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CRUISE REPORT

KY11-09

“Kaiyo” & “Hyper-Dolphin”

Aug. 2011

Earthquake and Tsunami Research Project
for Disaster Prevention

JAMSTEC

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A. DONET OPERATION

1. Introduction

DONET is a program to establish the technologies of large scale real-time seafloor research and surveillance infrastructure for earthquake, geodetic and tsunami observation and analysis. This program has been carried out since 2006 to settle on To-Nankai region in Nankai trough as the target of observation. From January to March 2010, the DONET backbone cable system was laid on the seafloor through the cable laying ship. First DONET science node and observatory was constructed on seafloor by using ROV "Hyper Dolphin" in the expedition NT10-04 on March 2010. And the following expeditions were also carried out; NT10-09, NT10-18, KY10-15, KY11-03, and KY11-06Leg2. Through the expeditions, all science nodes and seventeen observatories were installed. This expedition, KY11-09, is scheduled to deploy the remaining three observatories on the seafloor to complete the installation of the originally planned DONET observatories as shown in Fig. 1.

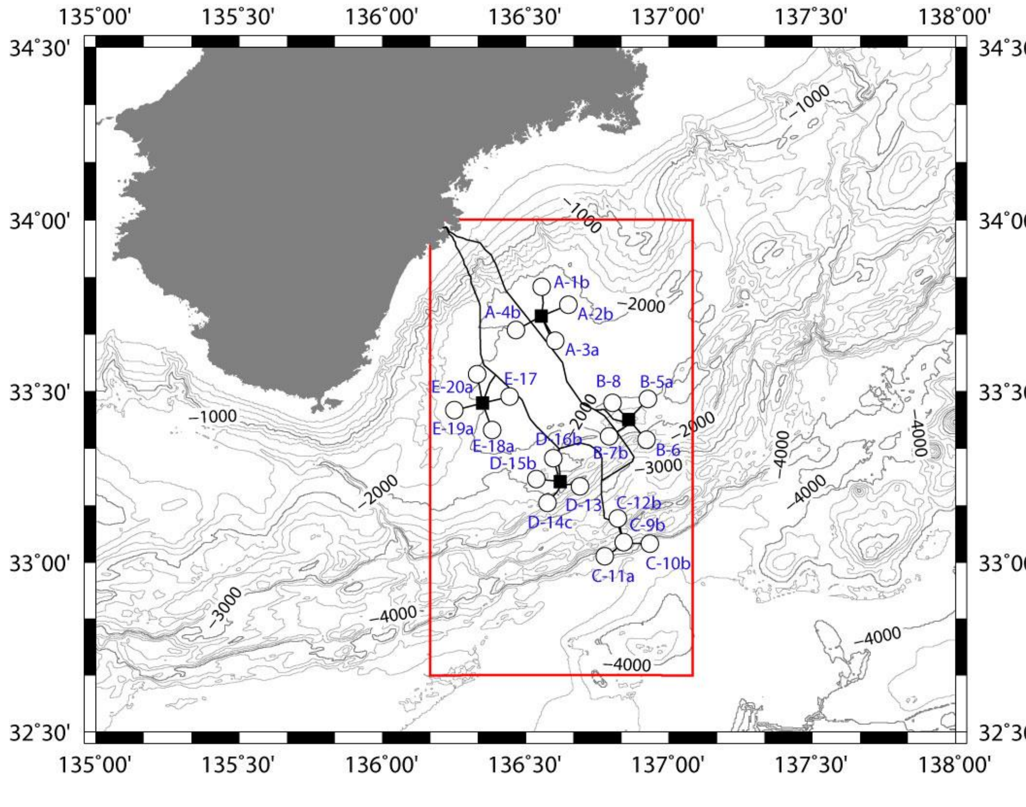


Figure 1 The original observatory network topology
White circles dots shows the observatories and black squares shows the science nodes,

2. Schedule

The present KY11-09 cruise is to conduct the following operations.

(1) Sensor installation operation
(2) Extension cable laying operation between the science node and the observatory
(3) Burial hole conditioning operation
(4) Backfilling burial hole operation
(5) Borehole observatory construction

Table 1 shows the summary of the KY11-09 cruise. Nine dives have been carried out in this cruise.

Table 1 Summary of KY11-09 cruise

Date	Dive No.	Site	Operation	Remarks
From 17-21 July			Canceled	Due to the influence of Typhoons
22 July			Departure	departure at 15:00 from JAMSTEC
23 July		C0002	Deploy a repeater and recorder for bore hole C0002.	Recovered two mooring systems
24 July			Free fall	
25 July	1298	C-12d	Burial-Hole conditioning	
26 July	1299	C-12d	Sensor installation	
27 July	1300	C-12d	Extension-cable laying	Startup C-12 sensors
28 July	1301	C-11b	Extension-cable laying	
29 July	1302	C-10c	Extension-cable laying	
30 July	1303	C-11b	Sensor installation	Startup C-11 sensors
31 July	1304	C-10c	Sensor installation	Startup C-10 sensors
1 August	1305	C0002	Check the sensors in borehole	
2 August	1306	A-4	Backfilling burial	
3 August				
4 August			Arrival at JAMSTEC	Arrived at 9:00

3. ROV "Hyper-Dolphin" Dive

(1) Dive 1298 on 25 July

This dive was carried out to clear the inside of the Burial-Hole at C-12d observatory. It took 30 minutes to clear the Burial-Hole with a new nozzle filter (Fig. 3.1). The inclination angle of the casing was checked by the level-meter (Fig. 3.2), and confirmed to be less than 10 degrees error. A lid was put on the casing, and four sand bags were deployed nearby the Burial-Hole. Hyper-Dolphin moved to C-12c, and recovered the miniature transponder ID12. The performance of the new casing installation kit named Vicki was checked (Fig. 3.3).

Dive Point C-12d Lat: 33-07.672'N, Long: 136-49.129'E, Depth: 3784m

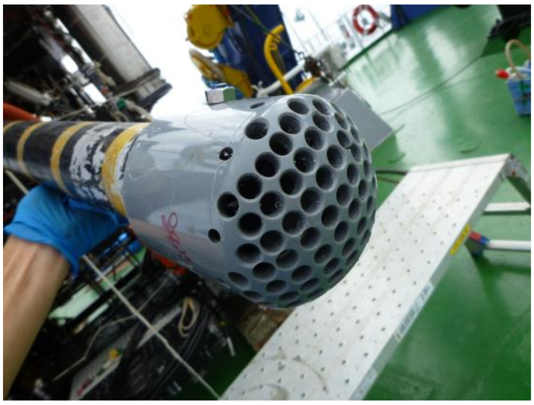


Fig. 3.1 The new nozzle filter

Fig. 3.2 Check of the inclination angle by the level-meter

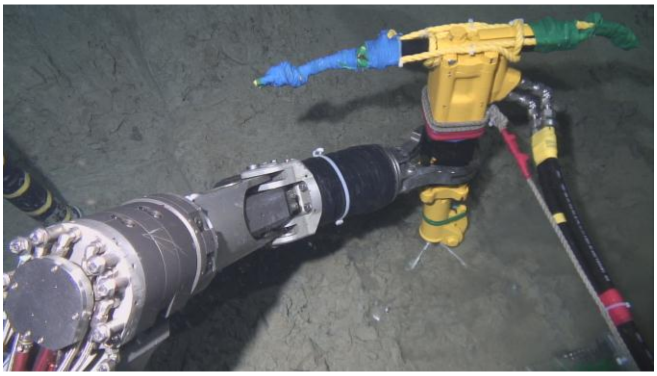


Fig. 3.3 Performance check of the new casing installation device

(2) Dive 1299 on 26 July

An ocean bottom seismometer and a pressure-gauge sensor package were deployed in this dive at C-12d. After the ocean bottom seismometer was inserted into the Burial-Hole (Fig. 3.4), the pressure-gauge sensor package was put on the seafloor. The miniature transponder ID30 was also put on the seabed near the pressure-gauge sensor package (Fig. 3.5). Four sand bags were put on near the ocean bottom seismometer, the lid was retrieved, and Hyper-Dolphin surfaced.

Dive Point C-12d Lat: 33-07.671'N, Long: 136-49.129'E, Depth: 3784m

Serial Number of the sensor: SPKG-C020

Fig. 3.4 The seismometer package and sand bags

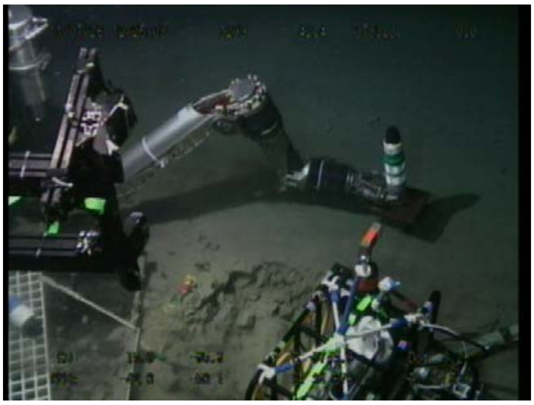


Fig. 3.5 The pressure-gauge sensor package and the miniature transponder

(3) Dive 1300 on 27 July

This dive was carried out to lay an extension cable from the science node C to observatory C-12d. At first, Hyper-Dolphin approached the science node C, and connected the flying connector of extension cable to the Port No.7 of the science node C (Fig. 3.6). After the joint box was put on the seabed, Hyper-Dolphin started the cable laying operation. Hyper-Dolphin approached C-12d observatory 9.5 hours later, and the end of the extension cable was connected to the pressure-gauge sensor package (Fig. 3.7). The connection between the node C and C-12d observatory was checked from the landing station, and Hyper-Dolphin left the C-12d observatory.

Start point (Node C) Lat: 33-3.318'N, Long: 136-50.642'E, Depth: 3591m

End point(C-12d) Lat: 33-7.670'N, Long: 136-49.129'E, Depth: 3783m

Serial Number of the bobbin: No.3 (Blue)

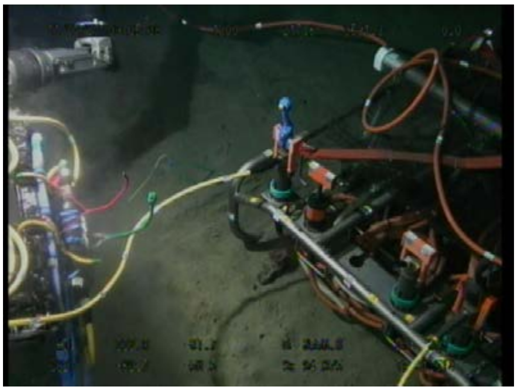


Fig. 3.6 Connection to the Port No.7

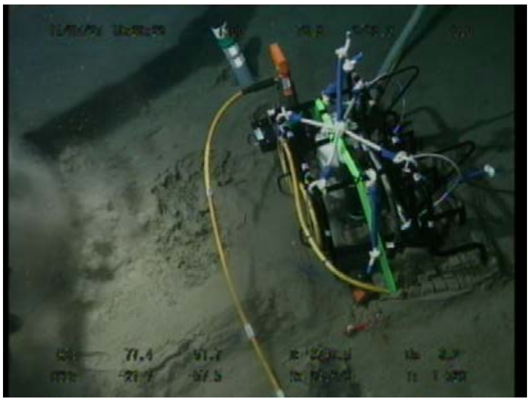


Fig 3.7 The pressure-gauge sensor package on C-12

(4) Dive 1301 on 28 July

This dive was carried out to lay an extension cable from the science node C to the predetermined point of observatory C-11b. At first, Hyper-Dolphin approached the science node C, and connected the flying connector of extension cable to the Port No.2 of the science node C (Fig. 3.8). After the joint box was put on the seabed, Hyper-Dolphin started the cable laying operation. 9 hours later, Hyper-Dolphin arrived at the predetermined point of observatory C-11b and put on the cable bobbin. The miniature transponder ID11 was placed near the cable bobbin (Fig. 3.9). The serial number of the bobbin is No.17 (Color: black).

