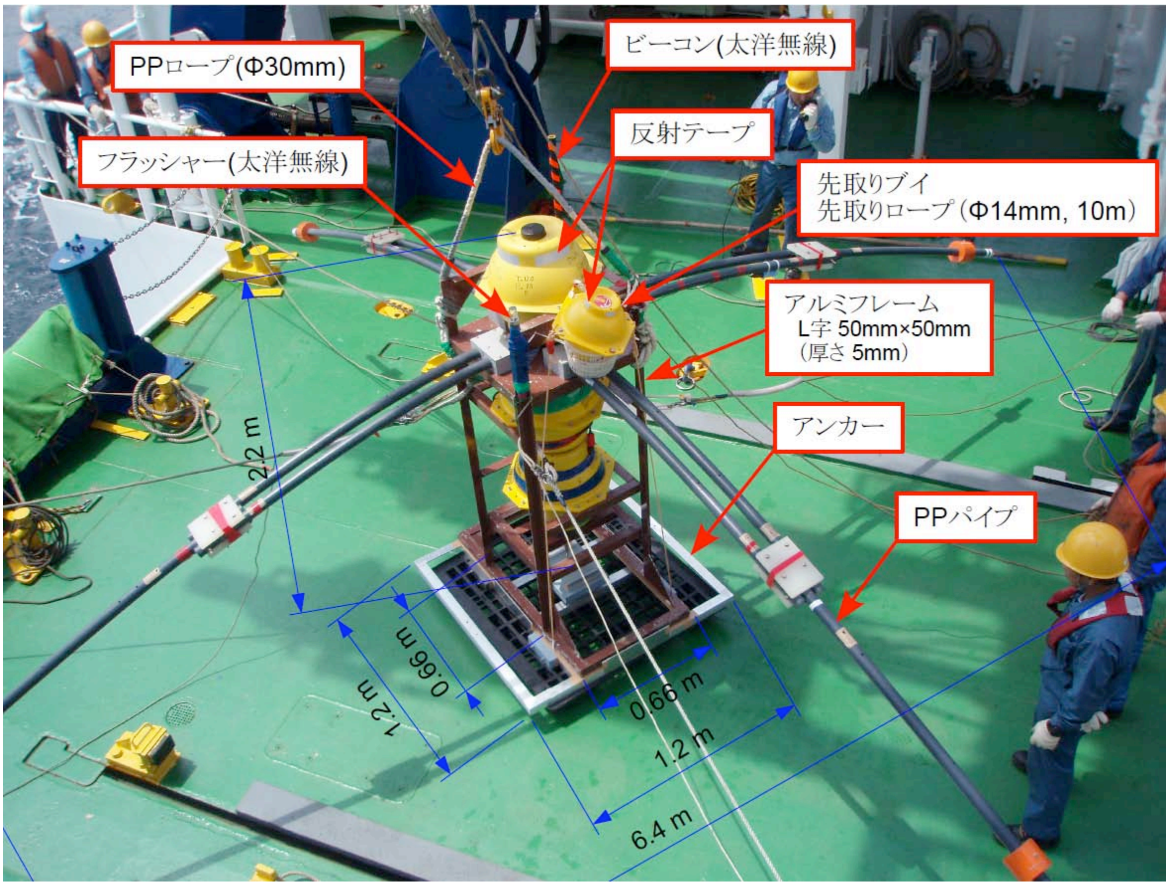

Figure 7. OBEM to be retrieved by Kaiko-7000II from Area 2.

