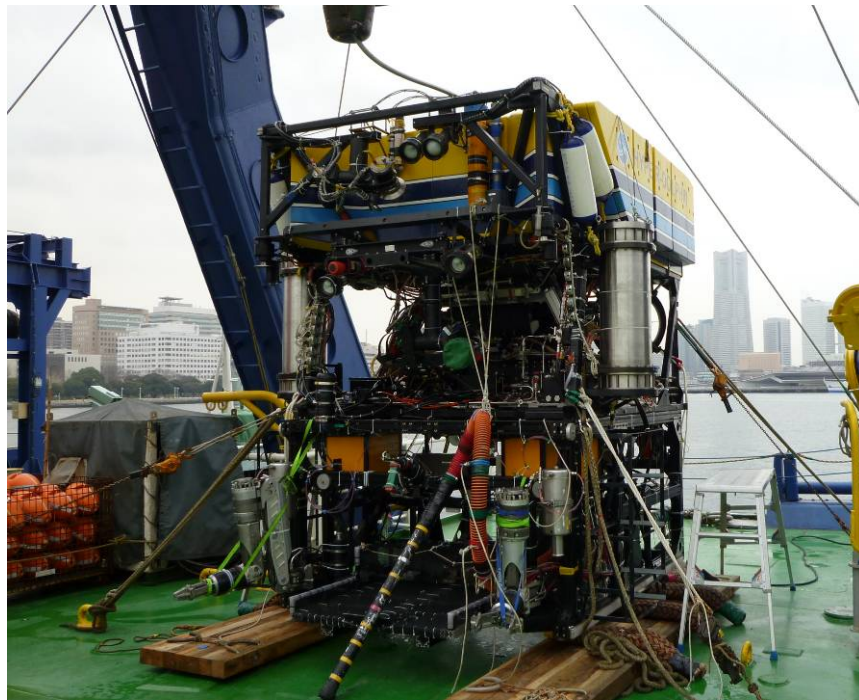


CRUISE REPORT

KY11-03

“Hyper-Dolphin” & “Kaiyo”



March 2011

Earthquake and Tsunami Research Project
for Disaster Prevention

JAMSTEC

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1. Introduction

Japan has started installing the offshore cabled observatories for disaster mitigation purposes since late 1970s. Seven cabled observatories have been deployed around Japan, in particular along the Pacific Rim, and brought us invaluable information. For example, the 2003 Tokachi-oki earthquake of M8.0, seafloor phenomena such as a generation process of tsunami, seafloor uplifts, etc., were observed (Mikada et al, 2006). At the 2004 off Kii peninsula earthquake of 7.4, the offshore observatory could detect tsunami 20 min before its arrival at the nearest coast (Matsumoto and Mikada, 2005).

Since 2006, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has started to develop a new dense observatory network system by using submarine cable off Kii-peninsula, where the last mega-thrust earthquake named Tonankai earthquake occurred in 1944. The Headquarters for Earthquake Research Promotion in the Ministry of Education, Culture, Sports, Science and Technology (MEXT), i.e., the Japanese government has estimated that the probability of the next Tonankai earthquake is 60 to 70 % in the next 30 years and more than 90 % in the next 50 years, because the recurrent interval of the plate boundary earthquake is approximately 100 to 150 years along the Nankai trough. Thus, the offshore seismic monitoring system for the forthcoming Tonankai earthquake is urgently needed to mitigate future disasters from the earthquake and resulting tsunami.

The system to be developed consists of twenty observatories containing seismometers, tsunami meters, and other geophysical sensors covering the expected Tonankai earthquake source region in order to monitor both long-term seismic activities and mega-thrust earthquake and tsunami. Our goals are to accomplish high precision earthquake prediction modeling, to detect precursory prior to the mega-thrust earthquake, and to contribute to mitigate disaster caused by the earthquake and the tsunami by providing the information before their arrivals.

The first DONET science node and observatory was established at A-3 location by using ROV "Hyper-Dolphin" during NT10-04 expedition on March 2010. The following surveys were done on May, October and December 2010 by NT10-09, NT10-18 and KY10-15, which installed all science nodes and developed eight observatories on the seafloor.

The present KY11-03 expedition is the second survey by R/V "Kaiyo" and 4500 meters class ROV "Hyper-Dolphin" operation. And it aims to increase observatories to connect science node and observatories by extension cable, and to deploy more observatories to round out the original observatory network layout as shown in Fig. 1.1.

