

**KY10-15**  
**“KAIYO” / “HYPER-DOLPHIN”**  
**Kumano-Nada**



**January 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.

First DONET science node and observatory was established at A-3 location by using ROV “Hyper-Dolphin” during NT10-04 cruise on March 2010 (e.g., Kawaguchi et al., 2010). The following expeditions were done on May and October 2010 by NT10-09 and NT10-18, respectively, in which three science nodes and three observatories were deployed and activated.

The present KY10-15 expedition is the first trial by R/V “Kaiyo” and 4500 meters class ROV “Hyper-Dolphin” operation, and to deploy one science node in the deepest area of DONET and to install more observatories.

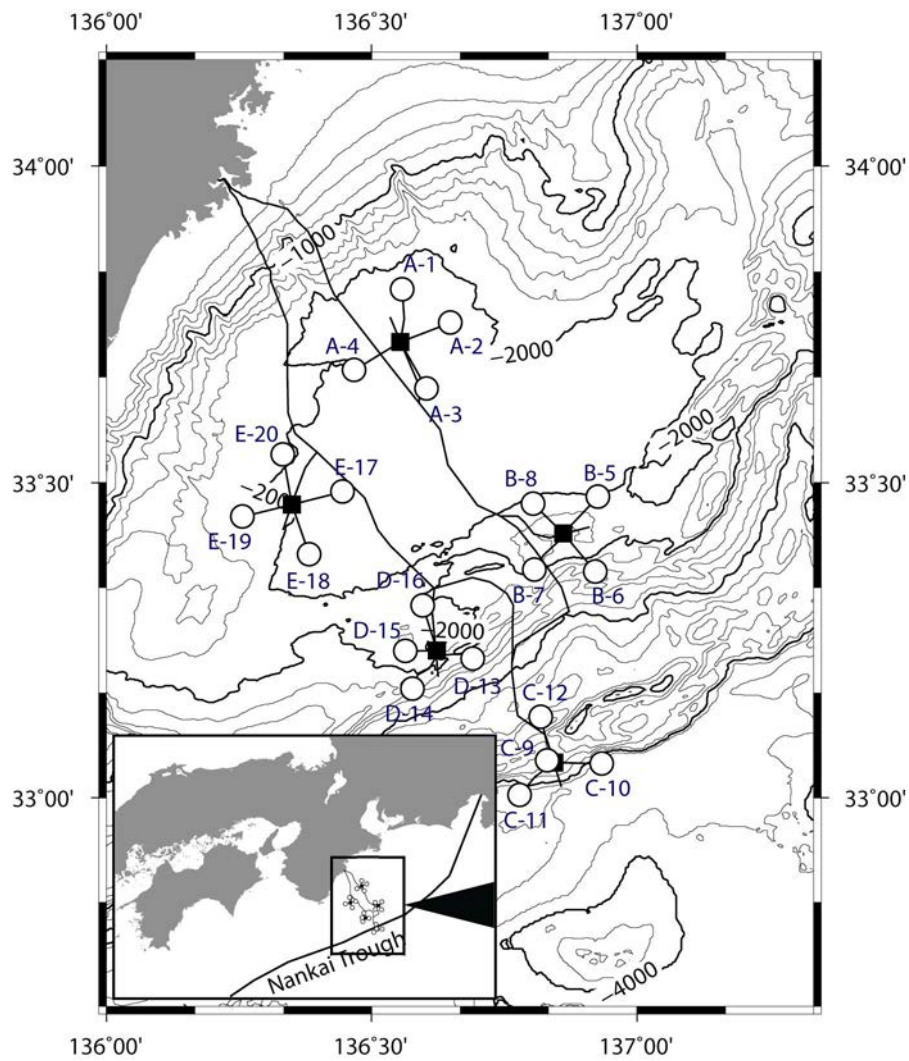


Figure 1 Map showing DONET observatory to be deployed in the Nankai trough. Open circles and square dots represent the observatories and the science nodes, respectively, which are connected by submarine cable.

## 2. SCHEDULE

The present KY10-15 cruise is to conduct the following operations.

- (1) Science node installation operation
- (2) Sensor package\* deployment and activation operation
- (3) Extension cable laying operation between the science node and the observatory
- (4) Burial hole conditioning operation
- (5) Backfilling burial hole operation

Sixteen dives were initially planned between 24 December 2010 and 12 January 2011 during the KY10-15 expedition. But the weather and the ocean conditions sometimes make us impossible to carry out the entire dives. The action items of “Hyper Dolphin” operation is summarized as follows.

Table 1 Summary of KY10-15 cruise

| Date        | Location        | Site | Dive No. | Operation                                             |
|-------------|-----------------|------|----------|-------------------------------------------------------|
| 23 December | Yokohama Port   |      |          | Departure at Yokohama for Kumano                      |
| 24 December | Kumano-Nada     |      |          | Free Fall of umbilical cable, preparation for payload |
| 25 December | Kumano-Nada     | A-1  | #1218    | Burial hole conditioning                              |
| 26 December | Kumano-Nada     | C    | #1219    | Node C installation                                   |
| 27 December | Kumano-Nada     | E-18 | #1220    | Extension cable laying                                |
| 28 December | Kumano-Nada     | B-8  | #1221    | Burial hole conditioning                              |
| 29 December | Kumano-Nada     | A-1  | #1222    | Extension cable laying, but not completed             |
| 30 December | Kumano-Nada     | B-8  | #1223    | Extension cable laying                                |
| 31 December | Off Shingu Port |      |          | Evading navigation                                    |
| 1 January   | Off Shingu Port |      |          | Evading navigation                                    |
| 2 January   | Kumano-Nada     |      |          | Dive cancelled due to stormy condition                |
| 3 January   | Kumano-Nada     | B-6  | #1224    | Extension cable laying                                |
| 4 January   | Kumano-Nada     | C-9  | #1225    | Burial hole conditioning                              |