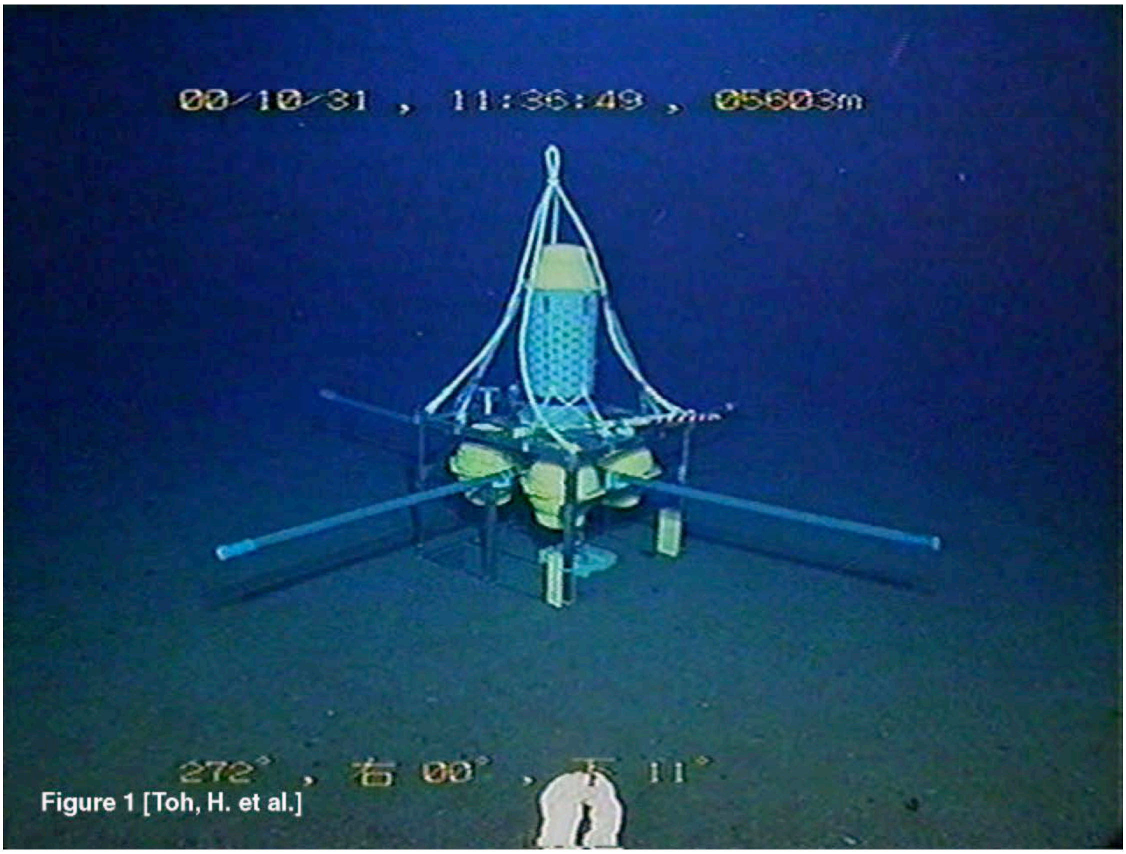

Figure 8. SFEMS to be retrieved by self pop-up at WP-2 in Area 3.