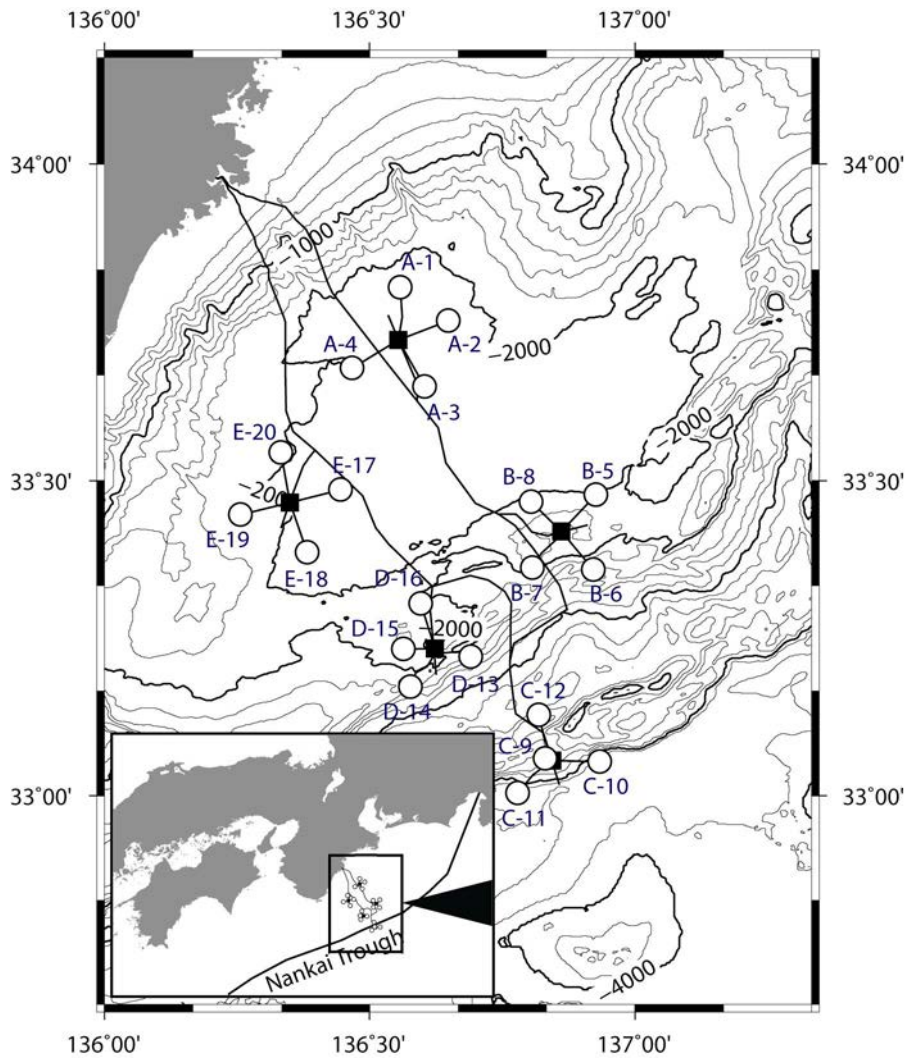


Fig. 1.1 Map showing DONET observatory to be deployed in the Nankai trough. Open circles and square dots represent the observatories and the science nodes, respectively, which are connected by submarine cable.

2. Schedule

The KY11-03 expedition is to conduct the following operations.

- (1) Observatory installation operation
- (2) Extension cable laying operation between the science node and the observatory
- (3) Burial hole conditioning operation
- (4) Backfilling burial hole operation

Actual schedule of the KY11-03 expedition is summarized in Table 2.1. Our expedition started from Yamashita Berth at Yokohama port to JAMSTEC via Kumano-nada. Eleven dives have been carried out as initially planned.

Table 2.1 Summary of the KY11-03 expedition

Date	HPD Dive	Location	Operation	Remarks
02 March			Departure	8:00 departed
03 March	#1251	C-9c	Burial hole conditioning	6 sand bags (12 bags in total) deployed
04 March	#1252	E-20b	Burial hole observation	Shift to E-20 due to the bad weather at B-5
05 March	#1253	C-9c	Extension cable laying	
06 March	#1254	B-5b	Extension cable laying and observatory boot-up	
07 March			Evading navigation	
08 March	#1255	A-1	Extension cable laying	Interrupted due to trouble on the cable laying system
09 March			Evading navigation	
10 March	#1256	C-9c	Observatory installation and boot-up	
11 March	#1257	D-14	Burial hole conditioning	

12 March	#1258	A-1	Extension cable laying	Recovering cable bobbin due to the cable laying system accident
13 March	#1259	D-14	Extension cable laying	
14 March	#1260	D-14	Observatory installation and boot up	
15 March	#1261	A-3	Backfilling operation by "Sand Feeder"	ROV-Homer recovered
16 March			Shift to Yokosuka	
17 March			Arrive at JAMSTEC	Arrived at 9:00

3. “Hyper-Dolphin” Dive

(1) Dive 1251 on 03 March

This dive was carried out the burial hole conditioning at C-9 observatory again, which was suspended in the last KY10-15 expedition. The bottom condition is known as high viscosity mud after the previous KY10-15 expedition, hence mixture tool was prepared (Fig. 3.1). After about three hours operation, burial hole conditioning has been completed.

After burial hole conditioning, six sand bags were deployed at the point of cable bobbin deployment (Fig 3.2). This is because the tilt of the C-9 observatory is relatively large, therefore the cable bobbin should be kept not rotated.

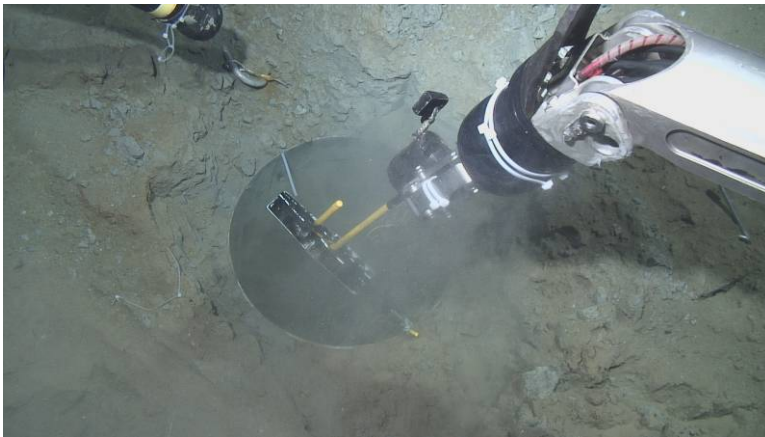


Fig 3.1 Mixture tool



Fig 3.2 Sand bags deployed near the C-9 observatory

(2) Dive 1252 on 04 March

The 1252 dive aimed to observe the bottom casing at E-20 observatory deployed KY10-03 and KY10-07 expeditions. There are two candidates to be constructed as DONET observatory at E-20 observatory. Hyper-Dolphin approached E-20b' first, which cannot be used because the bottom casing was broken (Fig. 3.3). ROV-Homer nearby was recovered.



Fig. 3.3 Bottom casing at E-20b'

Then Hyper-Dolphin approached E-20b. When the bottom casing was deployed at E-20b, the top was not penetrated under the ocean-bottom from the acoustic signal. Actually, the bottom casing is raised 35 cm from the ocean bottom. Tilt measurement was carried out, which shows that the tile is within 10 degrees. ROV-Homer of ID 69 has been deployed again nearby. The location of E-20b is as follows; [33-33.0238N](#), [136-19.8438E](#), [D=1969m](#).