|            |             |      |       |                                         |
|------------|-------------|------|-------|-----------------------------------------|
| 5 January  | Kumano-Nada | B-6  | #1226 | Sensor package installation and boot up |
| 6 January  | Kumano-Nada | B-8  | #1227 | Sensor package installation and boot up |
| 7 January  | Kumano-Nada | E-18 | #1228 | Sensor package installation and boot up |
| 8 January  | Kumano-Nada | D-16 | #1229 | Extension cable laying and boot up      |
| 9 January  | Kumano-Nada | B-5  | #1230 | Burial hole conditioning                |
| 10 January | Kumano-Nada | B-5  | #1231 | Sensor package installation             |
|            |             | B-6  | #1232 | Burial hole backfilling                 |
| 11 January |             |      |       | Arrive at JAMSTEC                       |
| 12 January |             |      |       |                                         |

\*Sensor package: the general DONET observatory is composed of a sensor package and an extension cable system. The sensor package consists of a ground motion sensing system and pressure sensing system.

### 3. DIVE RESULTS

“Hyper-Dolphin” dives for DONET construction were carried out during KY10-15 expedition. The first dive was done on 25 December and the last dive was done on 10 January. Summary of each dive is described as follows,

#### (1) #1218 dive on 25 December

Because of the windy weather, the dive site of “Hyper-Dolphin” of the #1218 dive was changed from C-9 to A-1. The burial hole conditioning operation by “Dorothy” has been completed at A-1c.

The location by “Hyper-Dolphin” and ROV-Homer ID of C-1c observatory are as follows,

33-48.279N, 136-33.422E, D=2,040m, ROV-Homer ID: 10

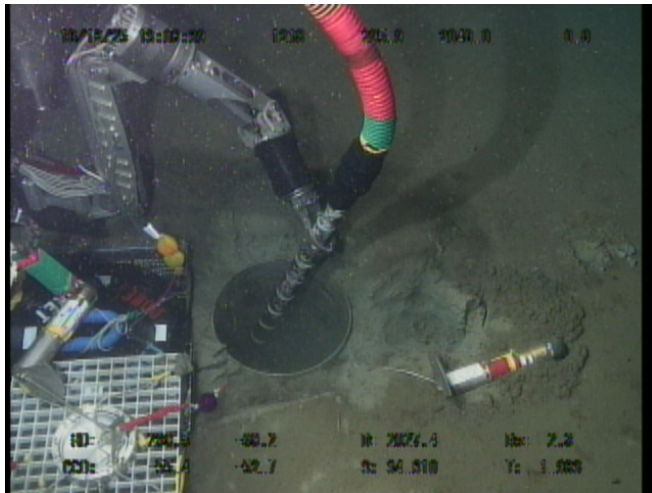


Photo 1 Burial hole conditioning operation by “Dorothy” at A-1c

(2) #1219 dive on 26 December

Science node installation was carried out in the #1219 dive at C area. Water depth of this site is more than 3,500 meters, so it was impossible to access by the conventional “Hyper-Dolphin” ever used. Advanced 4,500 meters class “Hyper-Dolphin” makes us possible to carry out operation at water depth more than 3,000 meters. At last it has become possible to deploy the node at C area.

“Hyper-Dolphin” carried science node and approached Terminal Unit C (TU-C) on the main cable at C area. TU-C is deployed at 33-03.334N, 136-50.627E, D=3,587 m by cable laying ship “KDDI PACIFIC LINK”. After approaching the TU-C, science node has been deployed near the TU-C, whose distance is 13.8 m. Then the science node cable has been connected to the TU-C. Booting up science node from the land station, the result is confirmed to be good. Finally, sea earth cable is deployed into the seabed.