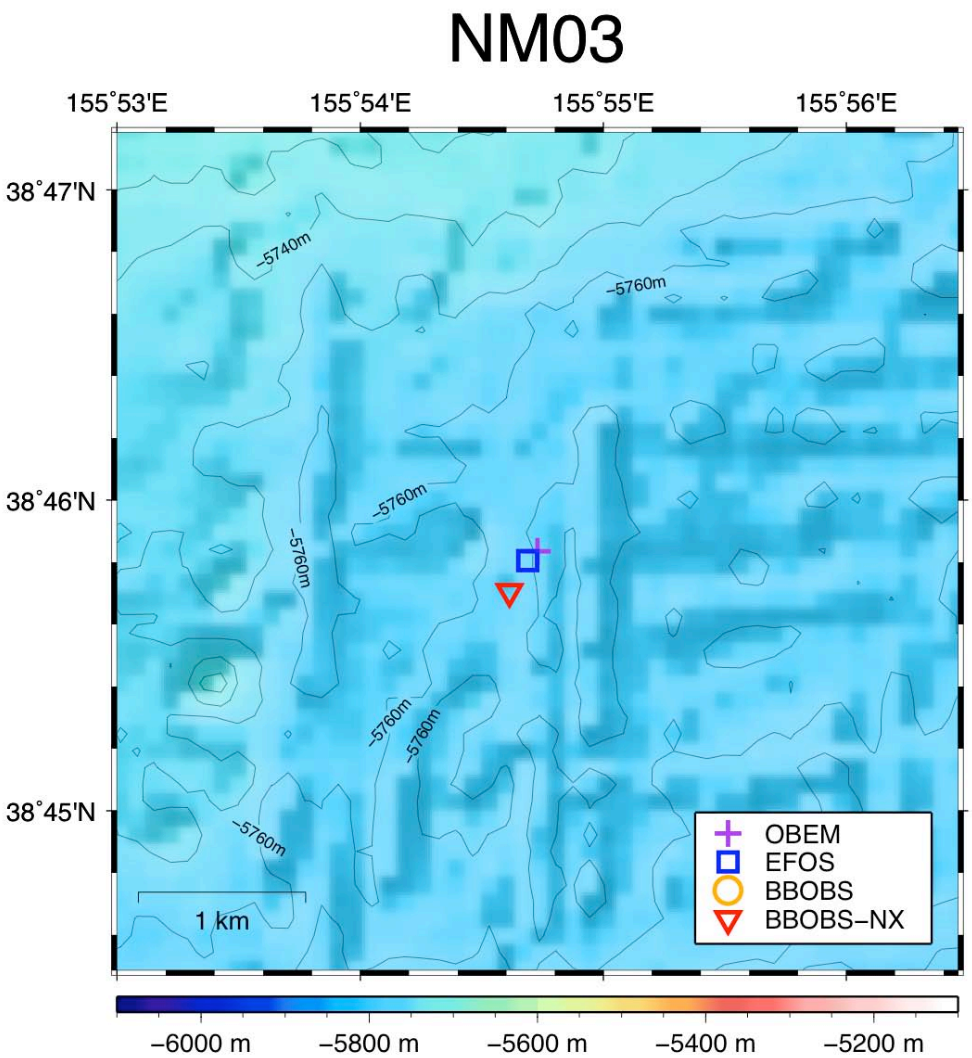

Figure 9. Location map of installation points at Site 03.