Fig. 3.4 Status of bottom casing at E-20b

(3) Dive 1253 on 05 March

The 1253 dive is to be deployed extension cable between the science node C and the C-9 observatory. The C-9 observatory is located 1.2 km from the node C. This is why the operation time was a few hours, which is relatively short compared to other observatories. Because the observatory has not been installed yet, only extension cable has been deployed in this dive.

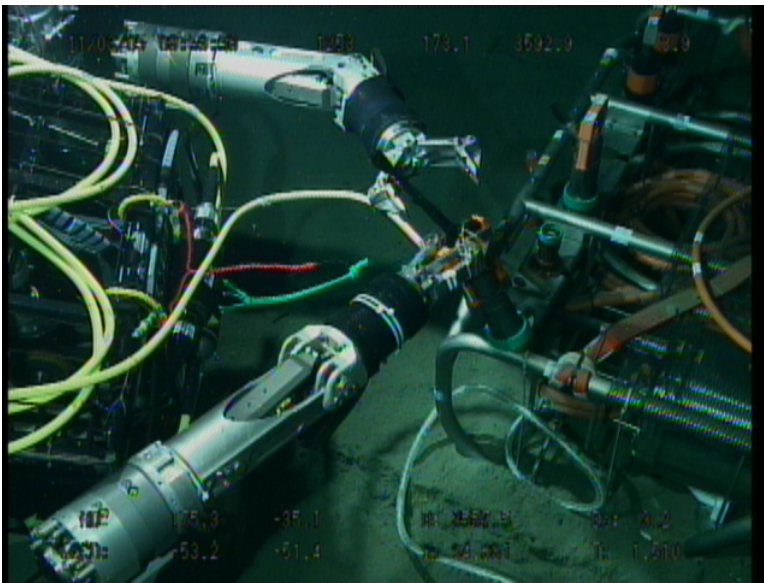


Fig. 3.5 Cable-end connected to **node C No.1 port**

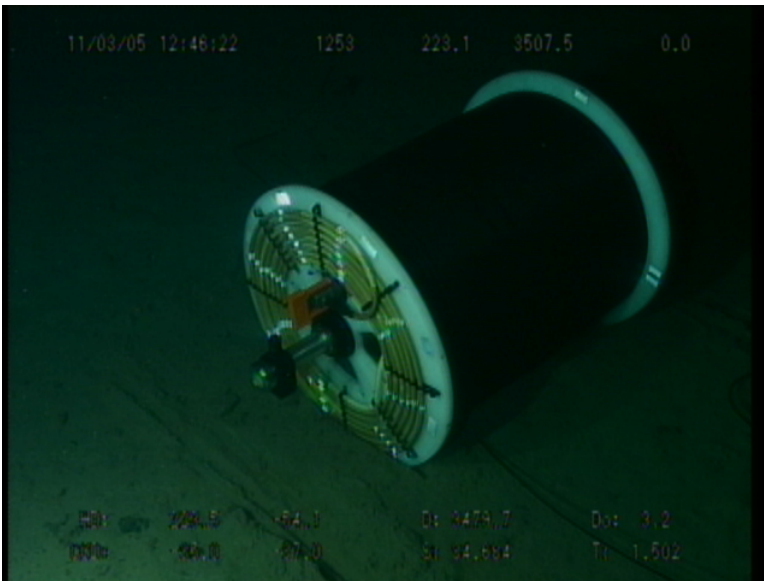


Fig 3.6 Cable bobbin deployed at C-9 observatory

(4) Dive 1254 on 06 March

In the 1254 dive, an extension cable laying operation has been carried out between the science node B and the observatory B-5. The observatory has been installed in the KY10-15 expedition, so new observatory has been boot up after the present dive. After connecting to the observatory, and the boot up of the observatory was confirmed from the Furue landing station. This is the ninth observatory of DONET. B-5 observatory position is measured to be $33-28.6364N, 136-55.6014E, D=1993m$ by the “Hyper-Dolphin”.

The science node interface is used at **node B No. 8 port** and the extension cable is used with **No. 7 cable** colored by blue.