Start point (Node C) Lat: 33-3.311'N, Long: 136-50.645'E, Depth: 3591m

End point(C-11b) Lat: 33-0173'N, Long: 136-46.720'E, Depth: 4380m

Serial Number of the bobbin: No.17 (black)

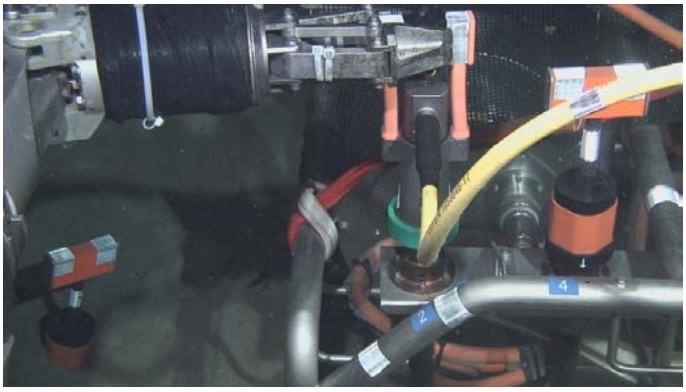


Fig. 3.8 Connection to the Port No.2

Fig. 3.9 The miniature transponder; ID: 11

(5) Dive 1302 on 29 July

This dive was carried out to lay an extension cable from the science node C to the predetermined point of observatory C-10c. Hyper-Dolphin approached the science node C, and connected the flying connector of extension cable to the Port No.8 of the science node C (Fig. 3.10). After the joint box was put on the seabed, Hyper-Dolphin started the cable laying operation. Hyper-Dolphin arrived at the predetermined point of observatory C-10c 9 hours later and put the cable bobbin (Fig. 3.11). The serial number of the bobbin is No.20 (Color: white).

Start point (Node C) Lat: 33-3.312'N, Long: 136-50.635'E, Depth: 3590m

End point(C-10c) Lat: 33-3.233'N, Long: 136-55.985'E, Depth: 4249m

Serial Number of the bobbin: No.20 (White)

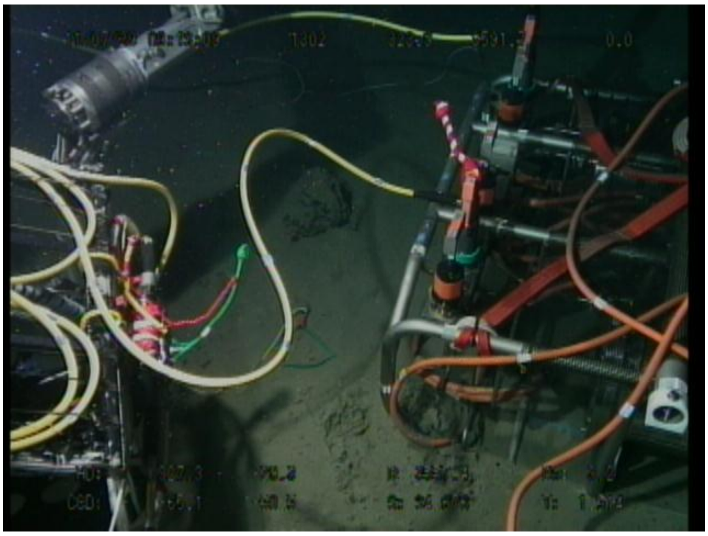


Fig. 3.10 Connection to the Port No.8 of the science node C

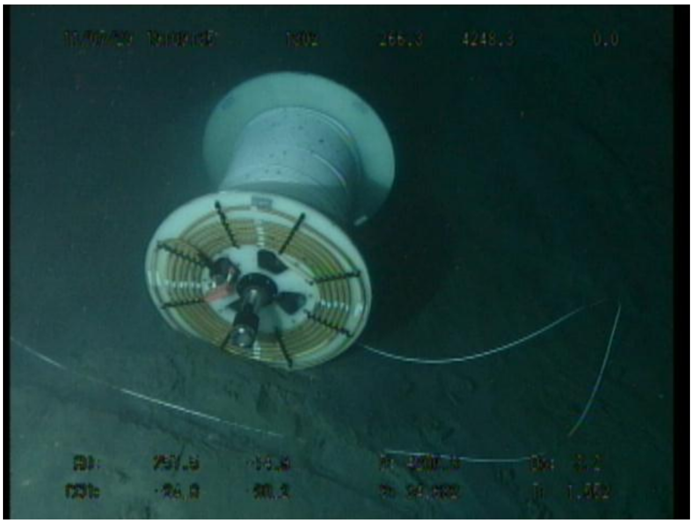


Fig. 3.11 Cable bobbin No.11

(6) Dive 1303 on 30 July

An ocean bottom seismometer and a pressure-gauge sensor package were deployed in this dive at C-11d. The seismometer package and sensor package were united using a grating panel (Fig. 3.11), and loaded on a new basket of Hyper-Dolphin. Hyper-Dolphin put the united sensor package on the seabed, and moved to the cable bobbin that was put in Dive 1301 on 28 July. The flying connector of the extension cable was connected to the receptacle connector on the pressure-gauge sensor package. The inclination angle of the united sensor unit was checked by level-meter, and it is confirmed that the horizontal error was less than 10 degrees (Fig. 3.12). The sensors were waked up by sending command from the landing station, and Hyper-Dolphin rose up to the surface.

Dive Point C-11d Lat: 33-0.195'N, Long: 136-46.739'E, Depth: 4378m

Serial Number of the sensor: SPKG-C010

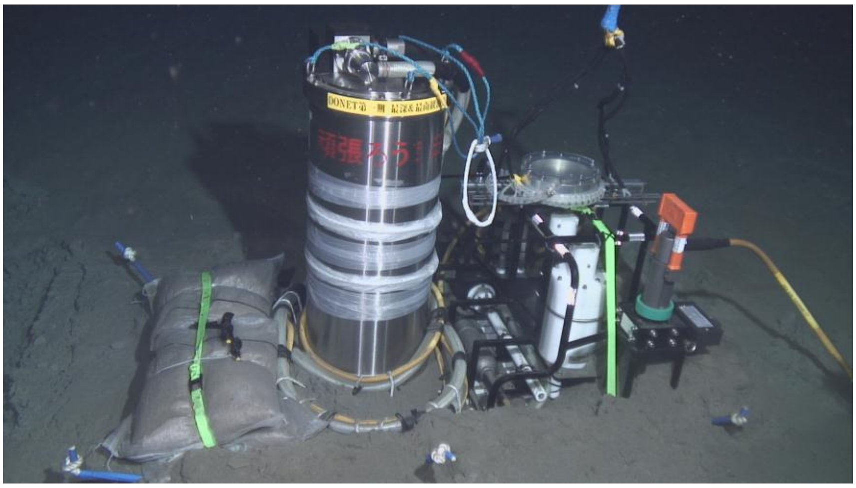


Fig. 3.11 The united sensors (C-11)

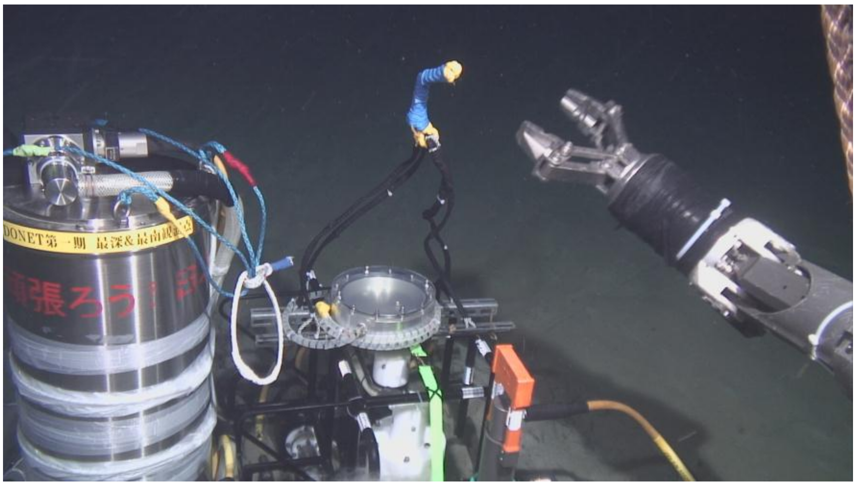


Fig. 3.12 Check of the horizontal error

(7) Dive 1304 on 31 July

An ocean bottom seismometer and a pressure-gauge sensor package were deployed in this dive at C-10c. The seismometer package and sensor package were united using a grating panel, and loaded on the new basket of Hyper-Dolphin. Hyper-Dolphin put the united sensor package on the seabed, and moved to the cable bobbin that was put in Dive 1301 on 28 July. Two sand bags were put under the bobbin to prevent the slippage and rolling (Fig. 3.13). The flying connector of the extension cable was connected to the receptacle connector on the pressure-gauge sensor package. The inclination angle of the united sensor unit was checked by level mater, and it is confirmed that the horizontal error was less than 10 degree (Fig. 3.12). The sensors were waked up by sending commands from the landing station, and Hyper-Dolphin rose up to the surface.

Dive Point C-10c Lat: 33-3.200'N, Long: 136-56.009'E, Depth: 4247m

Serial Number of the sensor: SPKG-A120

Fig. 3.13 The sand bags to prevent the slippage and rolling (C-10)

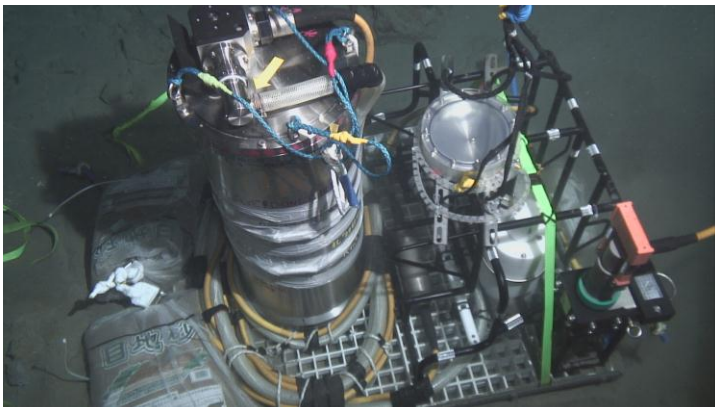


Fig.3.14 Check of the horizontal error by the level meter

(8) Dive 1302 on 2 Aug.

This dive aimed to backfill the burial hole and to release pressure sensor package frame at the observatory A-4. For backfilling sensor package in the burial hole, sand feeder was used (Fig. 3.15). It took about 9 minutes to complete to fill up the hole. Three sand bags were put on the laid cable to press down (Fig. 3.16).

Before the frame was released, the electric power of the sensors had been stopped from the landing station. After all operation was finished, the sensors were checked and the observation started its operation again.