The location and equipment ID of science node C is as follows,

33-03.331N, 136-50.624E, D=3,593m, Node ID: A050

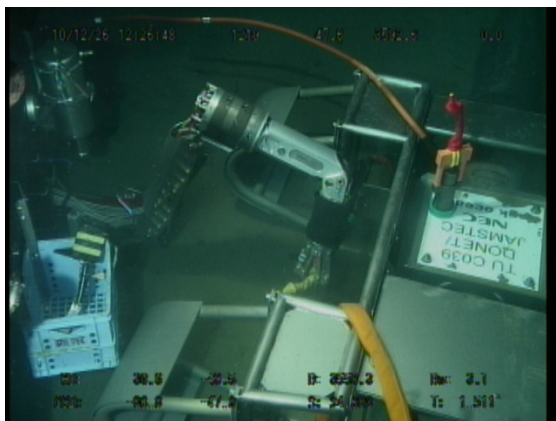


Photo 2 Terminal Unit C

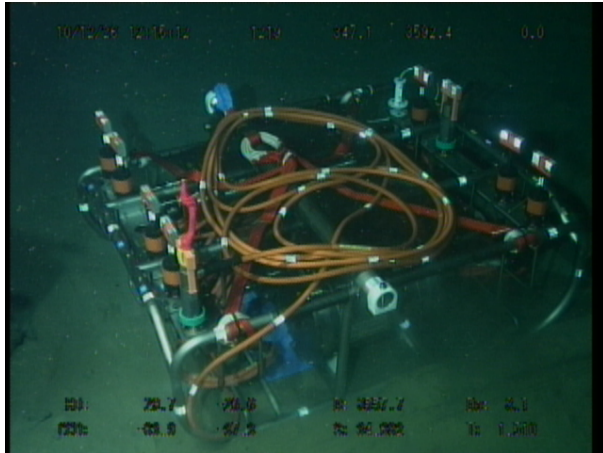


Photo 3 Installation of Node C

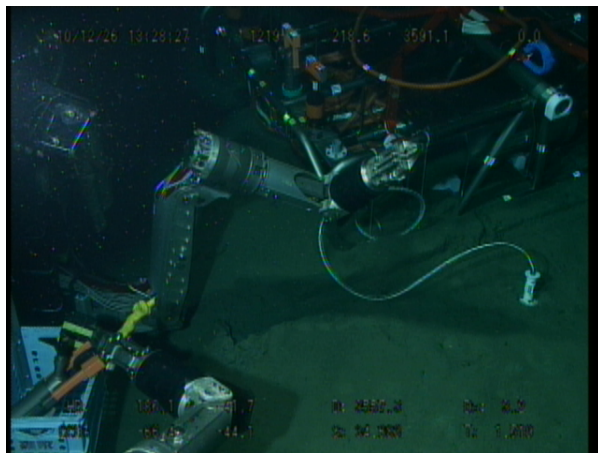


Photo 4 Installation of sea earth cable

(3) #1220 dive on 27 December

In the 1220 dive, an extension cable laying operation has been carried out between the science node E and the observatory E-18. Although the burial hole conditioning has been completed, the sensor package has not been installed yet. So, new observatory has not been available even after the present dive. It is noted that the bottom current was very strong around the observatory E-18

The science node interface is used at **Node E No. 8 port** and the **No.4 extension cable colored by white** was used.



Photo 5 Extension cable interface connecting No.8 port



Photo 6 Cable bobbin deployed near the observatory E-18



Photo 7 Burial hole observed at the #1220 dive

(4) #1221 dive on 28 December

This dive is done in order to make burial hole conditioning as done in the #1218 dive. The target observatory was B-8. The burial hole of B-8 has been completely deployed under the seabed. “Hyper-Dolphin” operated burial hole conditioning by “Dorothy”. It took about two hours to make conditioning, and the burial hole level was confirmed to be horizon within 10 degrees error. Finally, a lid has been covered on the burial hole and the sand bags have been laid near the observatory.

The location of observatory B-8 and ROV-Homer ID is as follows,

33-27.985N, 136-48.185E, D=1,925m, ROV-Homer ID: 11

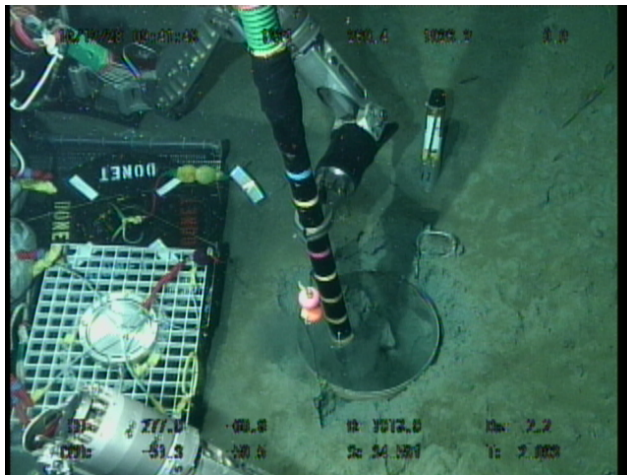


Photo 8 Burial hole conditioning operation of the observatory B-8 candidate

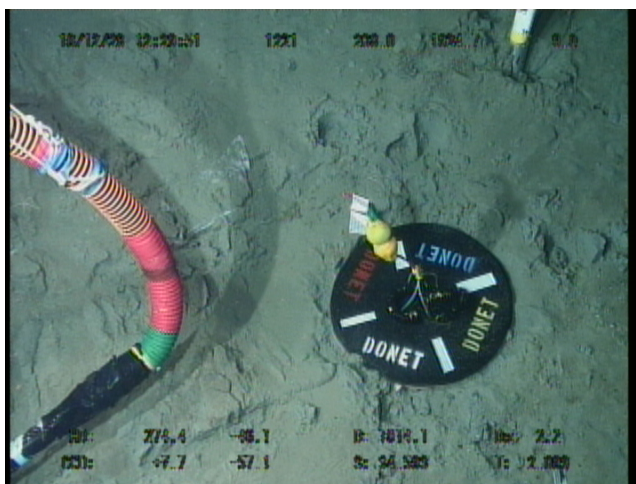


Photo 9 View of the burial hole for observatory B-8 candidate

(5) #1222 dive on 29 December

The #1222 dive was to operate the extension cable laying between the science node A and the observatory A-1. First, the cable end connector has been put **node A port 2** of the science node A. Then extension cable has been laid followed by the junction unit box deploying. On the way of extension cable route, however, “Hyper-Dolphin” suddenly stopped and seemed to be captured by something. For safety of ROV, the cable bobbin has been released where the ROV stopped. After returning 500 meters toward the node A, “Hyper-Dolphin” finished the dive.