Fig. 3.7 Extension cable interface connecting **node B No.8 port**

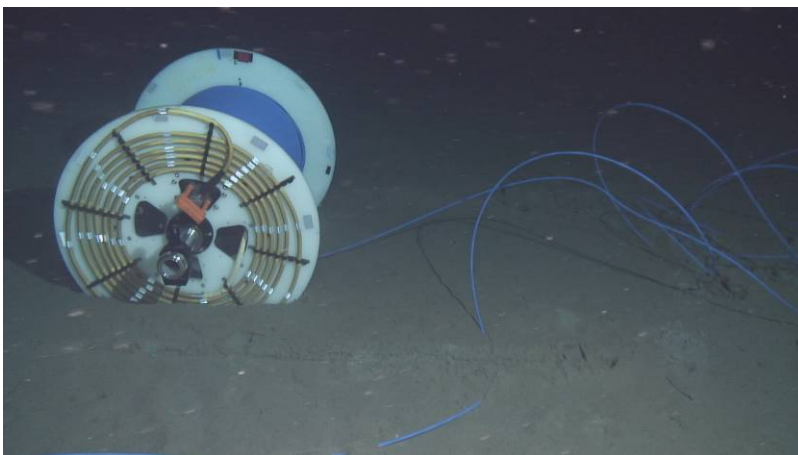


Fig. 3.8 Cable bobbin deployed near the observatory B-5

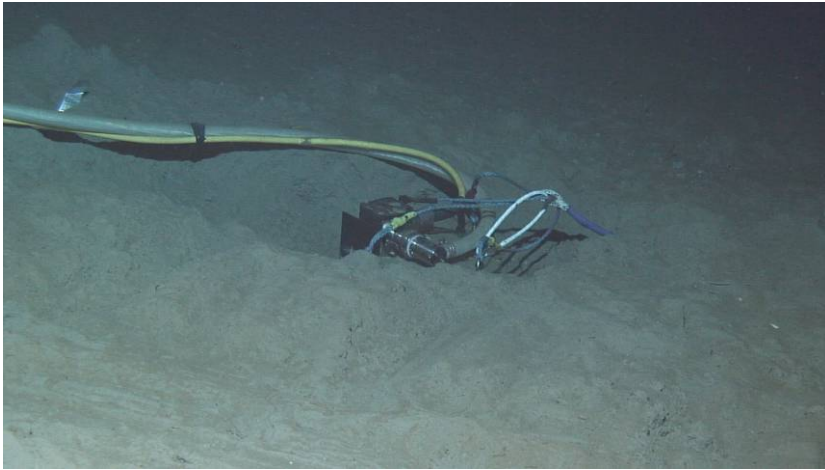


Fig. 3.9 View of observatory (ground motion sensing system) of B-5 observatory

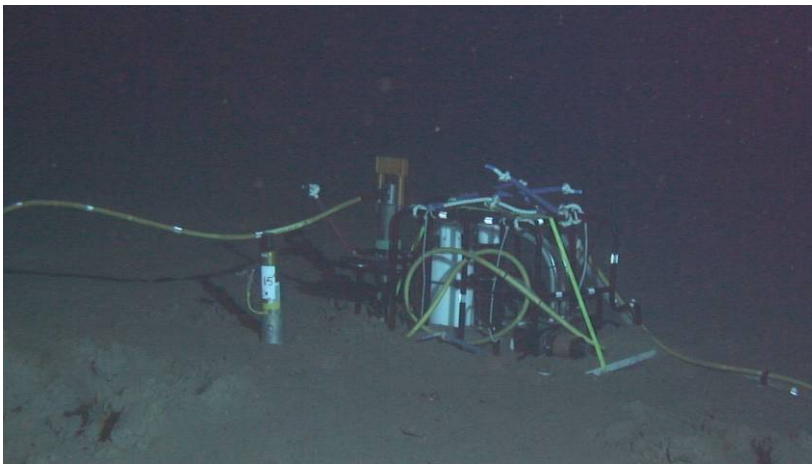


Fig. 3.10 View of the observatory (pressure sensing system) of B-5 observatory

(5) Dive 1255 on 08 March

The 1255 dive was to re-start extension cable laying after confirmation of the route safety by KY11-02 expedition, but some accidents occurred with the cable bobbin elevator. After the dive, Hyper-Dolphin hang-up extension cable bobbin once, but the cable bobbin could not be held properly. We had to deploy extension cable bobbin again at the same location (but about 15 meters proceeded).

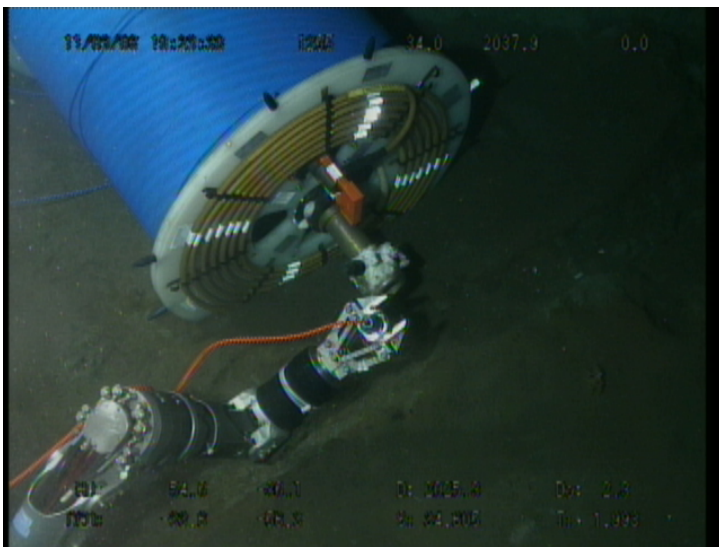


Fig. 3.11 Operation for continuing extension cable laying



Fig. 3.12 Cable bobbin deployed on the way

(6) Dive 1256 on 10 March

Observatory installation and its boot up at the observatory C-9 has been carried out in the 1256 dive. Burial hole conditioned by the previous 1251 dive was completed, and the extension cable had already been laid during the 1253 dive. The ground motion sensing system was deployed in the burial hole at first, then the pressure sensing system was put near the hole. After deploying the observatory, the cable was connected to the observatory. The boot up was confirmed from Furue landing station. The C-9 observatory is located in the slope, so sand bags have been put the bottom of extension cable bobbin.

The observatory location and the system ID of C-9 observatory are as follows,
33-03.503N, 136-49.879E, D=3511m, System ID: SPKG C130, ROV-Homer=93