Dive Point A-4 Lat: 33-40.684'N, Long: 136-28.043'E, Depth: 2054 m

Fig 3.15 Backfilling the burial hole by the sand feeder

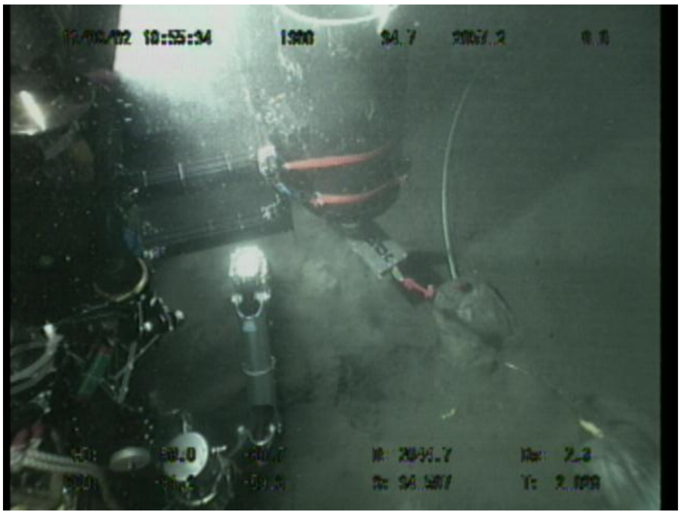


Fig 3.16 Sand bags to press down the cable

4. Concluding Remarks

In the KY11-09 cruise, three new observatories started their operation, and finally all twenty observatories that had been planned were deployed (Fig. 4.1).

At the end of the report, we would like to express our best thanks to all crew of “Kaiyo” and also to all member of “Hyper-Dolphin” operation team.

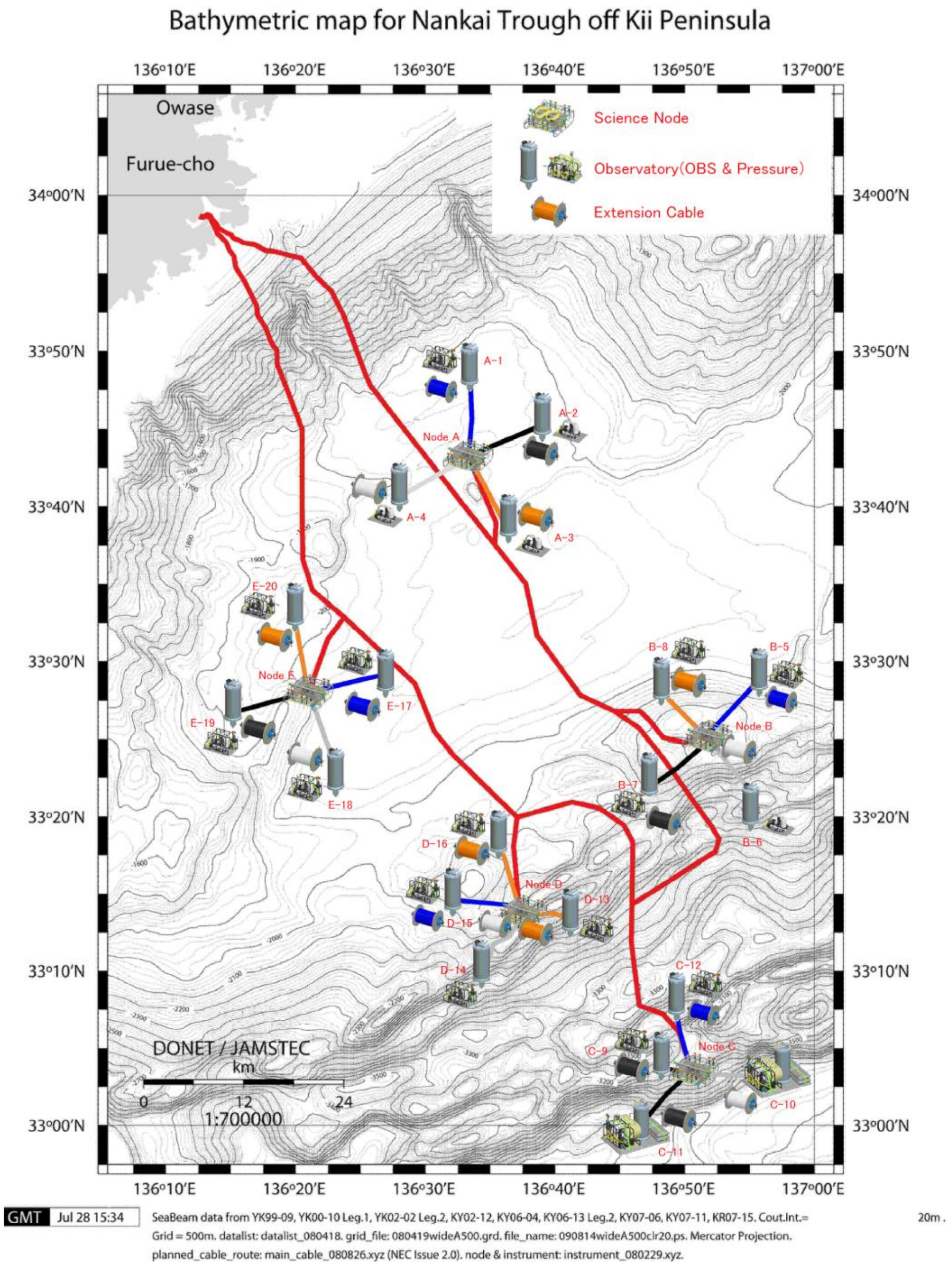


Fig. 4.1 Status of the DONET observatory after KY11-09

B. LTBS OPERATION

1. OBJECTIVES

In the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE), a series of Long Term Borehole Monitoring System (LTBMS) that combine elements of CORKs (e.g., ODP Leg 196 in the Nankai Trough) and NEREID (ODP Leg 186 at Japan Trench), are being installed into the four holes along the NanTroSEIZE transect offshore the Kii Peninsula, to investigate fault mechanism and seismogenesis along subduction megathrusts. The three boreholes are located within and above regions of contrasting behavior of the megasplay fault zone and plate boundary as a whole (i.e., a site ~6–7 km above the "locked" seismogenic plate boundary [Site C0009], a site above the updip edge of the locked zone [Site C0002], and a shallow site in the megasplay fault zone and footwall where slip is presumed to be aseismic [Site C0010]). Figure 1 shows the location of the LTBMS observatories. These observatories have the potential of capturing seismic activity, slow slip behavior, and possibly interseismic strain accumulation on the plate boundary and megasplay faults across a range of pressure, temperature, and kinematic conditions. Currently, the planned observation system for the boreholes consists of an array of sensors designed to monitor slow crustal deformation (e.g., strain, tilt, and pore pressure as a proxy for strain), seismic events including very low frequency earthquakes, hydrologic transients associated with strain events, ambient pore pressure, and temperature. To ensure the long-term and continuous monitoring necessary to capture events occurring over a wide range of timescales, these borehole observatories will be connected to submarine cabled observation network called Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET), which are constructed in and around the drilling target area during the KY11-09 cruise (Figure 1).

The first LTBMS was successfully installed into the borehole at Site C0002 by D/V CHIKYU last December during the IODP Expedition 332. In this KY11-09 cruise, the SAM (data recorder), Repeater, Battery instrument are planned to be deployed by the mooring system and connected them to the borehole sensors (strainmeter, tilt combo. and broad band seismometer) at Site C0002 by ROV Hyper Dolphin to perform long term borehole monitoring in the Nankai trough.

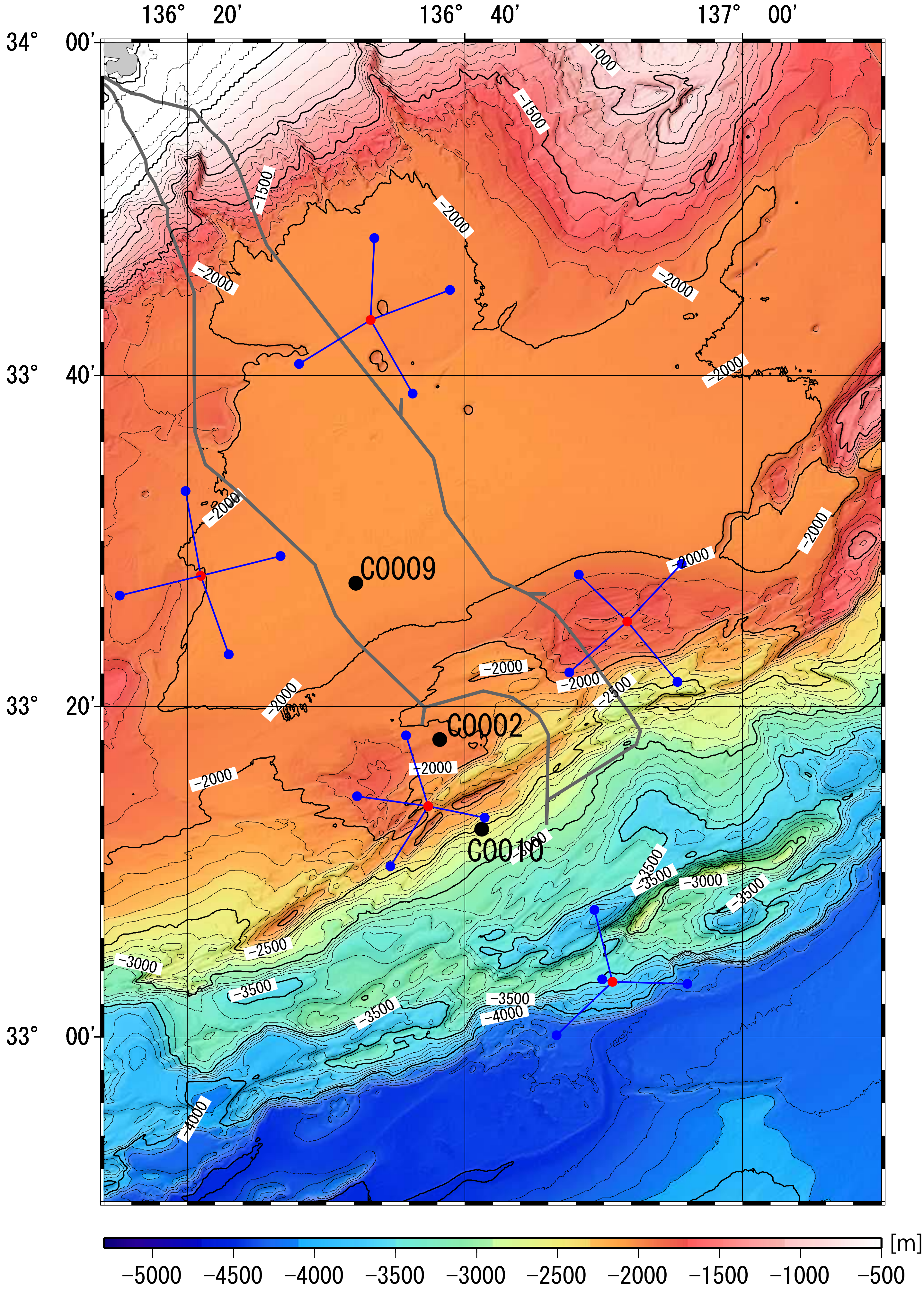


Figure 1 The location of the LTBMS observatories and the DONET cable layout.