The location of the cable bobbin release is **33-44.453N, 136-33.4274E, D=2,036m.**

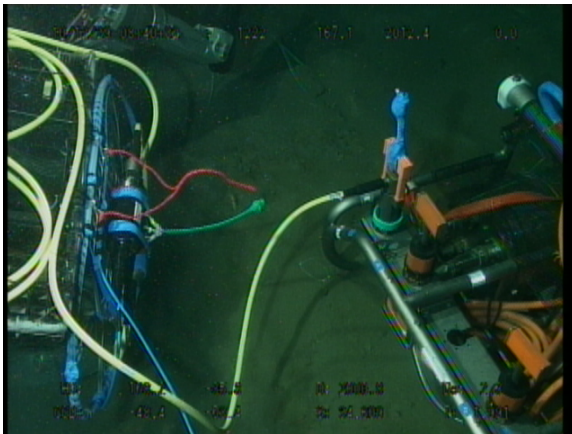


Photo 10 **Node A port 2** used for the observatory A-1 candidate

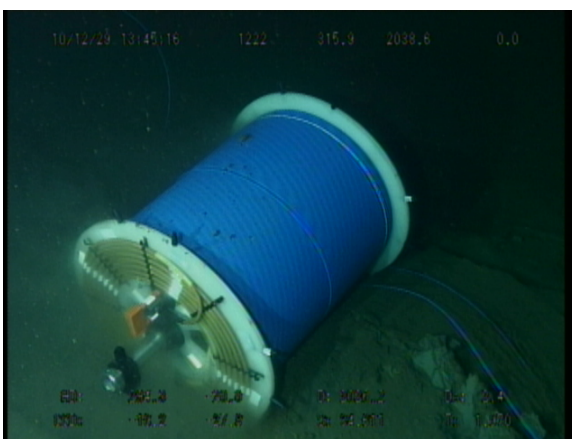


Photo 11 Cable bobbin released on the way of the observatory A-1 candidate

(6) #1223 dive on 30 December

The #1223 dive has completed to deploy an extension cable between the science node B and the observatory B-8. The connected port for the observatory B-8 is **No. 7 port**, and **No. 2 extension cable colored by orange** is used. After about 7.7 kilometers extension operation has been done by “Hyper-Dolphin”, the cable bobbin has been deployed at the observatory. The location of the cable bobbin deployed is **33-27.976N, 136-48.180E, D=1,924m**. Because the observatory has not been deployed at the B-8 observatory, there was no boot of the observatory in the present dive.