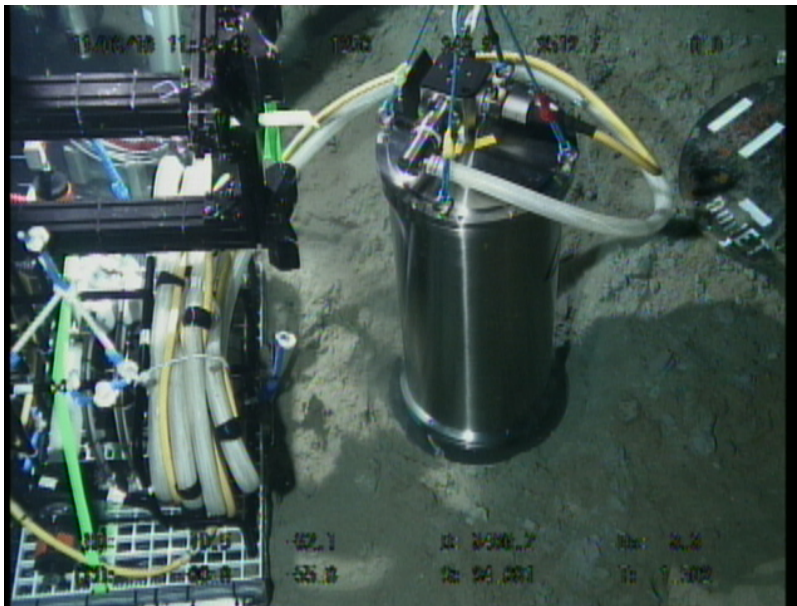


Fig. 3.13 Ground motion sensing system installation into the burial hole

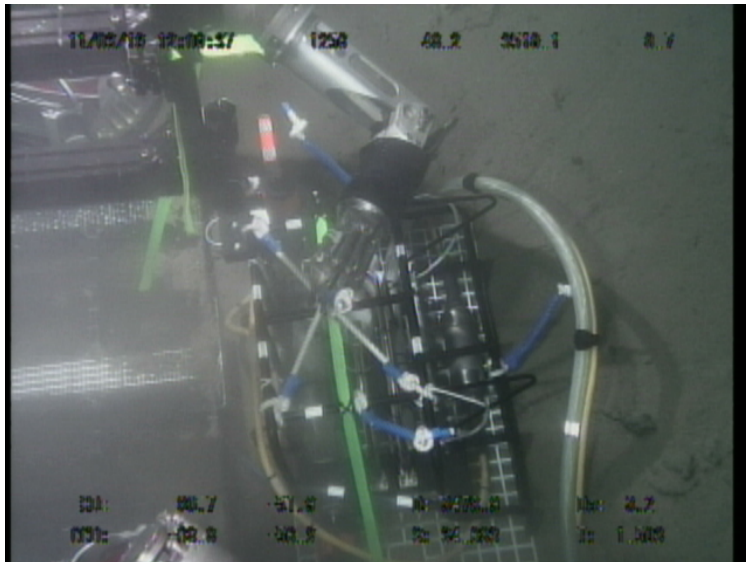


Fig. 3.14 Deployment of pressure sensing system



Fig. 3.15 Sand bags at the bottom of the extension cable bobbin

(7) Dive 1257 on 11 March

The 1257 dive was done in order to make burial hole conditioning. The target observatory was D-14. The burial hole of D-14 has been completely deployed under the seabed. "Hyper-Dolphin" operated burial hole conditioning by a suction pump system "DOROTHY". It took about two hours to make conditioning, and the burial hole level was confirmed to be horizon within 10 degrees error. Finally, the plate has been covered on the burial hole and the sand bags have been laid near the observatory.

The location of observatory D-14 and ROV-Homer ID is as follows,

33-10.3631N, 136-34.6322E, D=2,350m, ROV-Homer ID: 14

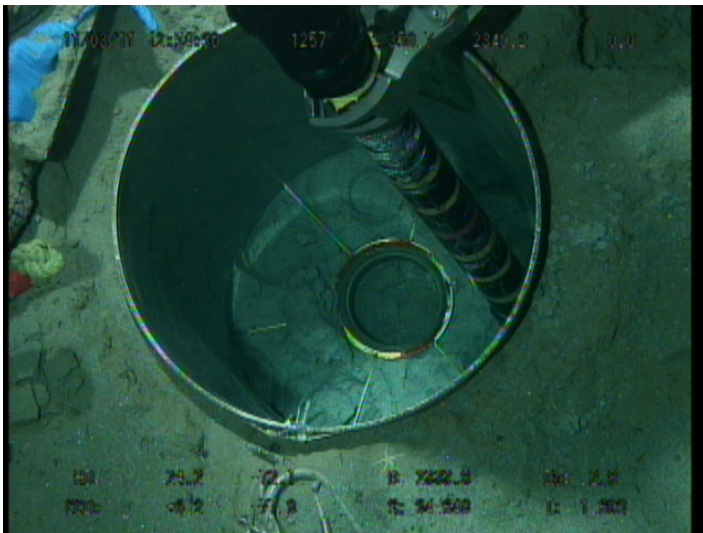


Fig. 3.16 Burial hole conditioning of the D-14 observatory



Fig. 3.17 View of the D-14 observatory

(8) Dive 1258 on 12 March

Originally, it was planned to carry out cable extension of D-14 observatory, but the water current was 4.5 kt, which was too strong to dive. This was the second trial of A-1 cable laying restarted. The 1258 dive tried to continue cable extension operation again on the way of A-1 as done in the 1255 dive. The bobbin could be recovered into the cable laying system under the ocean bottom, but the extension system attached vehicle had accidents with its function. Extension cable was buckled during the operation. Because it would take much time to continue operation as well as no guarantee for extension cable workability, the extension cable was released and the cable bobbin was recovered at last.

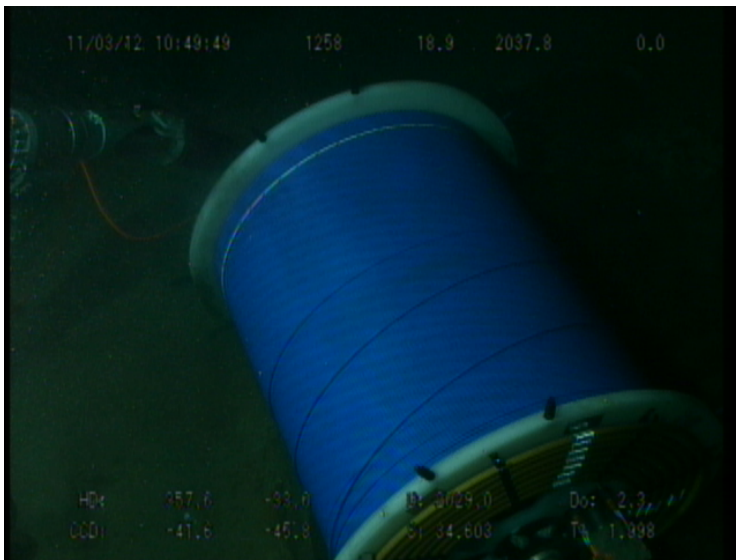


Fig. 3.18 Cable bobbin under the sea



Fig. 3.19 Extension cable released from the cable bobbin

(9) Dive 1259 on 13 March

This is an extension cable laying operation from the D-14 observatory candidate to the science node D. This extension started from the observatory, because the upward slope is preferable for ROV operation. There is no sensor at the observatory D-14, so an extension cable stopper named by "Pole hole" was used in order to prevent the connector and cable movement. It took 8 hours to do extension cable laying to the science node D after the dive.

The science node interface is used at **No. 5 port** and the extension cable is used with **No. 16 cable colored by white**.