2. LTBMS INSTRUMENTS SPECIFICATION

IODP C0002 LTMBS observatory has some borehole instruments including a volumetric strainmeter, broad-band seismometer, tiltmeter, geophone, accelerometer, thermometer and pressure gauge. 9-core electrical cables are used for power supply and data transmission. Three electrical cables are used for volumetric strainmeter, broadband seismometer and tilt combo respectively (Tilt combo consists of tiltmeter, geophone, accelerometer and thermistor array). In the top end of each electrical cable, UMC was mounted on CORK head to access borehole sensors. Pressure gauge was also installed in CORK head with some valves to switch pressure ports which were installed in borehole with different depths. For recording continuous data, we prepared a repeater and SAM (recorder). Additionally, to communicate from R/V Kaiyo to sensor instruments, we prepared two ROV interface instruments to connect borehole sensor or the recorder unit with data acquisition PC through HPD umbilical cable. One ROV interface unit is for connection with LTBMS sensor directly, and another one is for connection with recorder unit. Specification of each instrument is described as follows.

a)Broad-band seismometer (CMG 3T, manufactured by Guralp Systems)

CMG3T has wide dynamic range up to 140dB and wide frequency range from 360s to 50Hz. Our CMG3T is special one that has anti-vibration mechanism and a titanium housing as custom ordered.

b)Volumetric strainmerer (designed by JAMSTEC, assembled by Seismotec Corp.)

Volumetric strainemeter was designed to detect up to nano-order strain variation. The sensing principle of the strainmeter is very similar to that of Sacks-Evertson type volumetric strainmeter that measures volume of squeezed oil filled in a cylindrical sensing volume that respond to ground deformation, that type of strainmeter have been widely used in land borehole.

c)Tiltmeter

A tiltmeter was prepared to collect very low frequency dynamics that cannot be collected by seismometers. The tiltmeter can also be used as a seismometer in high frequency range. The tiltmeter, LILY was manufactured by Applied Geomechanics Inc. LILY is a biaxial bubble-type borehole tiltmeter that can be leveled by centering sensor elements using electric motor up to 10 degrees and has 5 nanoradians resolution over a dynamic range of ±330 microradians.

d)Geophone and accelerometer

Thereee-component geophone and accelerometer are used as motion sensors. The geophone elements, 4.5Hz GS-11D were manufactured by Oyo Geospace. The accelerometer elements, JA-5H200 were manufactured by JAE. Geophone is used as a weak motion sensor. Accelerometer is used as a strong motion sensor. Both sensors were digitized and telemetered by PCBs including 6 channels 24bit sigma-delta A/D converter, CPU board, power supply board and calibration board. PCBs, geophone and accelerometer were installed into one titanium housing. We called this module tiltlogger. Furthermore, thermistor digitizer and tiltmeter was connected with the tiltlogger through electrical cable. Acquired data are merged in CPU board. Therefore, we called sensor package that consists of tiltlogger, tiltmeter and Thermistor digitizer "Tilt combo" module. A schematic drawing of tilt combo module is shown in Fig.2

e)Thermistor array

Thermistor array consists of a digitizer unit and a thermistor string manufactured by Kaiyodenshi Corp. The thermistor string has five thermistors with different intervals along an electrical cable for array monitoring. Thermistors have approximately 2 mk resolution at room temperature (25 degree in Celsius).

To record continuous data, we prepared a repeater and SAM (data recorder). The details of these instruments were described as follows.

f)Repeater (manufactured by Clovertech and Kaiyo-denshi)

A Repeater is an interface instrument to connect LTBMS sensors to recorder unit. The repeater has three UMC hoses to be connected UMC of LTBMS sensors in CORK head. The repeater has some functions includes DC to DC up-converter, RS422 to RS232C serial conversion, switching electrical relays to select on/off of serial line connection or power supply and monitoring power consumption of all sensor unit. Three electrical lines were merged into one line by the repeater.

g)SAM (Recorder) (manufactured by Clovertech and Kaiyo-denshi)

A SAM is a recording instrument for LTBMS sensors. The SAM consists of a titanium sphere pressure housing, printed circuit boards and 52 parallel connected batteries with 27 V and 1520Ah totally. The SAM has 32 GB SDHC media card for recording continuous data of all LTBMS sensors and some serial ports RS232C and RS422 to connect to LTBMS sensors and ROV I/F unit. The SAM has some functions such as to record WIN and GCF packet data to SDHC cards and switching electrical relays to select on/off of serial line connections or power supply.

h) ROV I/F (manuafctured by JAMSTEC)

Two ROV I/F units were prepared. one is units for connection to LTBMS sensor with 7 pins UMC. Another one is for connection to SAM with 9 pin UMC. ROV I/Fs mounted on HPD and connected to penetrators via electrical cables. We can access ROV I/F from a laptop PC in HPD operation container through umbilical cable of HPD with serial data transmission. Two ROV I/Fs have also same shape and functions except for connector. ROV I/F has some function such as switching on/off of power supply and serial connection by electrical relays and to supply some difference voltages by DC to DC converters.

3. MOORING SYSTEM DEPLOYMENTS

We have deployed SAM (data recorder) for long term monitoring, Repeater and the Battery instruments by the mooring system for the Long Term Borehole Monitoring System (LTBMS). The schematic drawing of the mooring system during KY11-09 is shown in the Figure 2. The deployment procedures of the mooring system from the upper deck are follows: 1) tighten the mooring system from the top buoy to the transponder to the hand rail with the ropes; 2) deploy the anchors by using the transponder davit and fasten to the cleat nearby; 3) deploy the mooring system from the top buoy to the transponder for their towing; 4) pick up the instruments (SAM, Repeater and Battery) to the outside through the transponder davit with Sea catcher for release; 5) loosen the rope fastening the anchors to the cleat and move their own weight to the instruments; 6) reel out the transponder davit winch and release the instruments through Sea catcher. Figure 3 shows the mooring system deployment procedure.

The SAM (data recorder) for long term monitoring and Repeater were deployed at 23 of July. Figures 4-A and 4-B show the deployed instruments from the upper deck of R/V Kaiyo. The target site is C0002G where the first LTBMS were installed by D/V CHIKYU during IODP Expedition 332 last December. After arriving around Site C0002G at 9:00 the swell was still high (about 3.5m high) due to the typhoon, we stayed at the site for the deployments. At 14:54 the SAM for long term monitoring was deployed by the mooring system on the upper deck. The deployment position (~300m east form the site) was determined after the current survey around the target site. The SAM drifted to the ENE direction and the difference between the deployed and settled position was ~220m due to the strong sea current. At 15:56 the Repeater was deployed by the mooring system. The deployment position was adjusted by considering the first run of the mooring system. The SAM and Repeater were launched from the upper deck, and then sink to seafloor by self-weight. The settled positions were estimated by the SSBL positioning. The sinkers were released by the acoustic command from the ship and the mooring systems from the top buoy to the transponder were recovered on working deck by using the front provision davit at the port side of the R/V Kaiyo. The Figure 5 illustrates the recovery of the mooring system procedure and the photos of the recovered on the working deck. The deployed and settled instruments positions by the mooring system are plotted over the bathymetric map in the Figure 6 and summarized in Table 1.

After the HPD operation at 30 of July, we have deployed the Battery instrument (Figure 4-C) at 17:02 thorough the same operation procedure. The Battery drifted to the East direction and the difference between the deployed and settled position was ~300m.

The drifted distance was longer than the others due to the strong sea current (~4 knot) around the site. The sinking rate was 89.4m/min. The settled position was estimated by the SSBL positioning and the battery was settled at ~140m south of the target site (Figure 6 and Table-1). Then the sinkers were released at 17:30 the mooring system from the top buoy to the transponder was recovered on working deck by using the front provision davit at the port side. SAM for short term monitoring (Figure 4-D) was not deployed during the cruise because of the ship time reduction due to the strong typhoon.

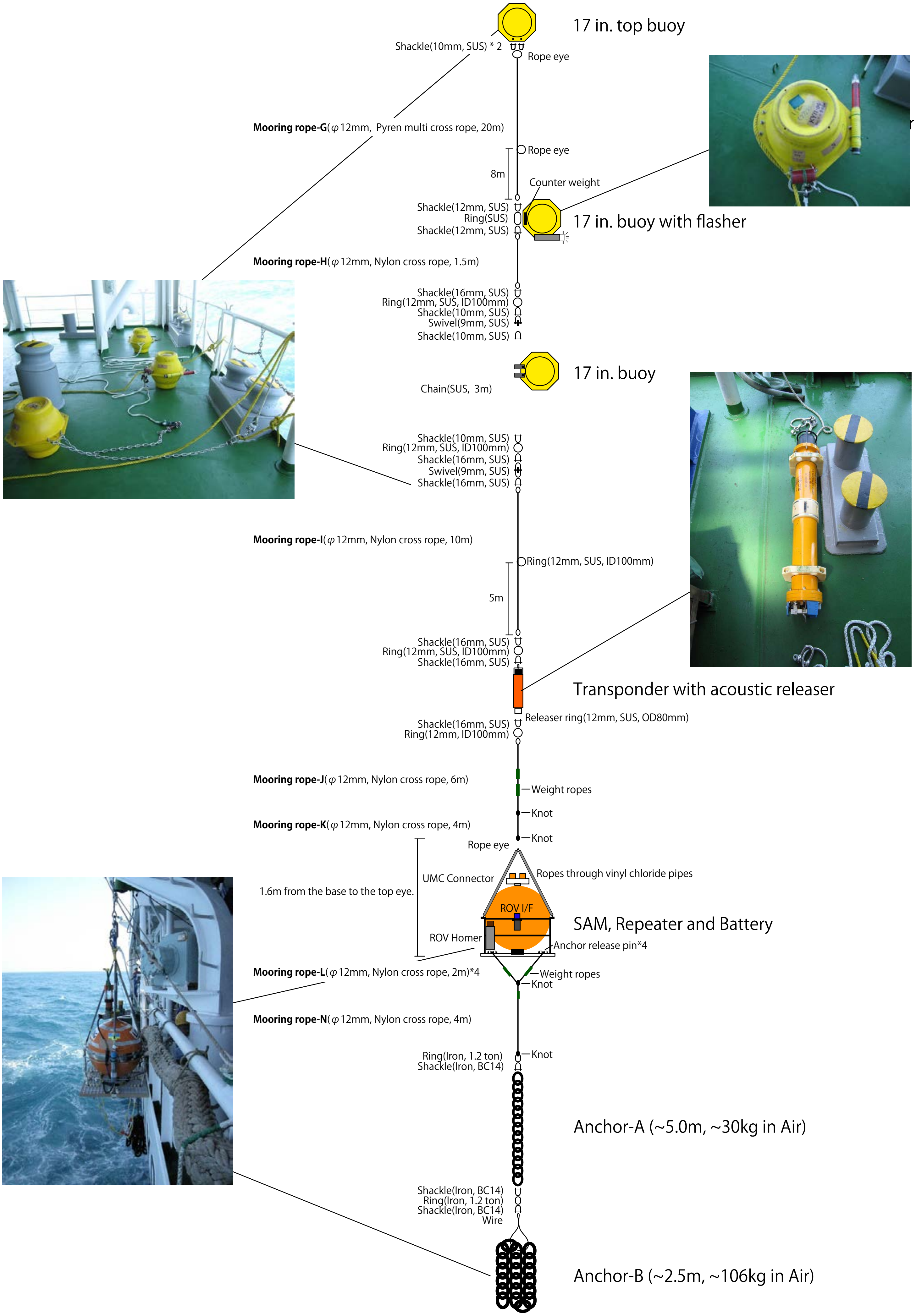
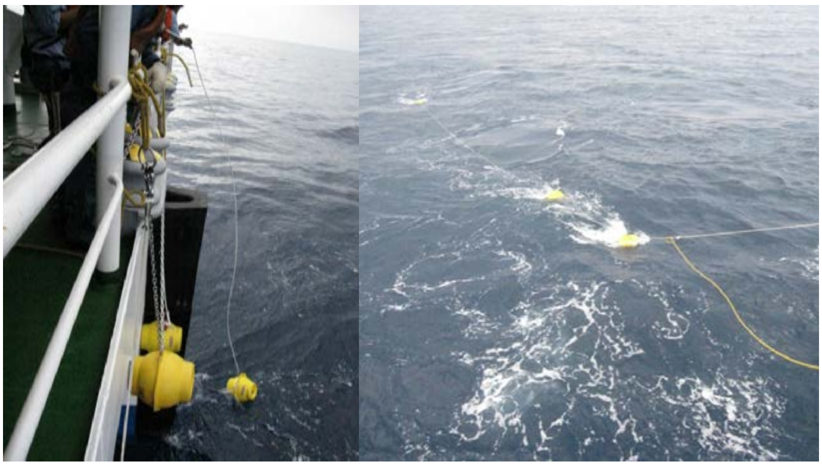


Figure 2 The schematic drawing of the mooring system during the KY11-09

1) Tighten the mooring system from the top buoy to the transponder to the hand rail with the ropes.