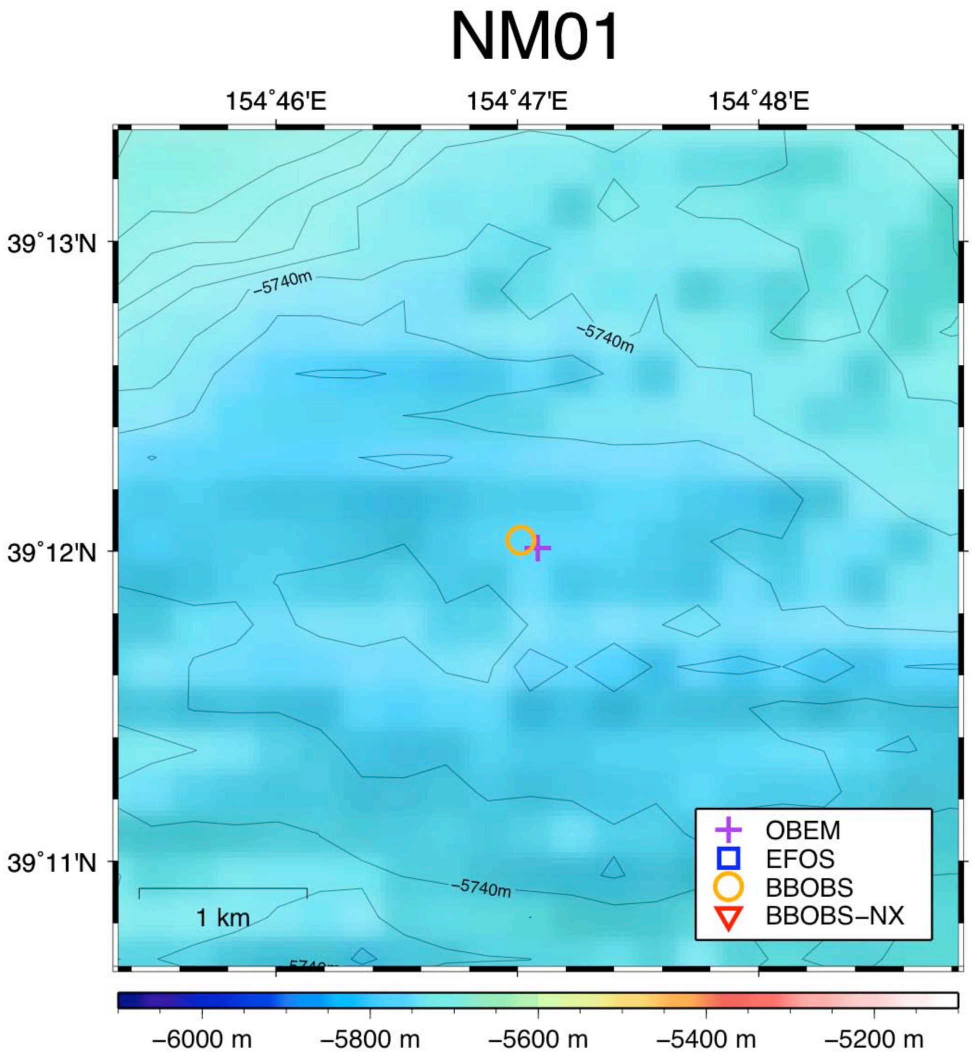

Figure 10. Location map of installation points at Site 01.