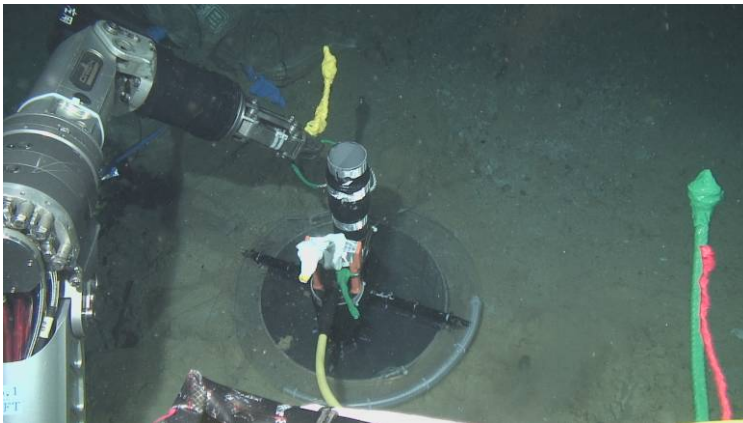


Fig. 3.20 Hole pole deployed at the observatory D-14

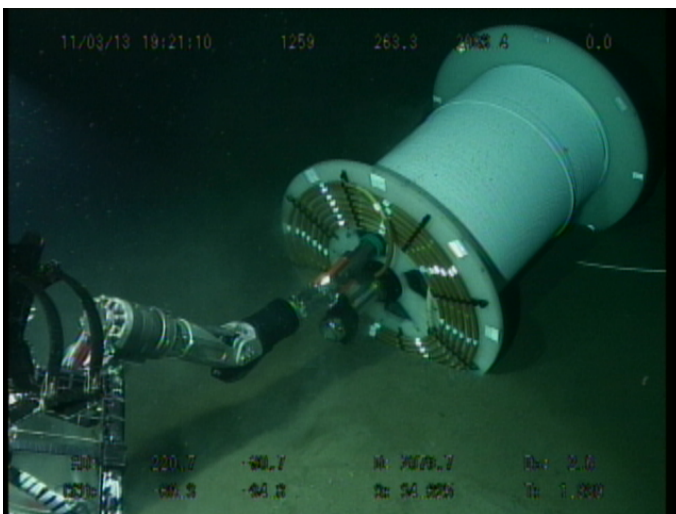


Fig. 3.21 Cable bobbin deployed near the science node D

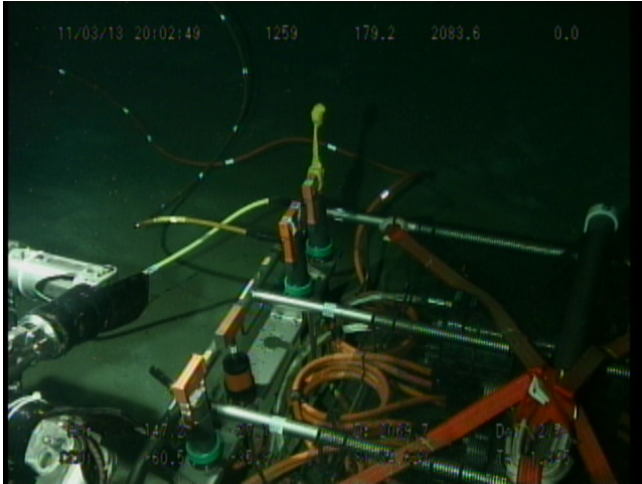


Fig. 3.22 Extension cable interface connecting to **node D No.5 port**

(10) Dive 1260 on 14 March

Sensor installation and its boot up at the observatory D-14 has been carried out in the 1260 dive. Burial hole conditioned by the previous dive was empty, but the extension cable had already laid during the 1259 dive. And for the reason of topography between the science node D and the observatory D-14, the extension cable has been laid from the observatory to the science node. So the extension cable stopper named by "Pole hole" was used. First the "Hole pole" was recovered in order to the connector from the science node was to be connect to the observatory. The ground motion sensing system was deployed into the burial hole, then the pressure sensing system was deployed near the hole. After deploying the observatory, the extension cable was connected to the observatory. Finally, D-14 observatory has been boot up from Furue landing station.