2) Deploy the anchors by using the transponder davit and fasten to the cleat nearby.



3) Deploy the mooring system from the top buoy to the transponder for their towing.

4) Pick up the instruments (SAM, Repeater and Battery) to the outside through the transponder davit with Sea catcher for release.

5) Loosen the rope fastening the anchors to the cleat and move their own weight to the instruments.

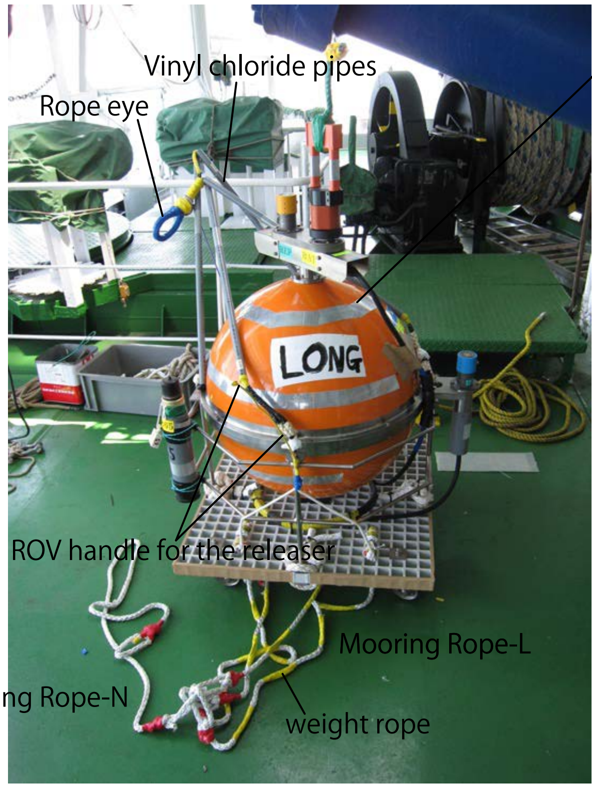
6) Reel out the transponder davit winch and release the instruments through Sea catcher.

Figure 3. The mooring system deployments procedure during the KY11-09

UMC connectors
Left: Male connector for the battery
Right: Female connector for the Repeater

Connecotrs for the deployment

ROV Homer (ID: 65)



SAM for long term monitoring

Female UMC for the ROV I/F

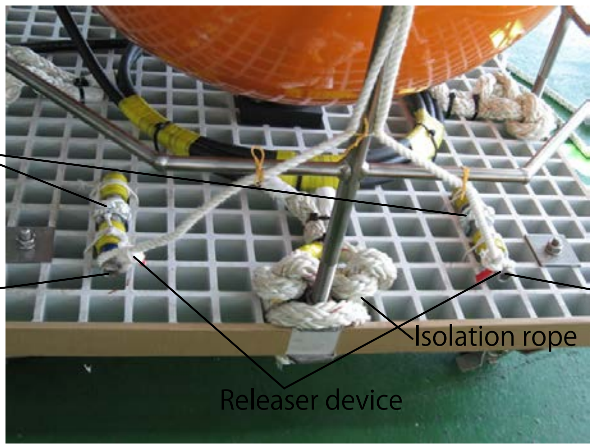
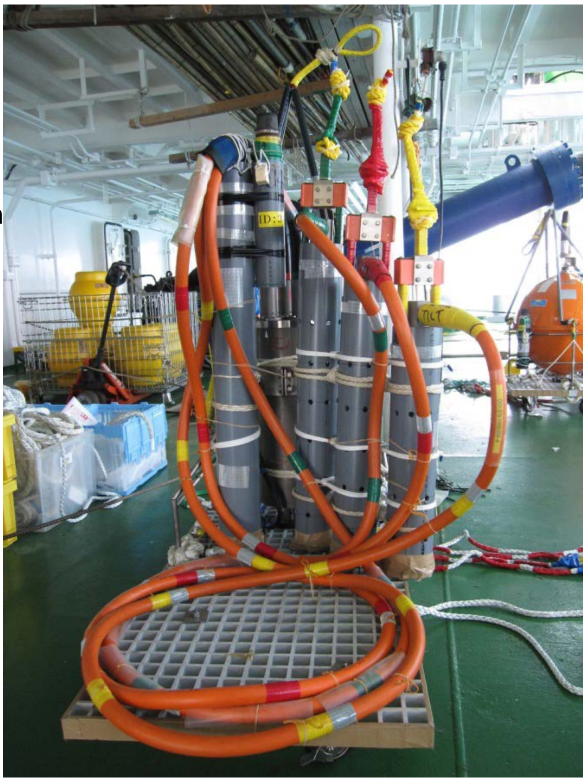
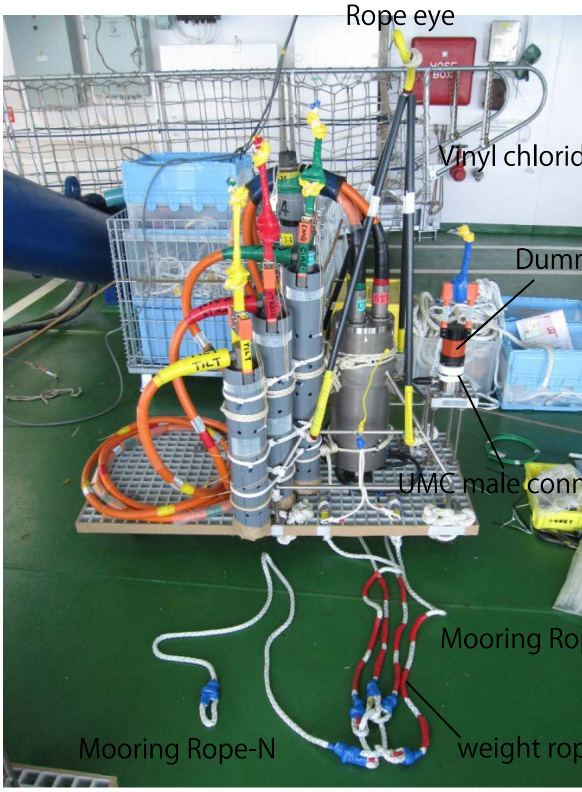


Figure 4-A Photos of the SAM for long term monitoring deployed by mooring system during the KY11-09

UMC connectors
Yellow: Male connector for the Tilt Combo
Red: Male connector for the Strainmeter
Green: Male connector for the CMG(Broad band seismometer)



Fastened ODI Cables (5m)



Repeater for long term borehole sensors

Figure 4-B Photos of the Repeater deployed by mooring system during the KY11-09

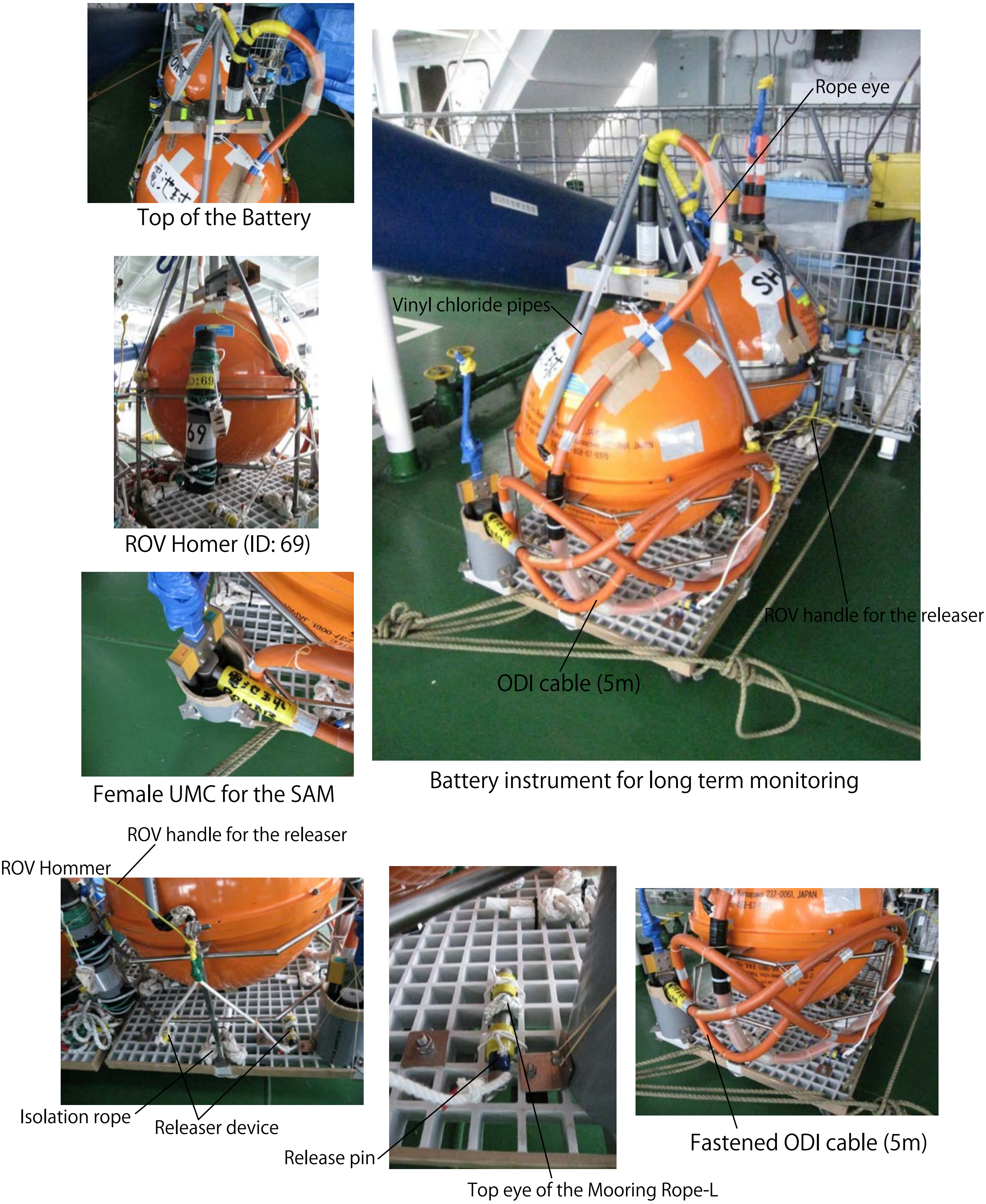
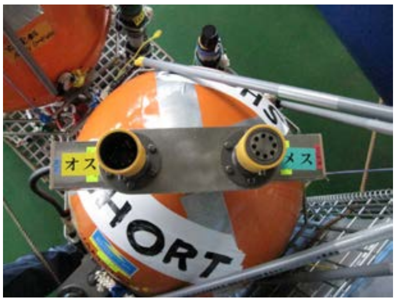
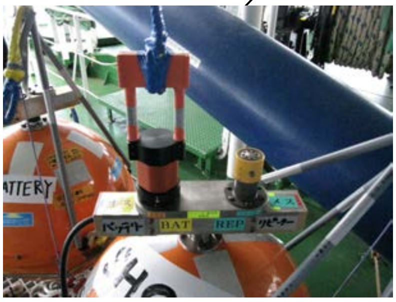


Figure 4-C Photos of the Battery instrument deployed by mooring system during the KY11-09

UMC connectors
Left: Male connector for the battery
Right: Female connector for the Repeater





SAM for short term monitoring

ROV Homer (ID: 17)

Female UMC for the ROV I/F

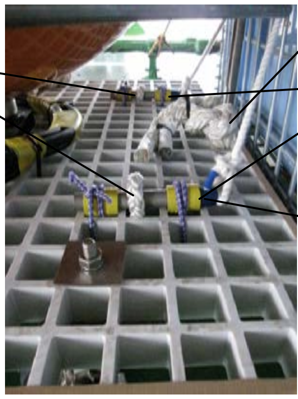


Figure 4-D Photos of the SAM for short term monitoring deployed by mooring system during the KY11-09

1) Founded bbuoys for picking up in the front side of the ship.