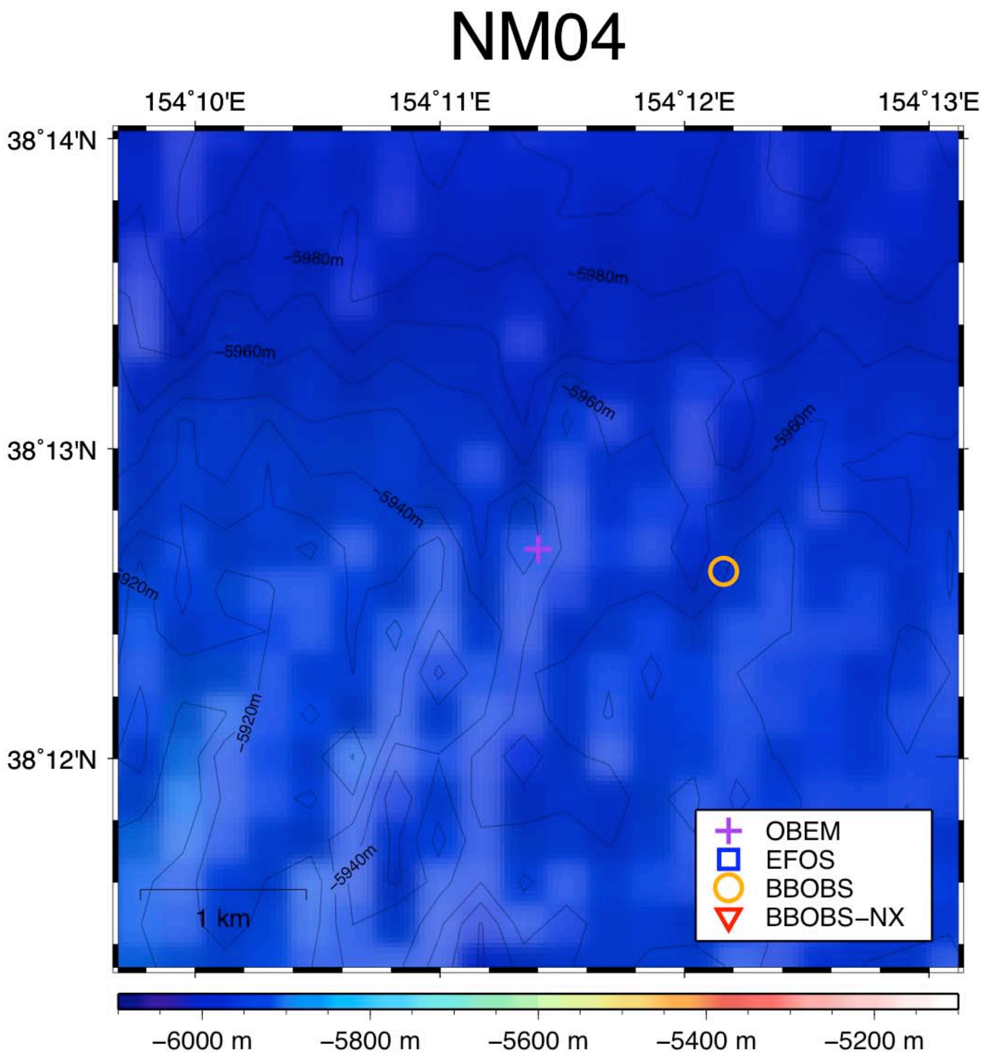

Figure 11. Location map of installation points at Site 04.

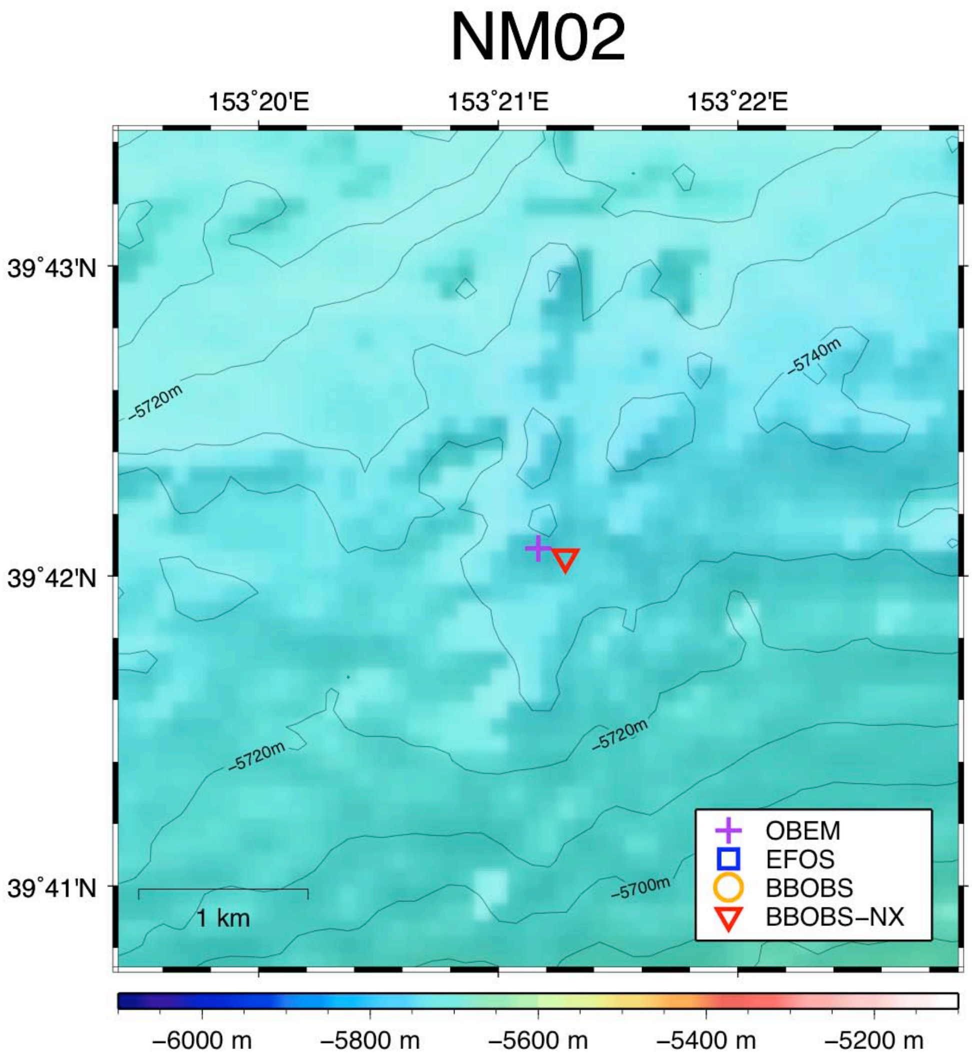

Figure 12. Location map of installation points at Site 02.