The observatory location and the system ID of D-14 are as follows,

33-10.3595N, 136-34.6172E, D=2,350m, System ID: SPKG C150, ROV-Homer=14

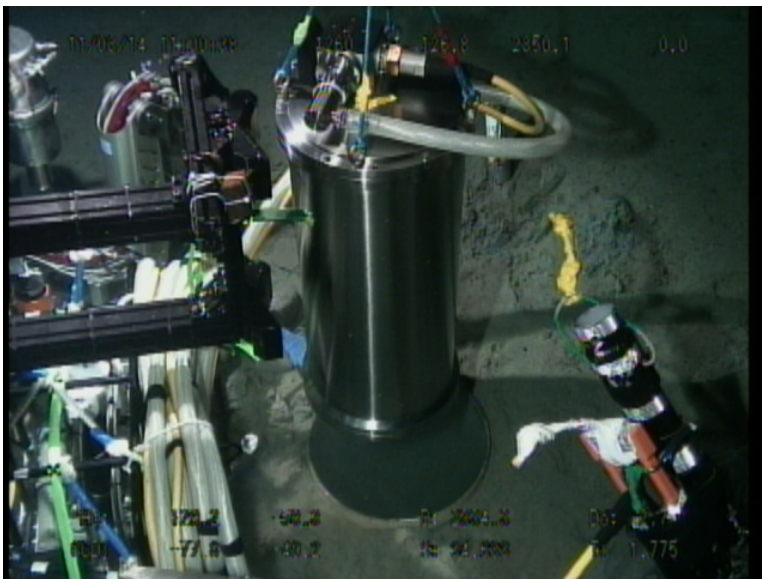


Fig. 3.23 Ground motion sensing system deployed into the burial hole

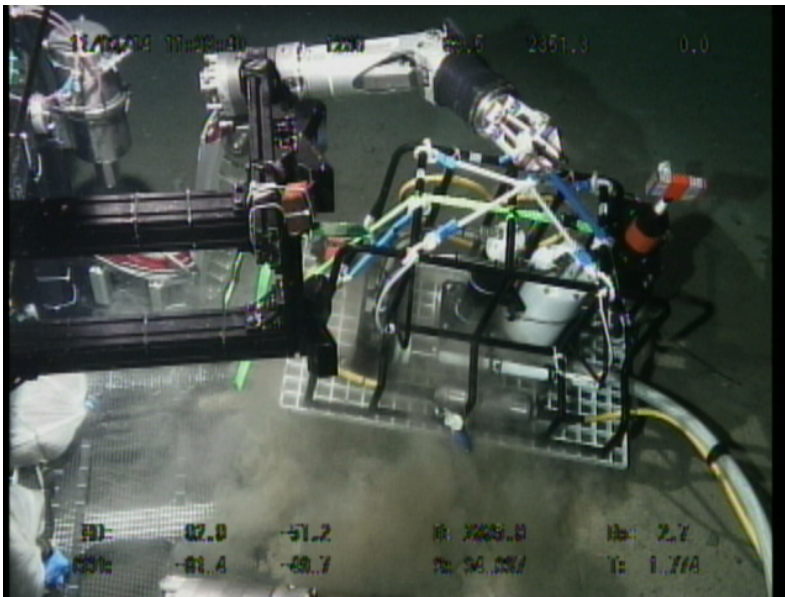


Fig. 3.24 Deployment of pressure sensing system

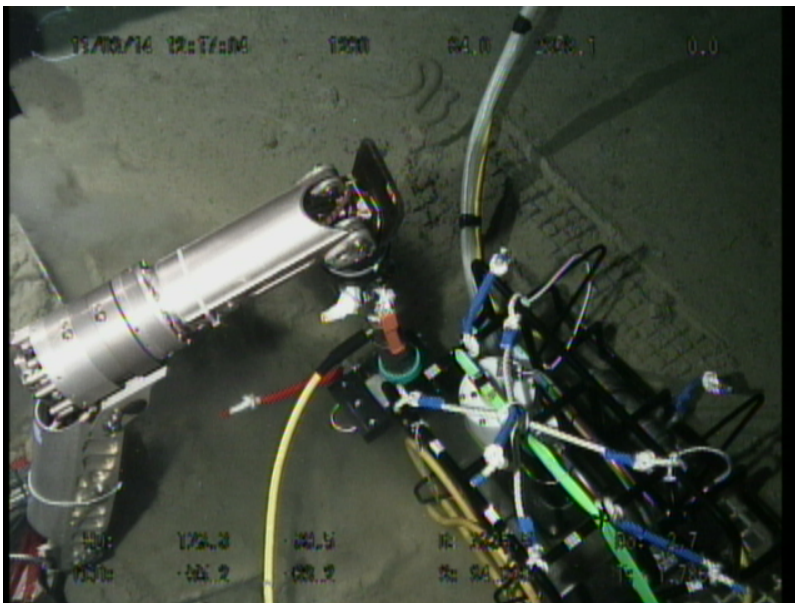


Fig. 3.25 Extension cable connecting to the observatory

(11) Dive 1261 on 15 March

The 1261 dive is the last dive of KY11-03 expedition. This dive aimed to backfill the burial hole and to release the frame structure of pressure sensing system at the observatory **A-3**. For backfilling ground motion sensing system in the burial hole, “Sand-Feeder” was used. Finally the guard frame of the pressure sensing system was removed.

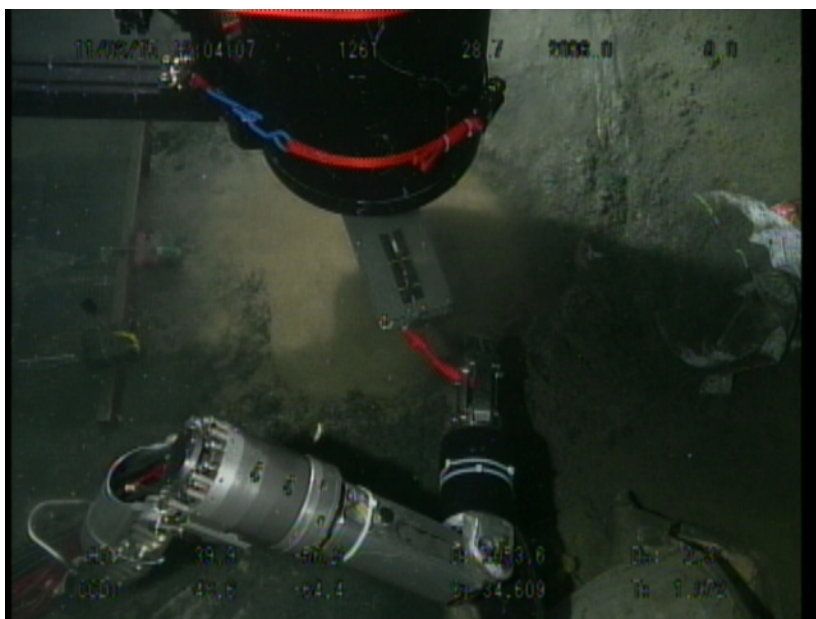


Fig. 3.26 Backfilling burial hole operation by “Sand Feeder”