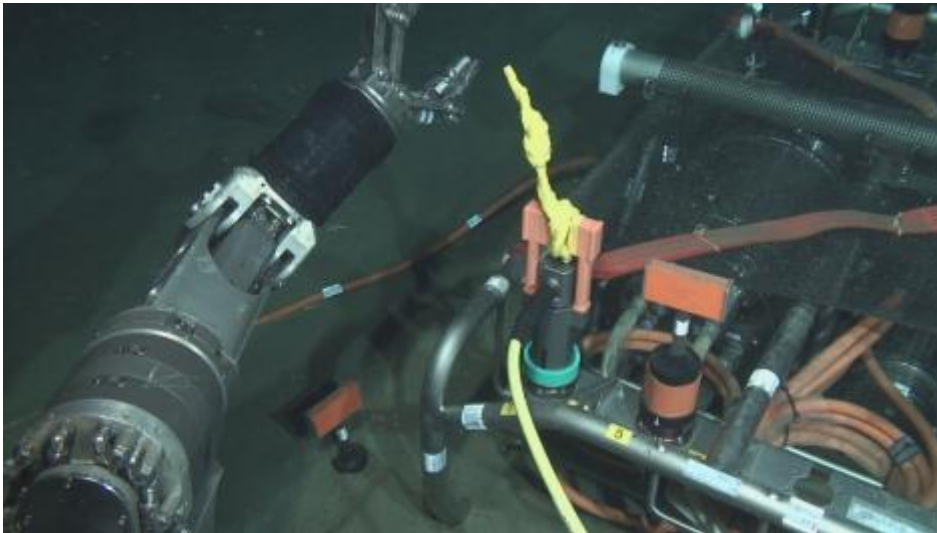


Photo 12 Extension cable interface connecting **node B No.7 port**

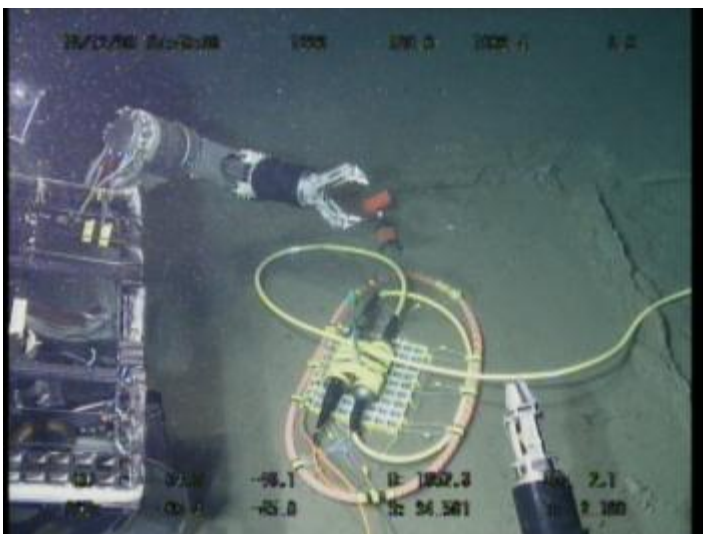


Photo 13 Joint box near the science node B

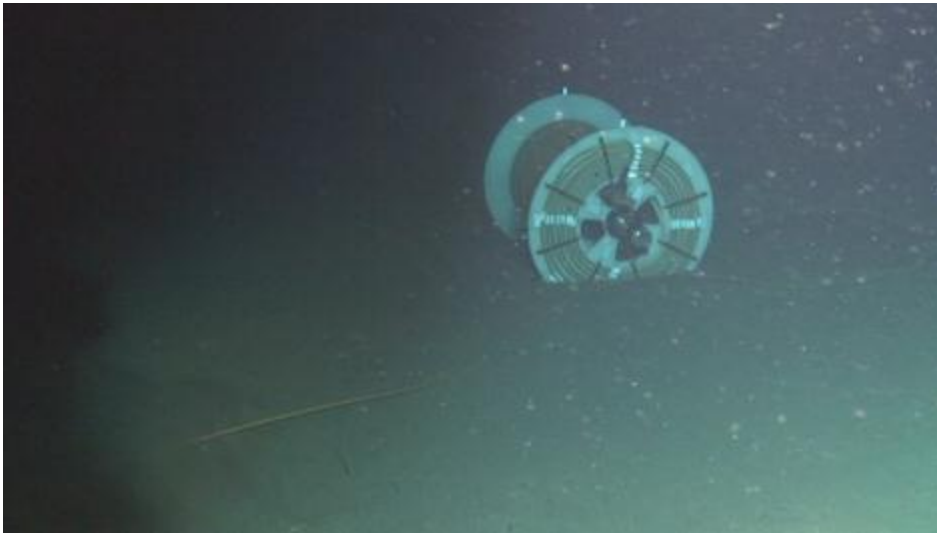


Photo 14 Cable bobbin deployed near the observatory B-8 candidate

(7) #1224 dive on 3 January

This is the first dive in 2011, which carried out extension cable laying operation from the observatory B-6 candidate to the science node B. This operation started from the observatory, because up-slope topography is preferable for ROV operation. There is no observatory at the observatory B-6 candidate, so we used the “Hole-Pole” in order to prevent the connector and extension cable movement. Because some steep slopes and strong bottom current made difficult to lay extension cable on the seafloor, and it took 12 hours to complete the cable laying operation.

The science node interface is used at **node B No. 2 port** and **No. 12 extension cable colored by white** is used.



Photo 15 “Hole-Pole” deployed at the observatory B-6 candidate



Photo 16 Cable bobbin deployed near the node B

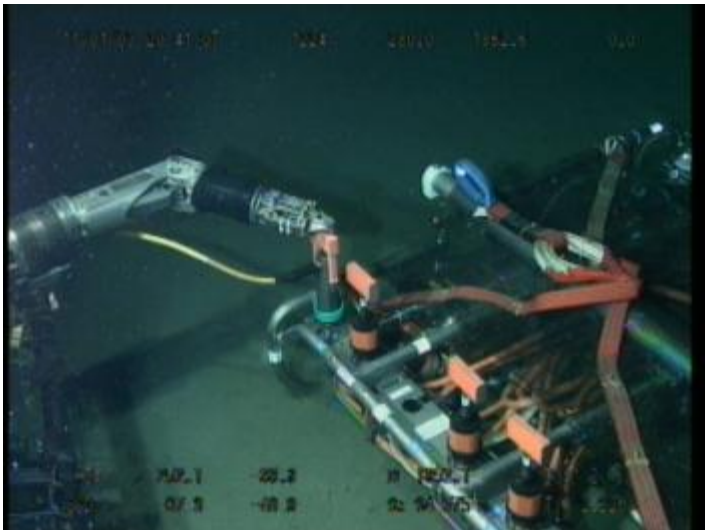


Photo 17 Extension cable end connecting node B No.2 port

(8) #1225 dive on 4 January

The #1225 dive aimed to condition the burial hole at the observatory C-9 candidate. The bottom casing of C-9 has been completely penetrated in the seafloor. “Hyper-Dolphin” operated burial hole conditioning by “Dorothy”. However, the bottom sediment is too hard to open the hole entirely. About 70% of the burial hole conditioning has been finished in the present dive, and additional ROV dive is required to complete the burial hole conditioning. We confirmed that tilt of the casing is within 10 degree, which is possible to use as the observatory platform. At the end of operation, a lid has been deployed on the casing.

The location of observatory C-9 candidate and ROV-Homer ID is as follows,

33-03.416N, 136-49.818E, D=3,513m, ROV-Homer ID: 93



Photo 18 Burial hole conditioning operation of the observatory C-9 candidate



Photo 19 View of the burial hole of the observatory C-9 candidate

(9) #1226 dive on 5 January

Observatory installation and its boot up at the site B-6 has been carried out during the #1226 dive. The burial hole conditioning of B-6 was completed in the previous NT10-18 expedition, and the extension cable had already laid during the preset KY10-15 expedition. And for the reason of topography between the science node B and the observatory B-6, the extension cable has been laid from the observatory to the science node. So the stopper tool named by “Hole-Pole” was used. First the “Hole-pole” was recovered in order to the connector from the science node was to be connect to the sensor package. 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 end was connected to the observatory. The communication was confirmed from Furue landing station. B-6 observatory has been succeeded to boot up.