3) Recover the transponder with releaser.

2) Picking up the buoys using the crane on the working deck at the port side.

4) Recovered the mooring system from the top buoy to the transponder.

Figure 5 The recovery of the mooring system during the KY11-09.

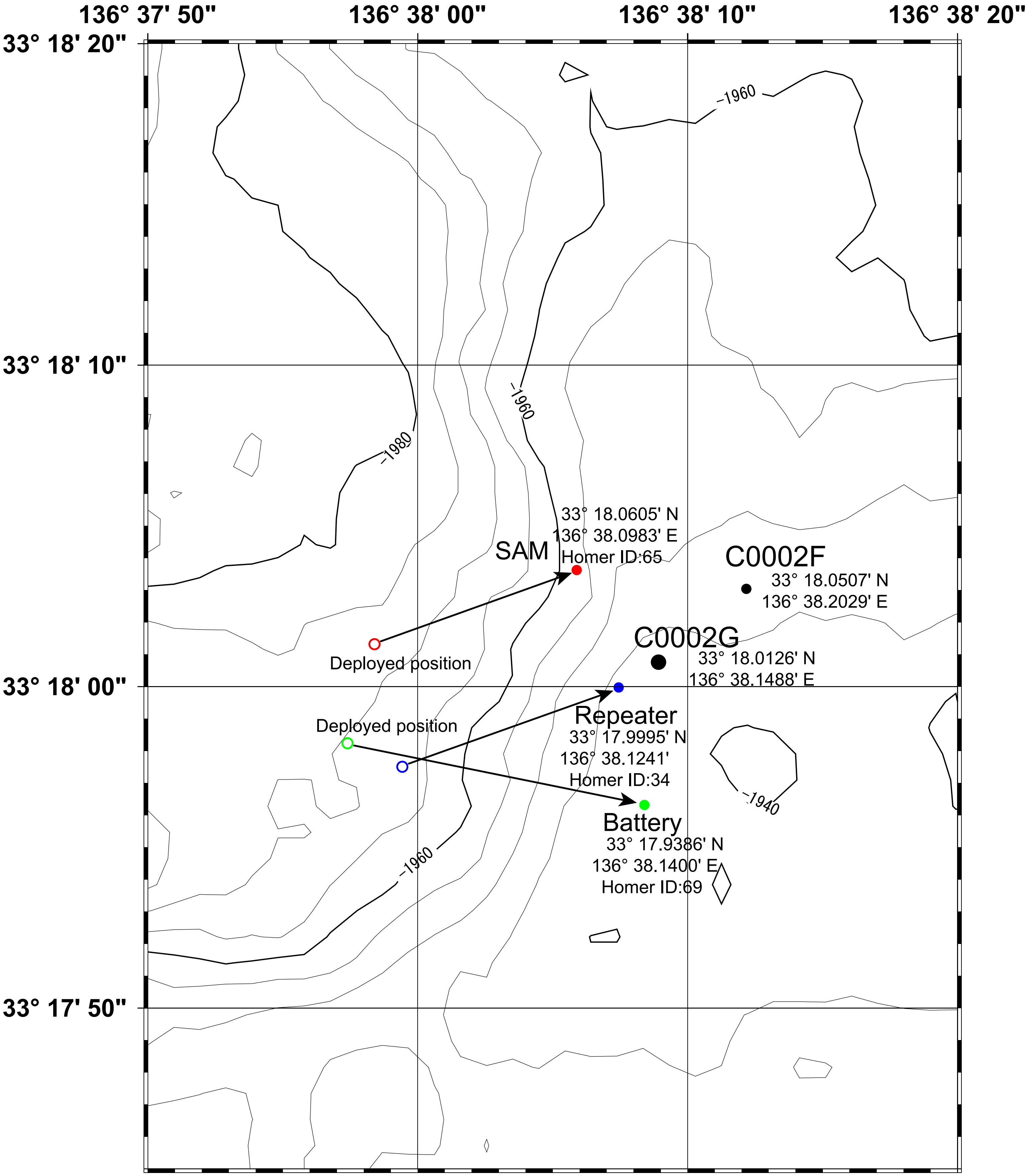


Figure 6. The deployed and settled instruments positions by the mooring system shown over the bathymetric map.

Table-1 Deployed and estimated position of the Instruments for Long Term Borehole Monitoring

No.	Instrument	Deployed position (WGS84)					Estimated settled position (WGS-84)					Homer ID
		Day	Time	Latitude	Longitude	Depth	Day	Time	Latitude	Longitude	Depth	
1	SAM (for long term monitoring)	7/23	14:54:42	33°18.0219′N	136°37.9732′E	1967m	7/23	15:13:55	33°18.0605′N	136°38.0983′E	1948m	65
2	Repeater	7/23	15:56:58	33°17.9585'N	136°37.9905′E	1968m	7/23	16:19:02	33°17.9995′N	136°38.1241′E	1935m	34
3	Battery instrument	7/30	17:02:49	33°17.9706'N	136°37.9566′E	1975m	7/30	17:22:33	33°17.9386′N	136°38.1400′E	1937m	69

4. ROV "HYPER DOLPHIN" DIVE TO SITE C0002G FOR DATA ACQUISITION ACQUISITION

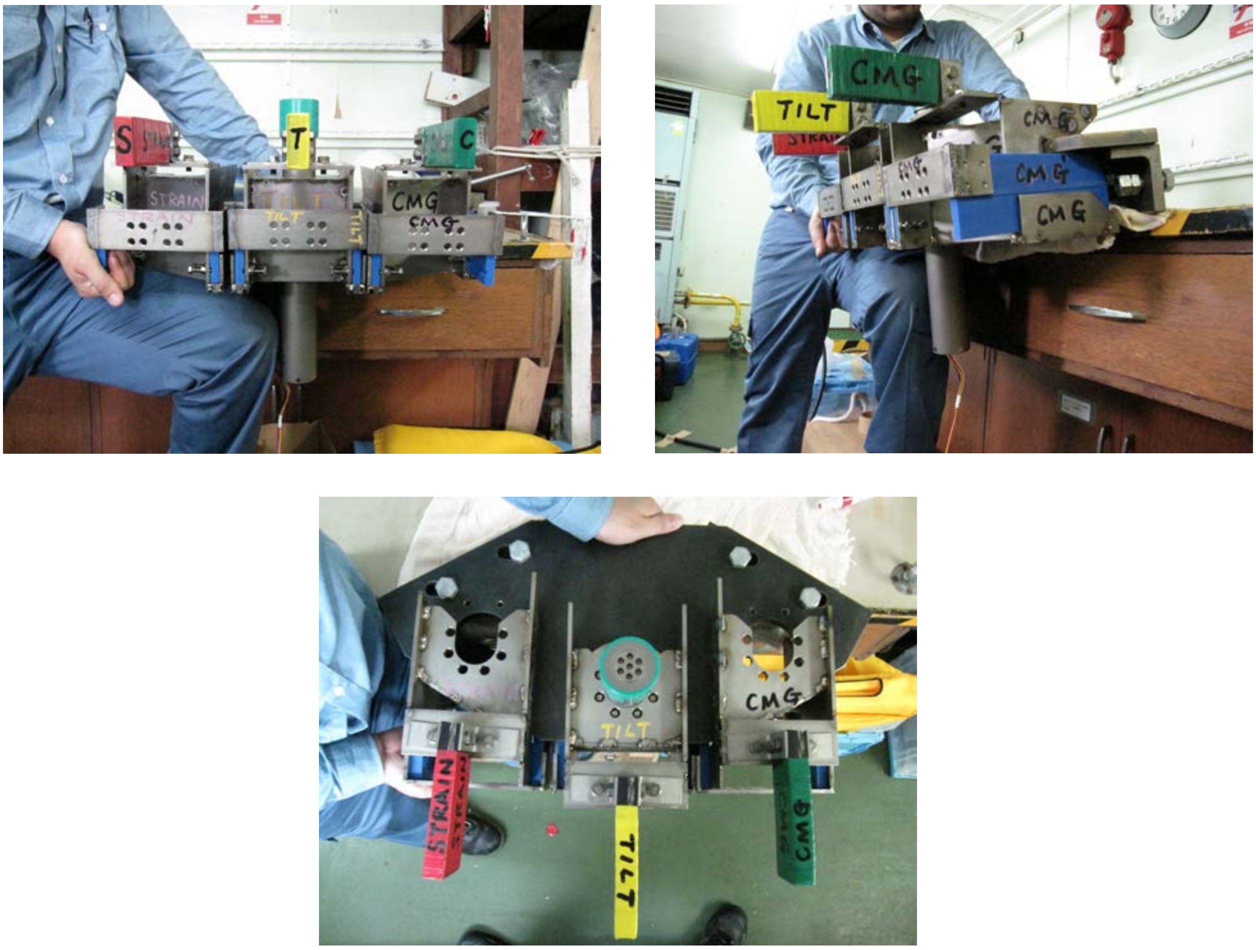
After the dive for the DONET operation at the 31 of July, the payload for the LTBMS operation was installed on the ROV Hyper Dolphin (HPD). Two type of the ROV I/F equipments for the LTMS sensors and SAM were mounted on the HPD. The communication tests were conducted using loop back connectors, HPD umbilical cables and HPD junction box. 15m ODI cable with the connectors at both ends, three connector protectors, connecters cover for the CMG and mantid cutter were set on the sample basket in front of the HPD. The left manipulator was adjusted the height to 870mm from the ground level for the secure handling of the UMC connectors against the connector damages. Also, the motorbike tire was attached the bottom of the HPD to avoid slipping on the ROV platform at the Site C0002G.

Hyper Dolphin dove to the Site C0002G at the 1st of August, although the dive was 1 hour delayed due to the swells caused by typhoon and the strong sea current (~4knots). The planned operation procedure during the dive was follows: 1) check the seafloor around the Site C0002G; 2) remove the connectors cover; 3) attach the connector protectors for Tilt-comb., strain and broad band seismometers respectively after checking the borehole sensor connectors; 4) connect ROV I/F to the borehole sensors which the connector protectors are attached and check the sensor status and function; 6) data acquisition of the sensors. 7) Check pressure logger equipment and valves bay; 8) check the ROV homer communication from the HPD to the deployed Repeater, SAM and Battery instrument. The operation from 4) to 6) is conducted in the order of the strainmeter, tilt combo. and CMG.