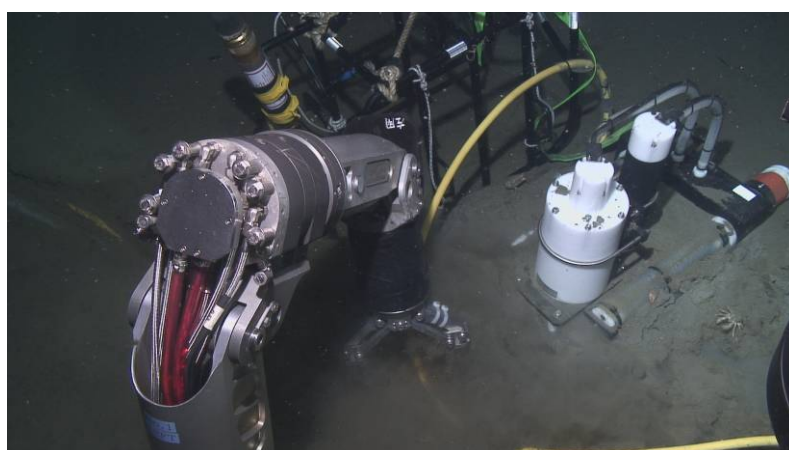


Fig. 3.27 Removal of the guard frame of pressure sensing system

4. Concluding Remarks

KY11-03 is 5th expedition for DONET (Dense Ocean-floor observatory network for Earthquakes and Tsunamis) sub-sea observatory construction. At the time of the start this expedition, DONET backbone submarine cable system, five science nodes and eight observatories were already sit on the seafloor and in operation. Eleven ROV diving days were scheduled for observatory construction (include burial hole conditioning, observatory installation, and backfilling burial hole operation), and extension cable laying operation between node and observatory.

The expedition was done during March 2 to March 17, 2011.

In this duration, HPD4500 implement 11dives (Dive #1251 to #1261). There were

- Burial Hole Conditioning: 3Dives (C-9(#1251), D-14(#1257), E-20(#1252))
- Observatory Installation: 2Dives (C-9(#1256), D-14(#1260))
- Cable Laying Operation: 3Dives (B-5(#1254),C-9(#1253), D-14(#1259))
- Burial Hole fill up: 1Dive ((A-3(#1261))
- Additional Operations: 2 Dives (Backup operation for A-1 cable laying suspension(#1255), (#1258))

In the expedition KY11-03, three new observatories were able to be activated, and total number of in-operation observatories became eleven. On March 11 when on the expedition KY11-03, a M9 class mega thrust earthquake hit the north-eastern part of Japan and associated tsunami rising over the seaboard cities. This disaster made us recognize the importance of earthquakes and tsunamis prevention over again. At that time, Ten observatories were operating in the DONET system where the approximately 800km far from hypocenter of the 2011 Tohoku-oki earthquake. From this data, it can be confirmed that the tsunami of 60cm pp surges several times in this area.

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

Bathymetric map for Nankai Trough off Kii Peninsula

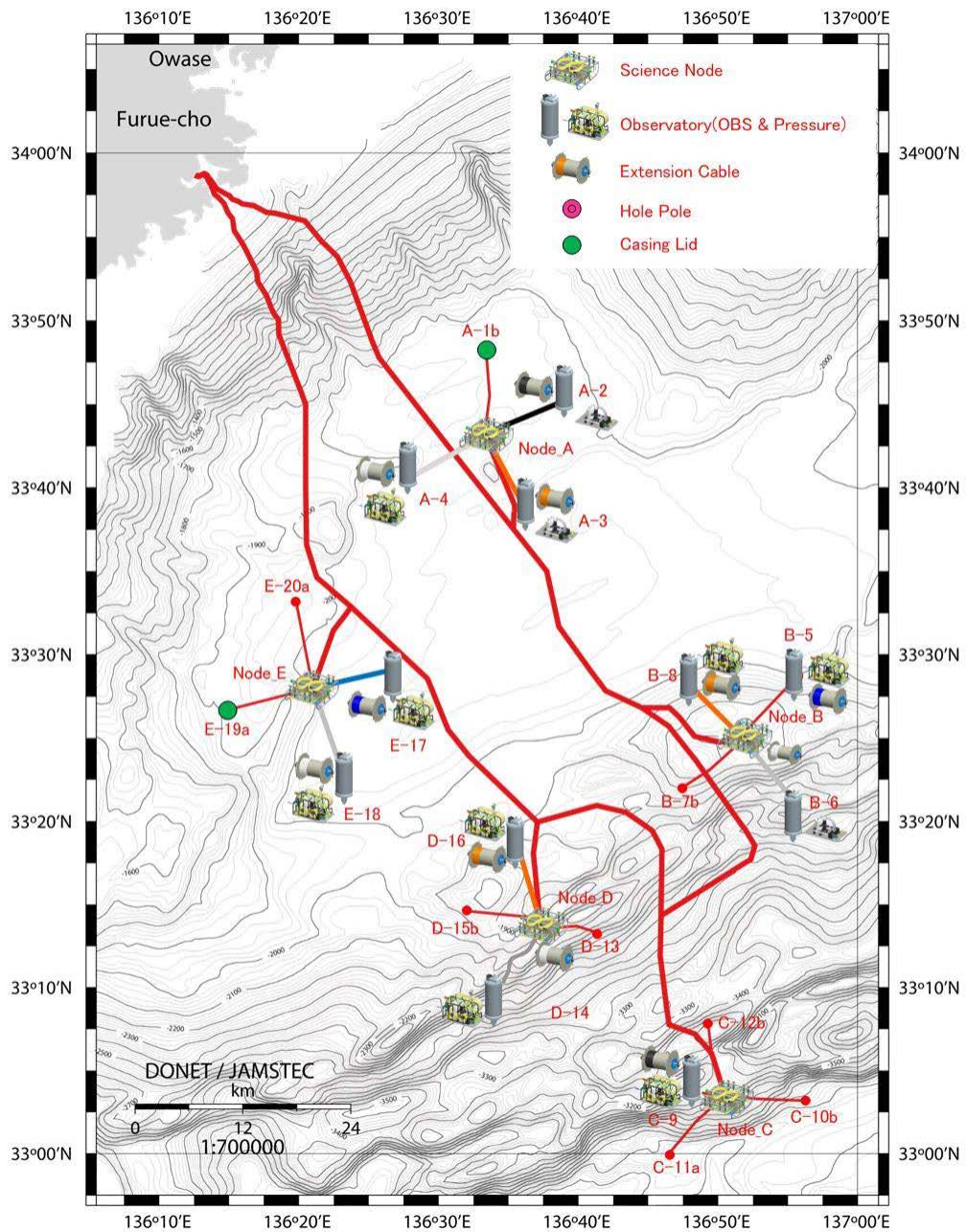


Fig. 4.1 Status of the DONET observatory after the KY11-03 expedition