The observatory location and the sensor package ID of B-6 are as follows,

33-21.505N, 136-55.295E, D=2499m, System ID: SPKG A100, ROV-Homer=90

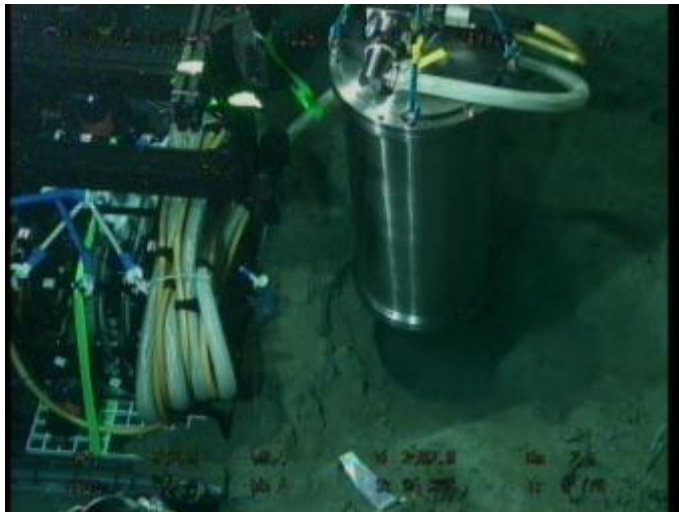


Photo 20 Ground motion sensing system installed into the burial hole

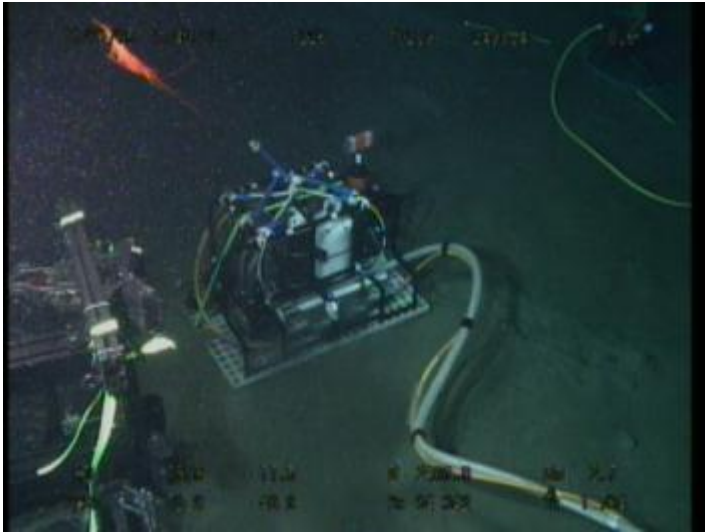


Photo 21 Pressure sensing system deployment

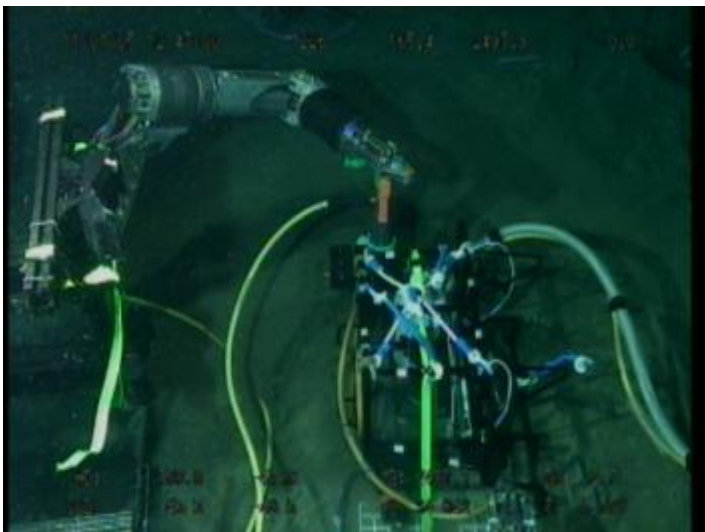


Photo 22 Connection of the cable to the observatory

(10) #1227 dive on 6 January

Observatory installation and boot up were carried out at the B-8 in the #1227 dive. First the ground motion sensing system has been deployed into the burial hole, then the pressure sensing system also deployed near the burial hole. The observatory boot up was confirmed from the cable landing station. Before leaving the observatory, back filling operation of the observatory was done by using sand bags. It took a few hours, and it achieved 90% back filling.