During the LTBMS installation into the borehole last December, one of the UMC connectors (CMG; broad band seismometer) was detached from the connector base plate on the CORK Head because of the difficultly in the ROV operation at such a connector height. We adjusted the manipulator height for the connection and also the connector protect tools were tried to be attached to the all of the borehole sensors for reducing the further damage of the connector during their connection by ROV. During the first dive of the HPD the connector protectors for the tilt combo. and strainmeter were successfully attached to their UMC connectors on the CORK Head (Figure 7). For the CMG connector, unfortunately the protector was not attached because the detached connector was not down to the initial position for the protector attachments although we tried the several ways. Then, we decided to proceed to the next step, ROV IF connection to the sensors without CMG. The further developed protector tools and/or the connection method (e.g. use of the protector tools, the interface cable connectors and

etc.) for reducing any damage risk are needed for the CMG sensor connection by ROV.
After connector protect tool attached, data download was carried out using ROV I/F. A schematic drawing of instruments connection is shown in Figure.8. We could not attach protector tool for CMG connector, so we accessed to only strainmeter and tilt combo to download data. After connecting ROV I/F to sensors (Figure.9), data download was carried out according to the following procedures. 1) starting the terminal software (console_borehole) on Linux laptop PC 2) connect science console panel with Laptop PC by serial cable. 3) starting 24V power supply from HPD 4) confirm startup characters transmitted from ROV I/F unit 5) transmit g and boot ROV I/F unit 6) powerup ROV I/.F unit by rov_powerup command 7) change voltage by rov_midvolt to 24V 8) activate serial and power connection by rov_connect. 9) confirm startup characters transmitted from sensors. 10) start checking procedure for sensor health check and continuous data recording. 11) after recording, disconnect power supply by ROV I/F rov_exit command. 12) Power down by HPD and disconnect UMC of ROV I/F from sensors.
As a result of data recording, we confirmed that strainmeter and tilt combo has no problem. Finally, we collect 30 minute continuous data of straineter and 1 hour continuous data of tilt combo including tiltmeter, geophone accelerometer and thermometer. After data download, UMC of ROV I/F was disconnected. Before HPD left ROV platform, we confirmed the situation of pressure bay (Figure.10). We also confirmed that homer responses from SAM (Homer ID 65), repeater (Homer ID 34) and battery (Homer ID 69) were 91.5m, 36.1m, 108.9m respectively. After HPD left ROV platform, we confirmed seafloor around ROV platform to consider deployment place for instruments (Figure.11). We confirmed that repeater deployed by mooring system was deployed on seafloor successfully (Figure.12).

(1) Connector protector tools



(2) Connector protector tools attachment

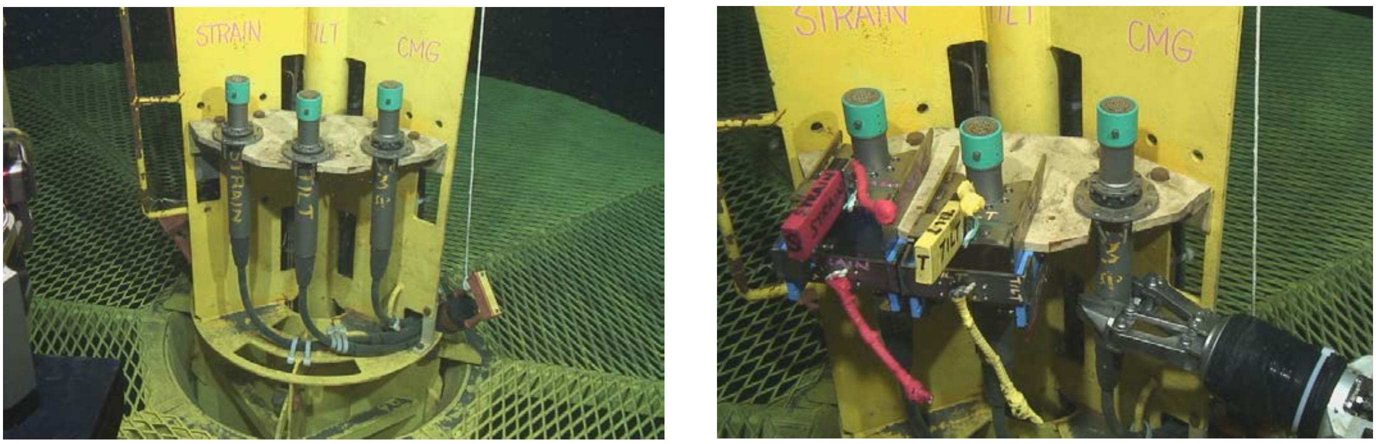


Figure 7 The attachment of the connector protector tools for the LTBMS sensors.

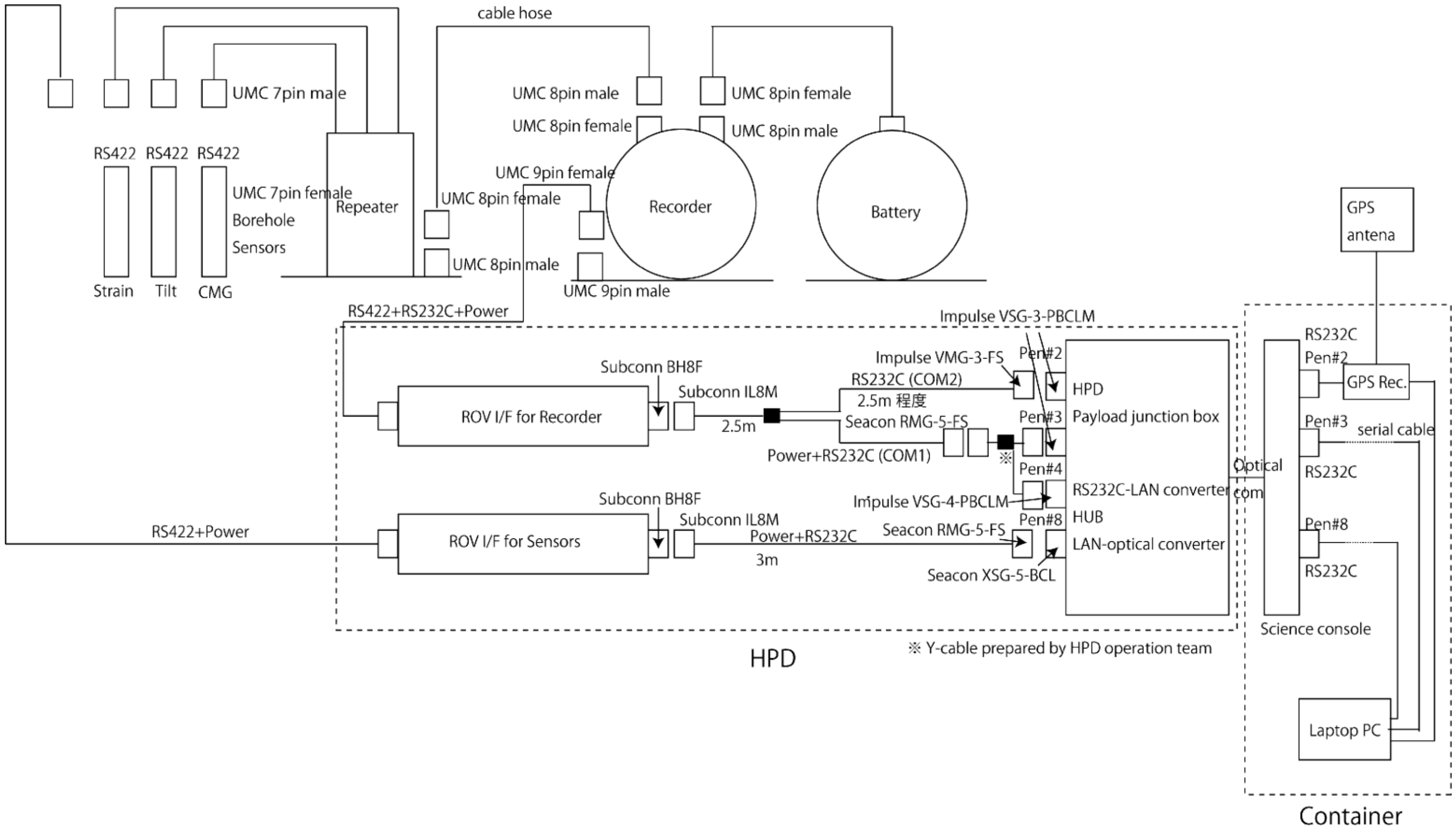


Figure.8 A schematic drawing of connection of instruments for HPD operation.

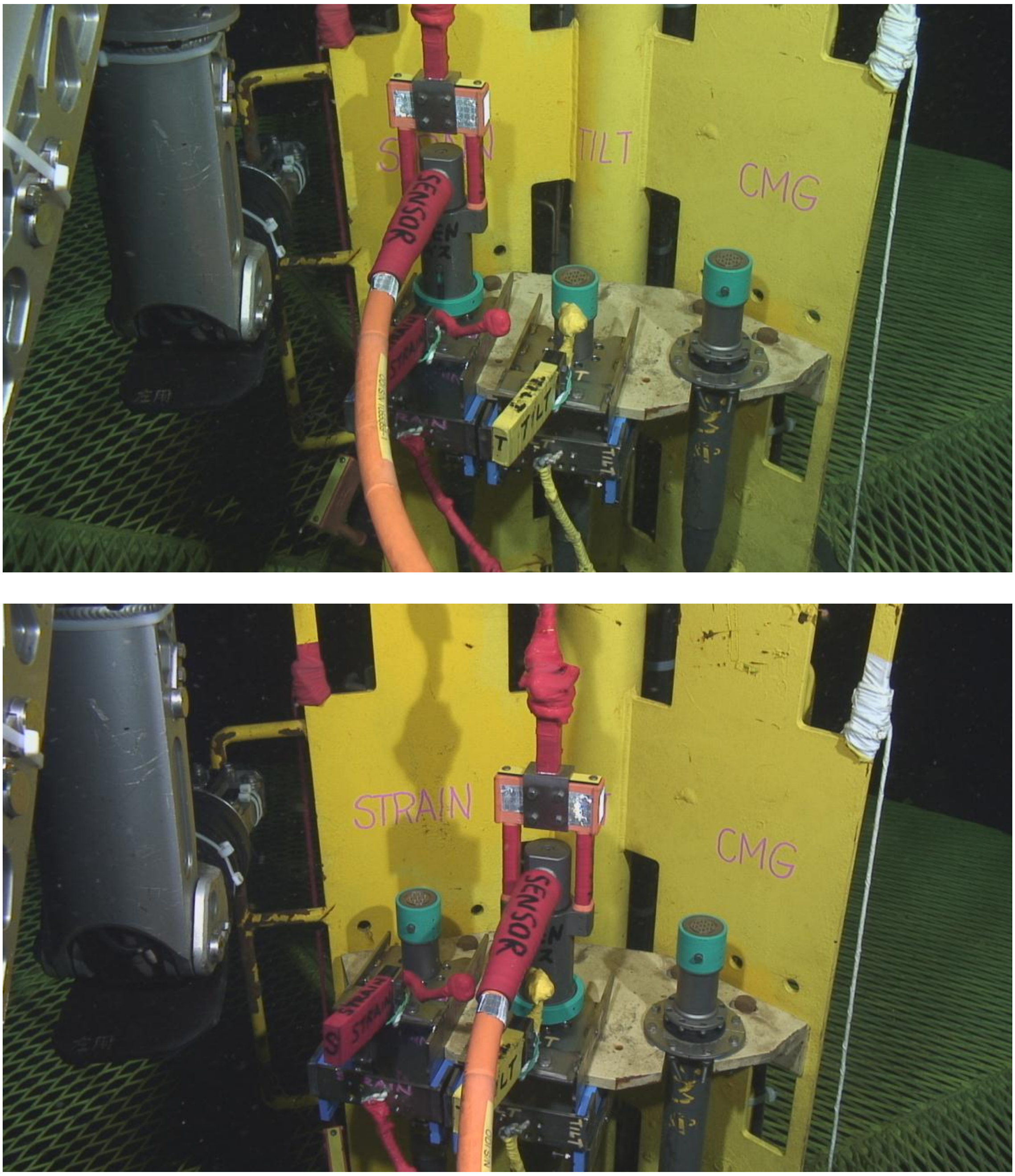


Figure.9 Photos of ROV I/F connection to strainmeter (top) and tilt combo (bottom).