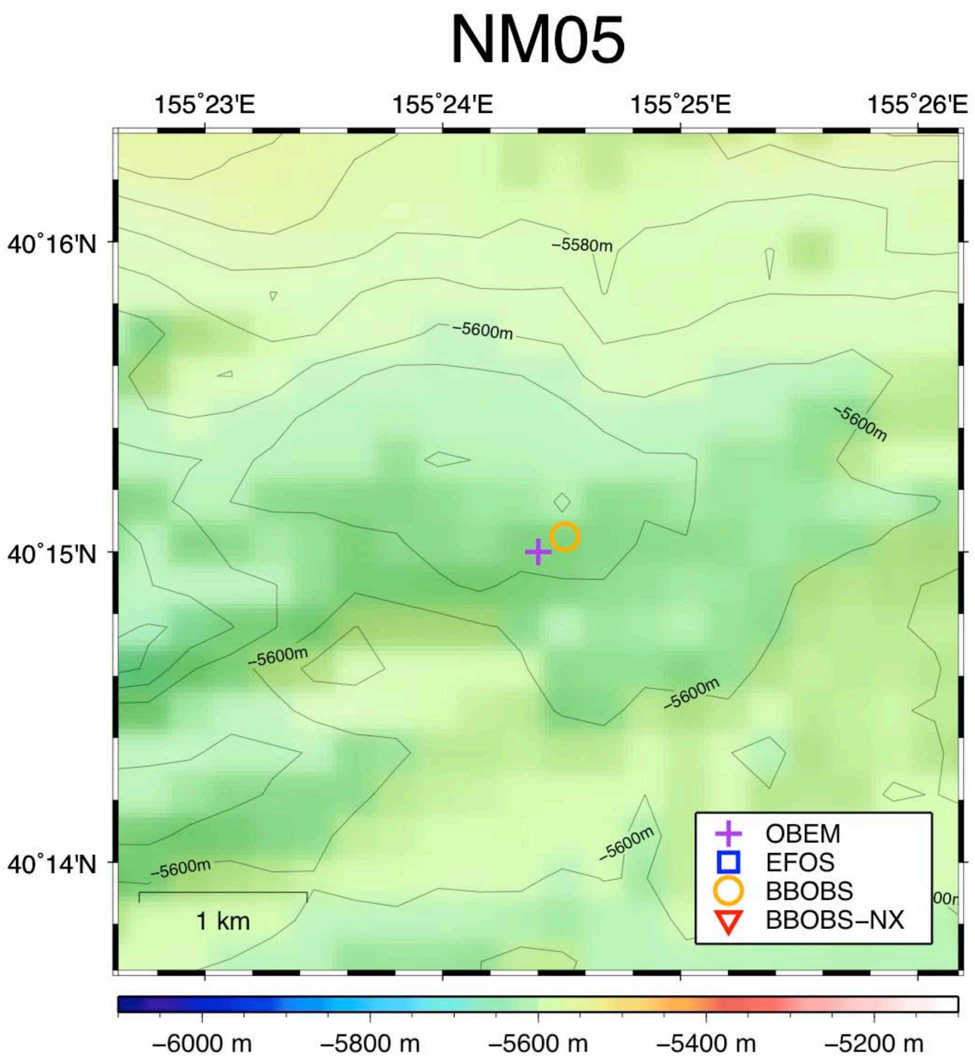

Figure 13. Location map of installation points at Site 05.