The observatory location and the sensor package ID of B-8 are as follows,

33-27.985N, 136-48.185E, D=1922m, System ID: SPKG A070, ROV-Homer=11

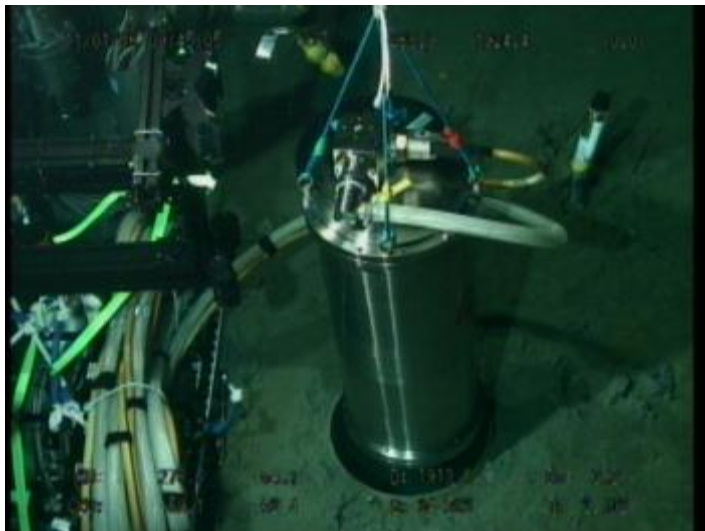


Photo 23 Ground motion sensing system installation into the burial hole



Photo 24 Pressure sensing system deployment

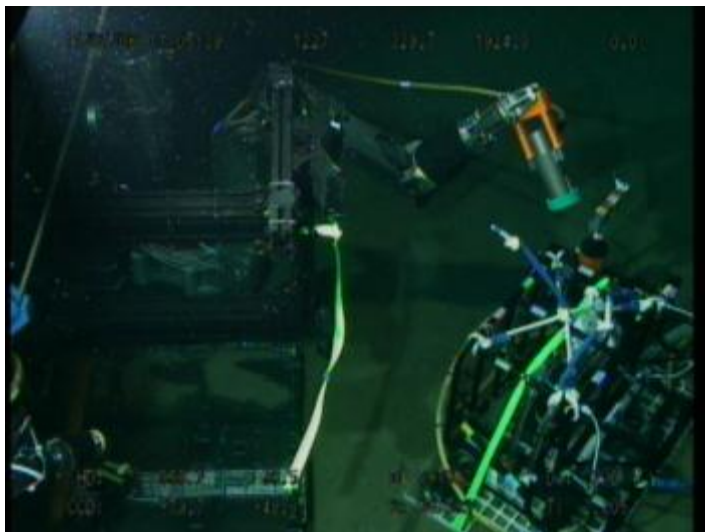


Photo 25 Connection of the cable to the observatory

(11) #1228 dive on 7 January

Continuously, observatory installation and boot up were carried out at the E-18 candidate in the #1228 dive. Extension cable bobbin has already prepared near the observatory E-18. First the ground motion sensing system has been deployed into the burial hole, then the pressure sensing system also deployed near the burial hole. Finally extension cable has been connected to the observatory. The boot up has been confirmed from the Furue landing station. Before leaving the observatory, backfilling operation of the observatory was done by sand bags. It took a few hours, and it achieved 80% back filling.

The observatory location and the sensor package ID of E-18 are as follows,

33-27.985N, 136-48.185E, D=1922m, System ID: SPKG A030, ROV-Homer=31

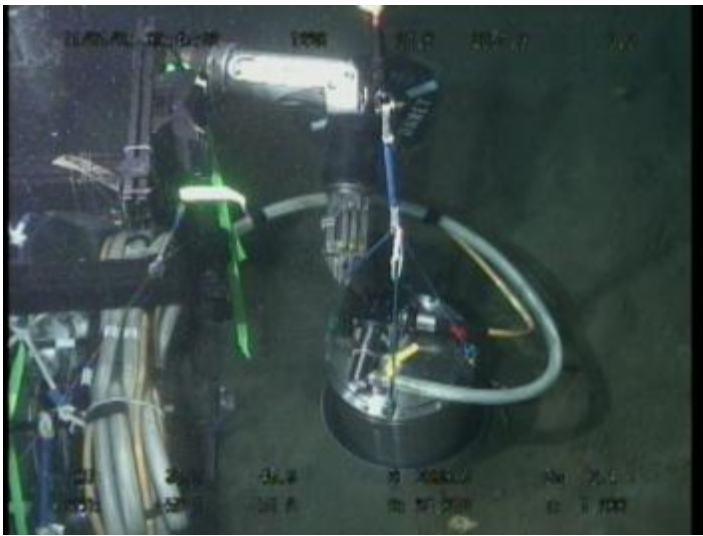


Photo 26 Ground motion sensing system installation into the burial hole

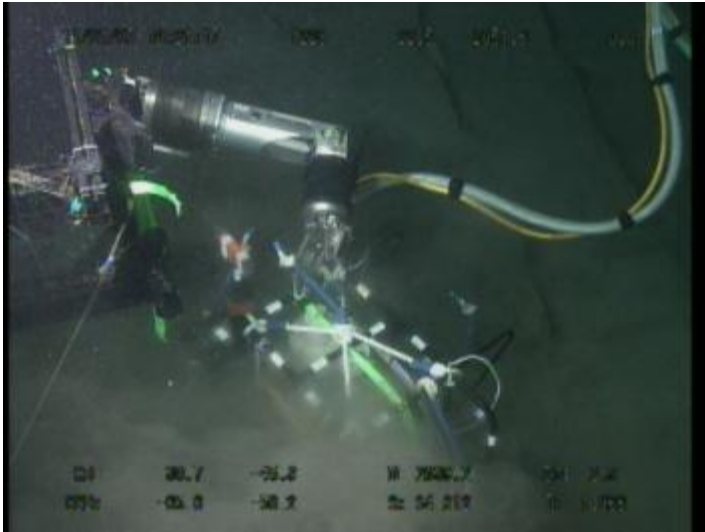


Photo 27 Pressure sensing system deployment



Photo 29 Burial hole back filling by sand bags

(12) #1229 dive on 8 January

The #1229 dive aimed to boot up the observatory **D-16** after the extension cable laying operation. The observatory at the D-16 site has already deployed inside the burial hole in the previous NT10-18 expedition. The connector of the extension cable **No.10 colored by orange** has connected to **node D port No. 7**, and then 8.6 kilometers cable extension operation has been done. At the observatory D-16, the extension cable has been connected to the observatory **SPKG A090**. The boot up has been done well confirmed by the Furue landing station.

The observatory location and the sensor package ID of **D-16** are as follows,  
**33-18.270N, 136-35.748E, D=1970m, Sensor ID: SPKG A030, ROV-Homer=13**