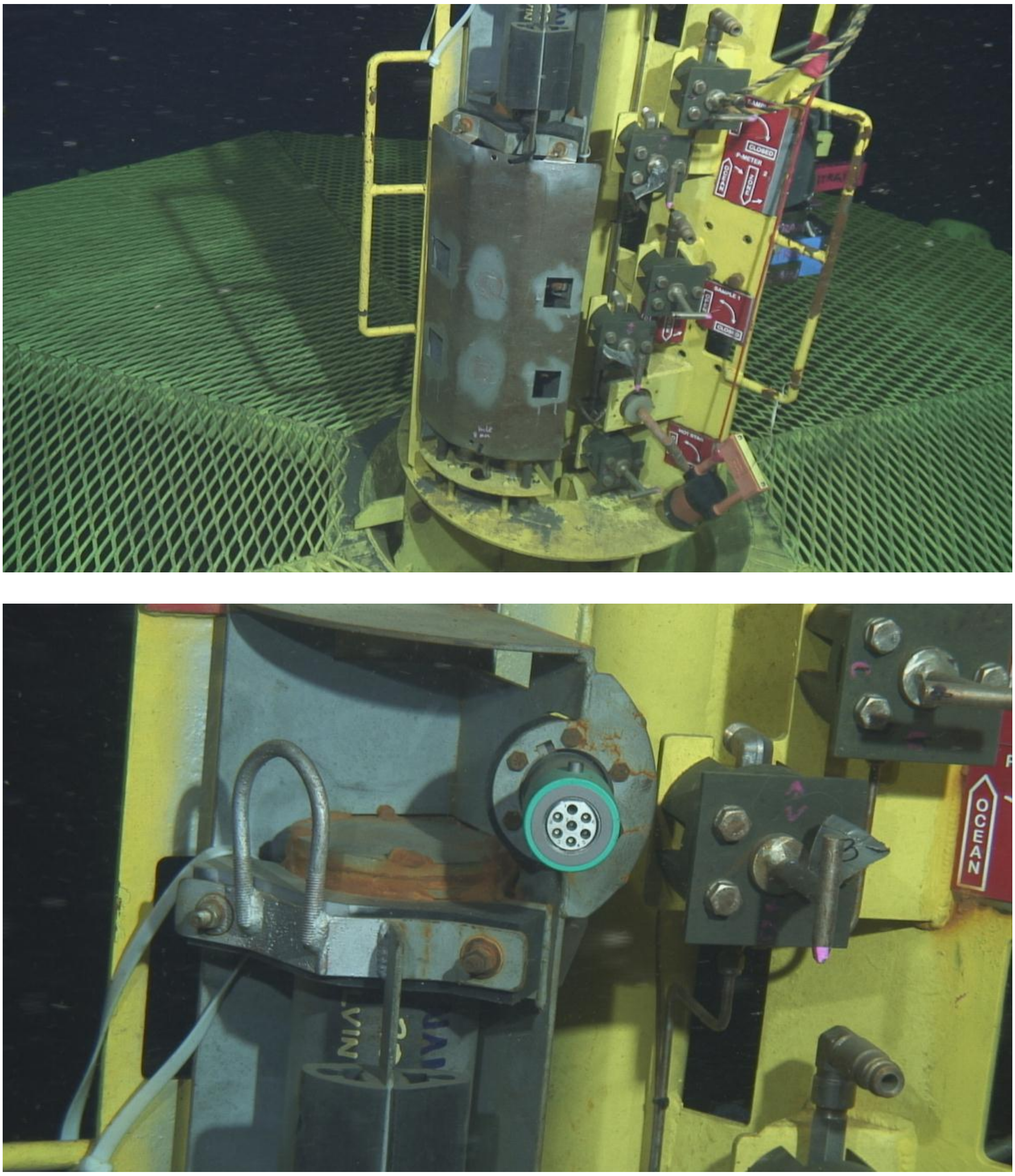


Figure.10 Photos of pressure bay on CORK head.

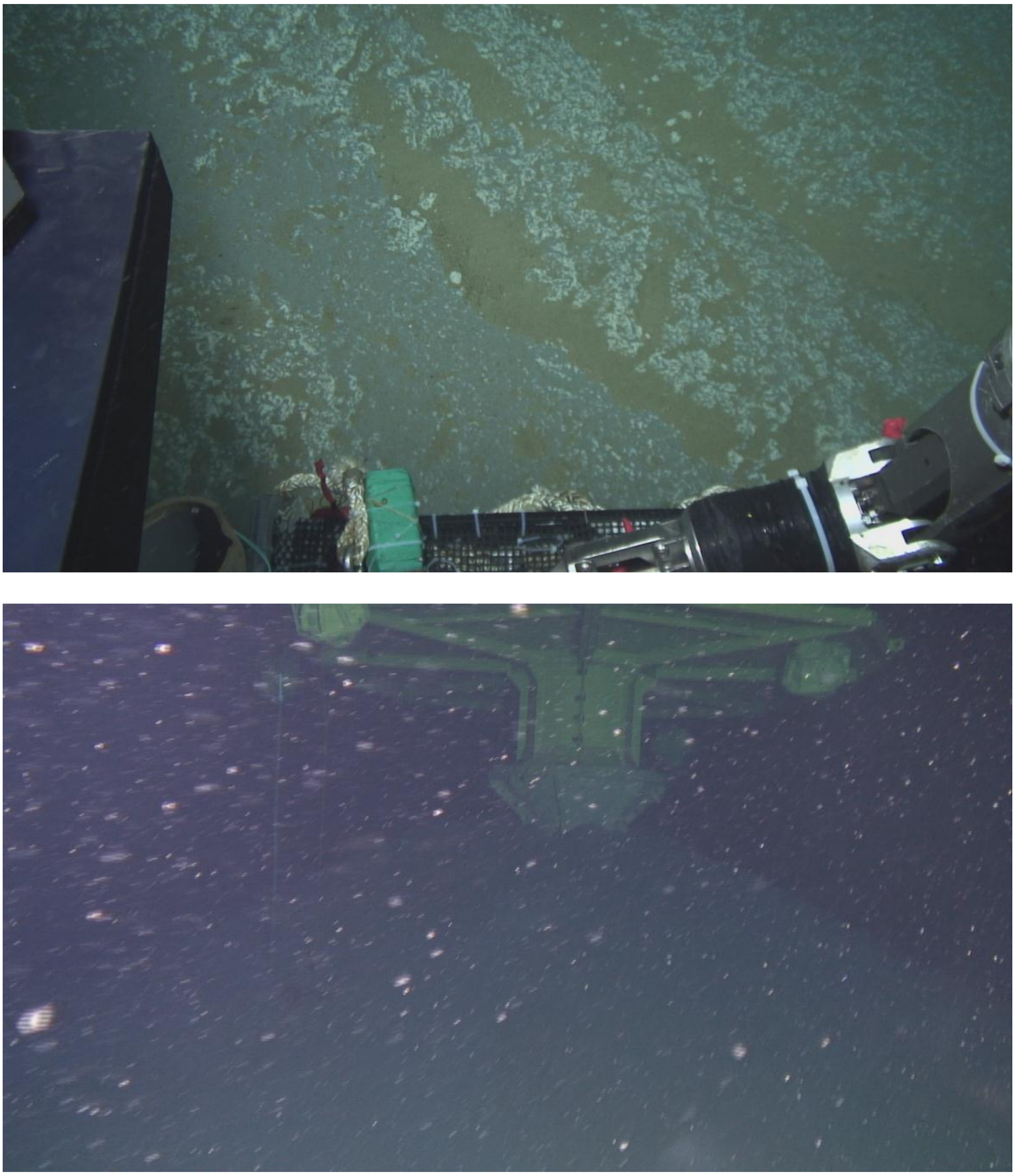


Figure.11 Photos of seafloor under ROV platform.

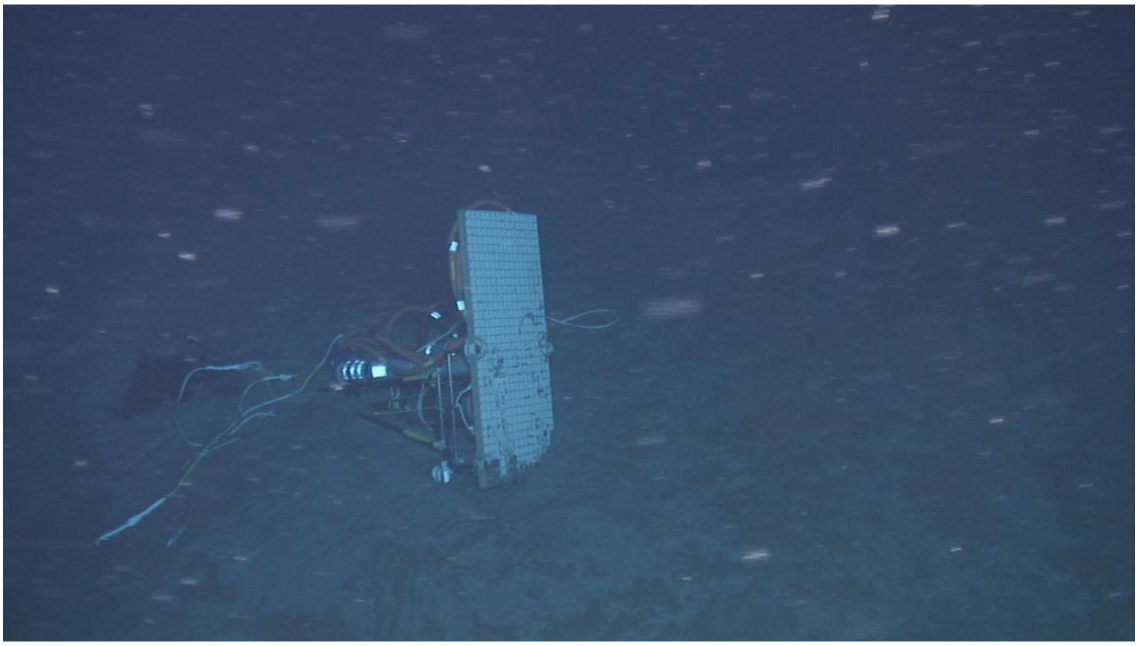


Figure.12 Photo of Repeater on seafloor after deployed by mooring system.