Photo 30 Connection of the cable end to the science node D port No.7

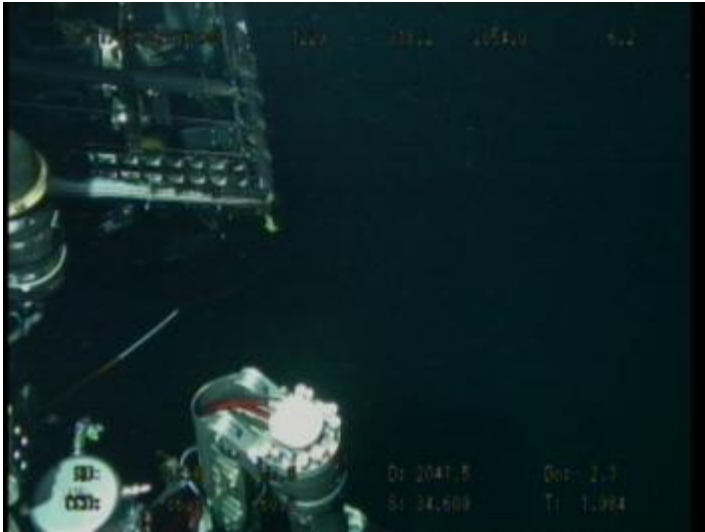


Photo 31 Extension cable laying operation

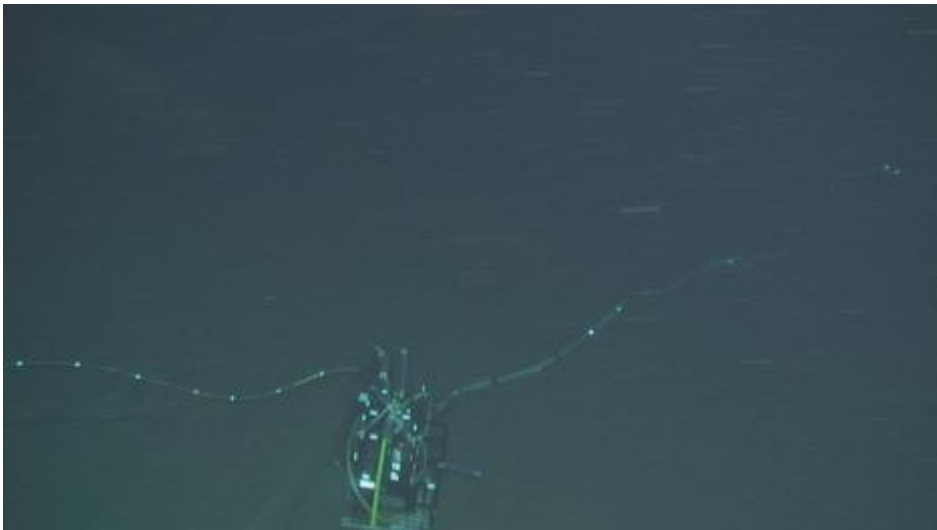


Photo 32 Whole view of the observatory D-16 (Center: pressure sensing system, Right: buried ground motion sensing system)

(13) #1230 dive on 9 January

Burial hole conditioning operation by “Dorothy” was done in the #1230 dive at the B-5 site candidate. Burial hole has been completely penetrated under the seafloor. About an hour burial hole conditioning operation, the burial hole has been open for deployment of ground motion sensing system, and the tilt of the casing is within 10 degrees. Finally, eight sand bags have been left near the observatory.

The location of observatory B-5 and ROV-Homer ID is as follows,

33-28.633N, 136-55.603E, D=1997m, ROV-Homer ID: 92



Photo 33 Burial hole conditioning operation at the B-5 site candidate



Photo 34 View of the B-5 site candidate

(14) #1231 and #1232 dives on 10 January

The #1231 dive aimed to deploy a observatory at the B-5 site, which has been conditioned in the #1230 dive. First, ground motion sensing system has been installed into the burial hole, then the pressure sensing system has been deployed near the hole.

The observatory location and the sensor package ID of B-5 are as follows,

33-N, 136-E, D=m, System ID: SPKG A110, ROV-Homer=15

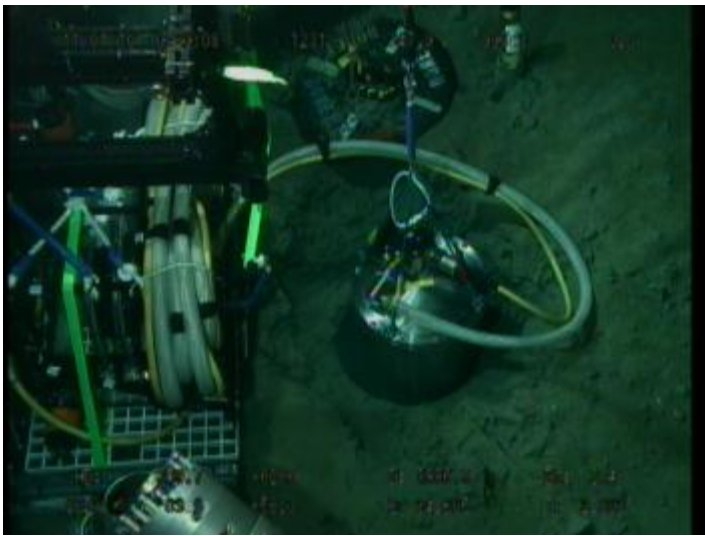


Photo 35 Ground motion sensing system installation into the burial hole



Photo 36 Deployment of pressure sensing system.

The following #1232 dive is the last dive of KY10-15 expedition. This dive aimed to backfill the burial hole and to remove the guard frame from the pressure sensing system at the observatory B-6. For backfilling the burial hole, a new “sand feeder” was used. It took about 8 min to complete to backfill the burial hole, whereas it took a few hours without “sand feeder” for the same operation.



Photo 37 Backfilling burial hole by “sand feeder”



Photo 38 Whole view of observatory B-6

#### 4. CONCLUSIONS

KY10-15 is a first expedition for DONET (Dense Ocean-floor observatory network for earthquakes and tsunamis) sub-sea observatory construction using R/V KAIYO (for mother ship) and remodeled ROV “Hyper-Dolphin4500”. Four new observatories were able to be activated, and one candidate observatory (B-6) was prepared, and two candidate sites (A-1 and C-9) were conditioned. Eight DONET observatories in total are in operation. This has been a very excellent result for DONET project. We can expect several more observatories activation in the forthcoming cruise scheduled March 2011.

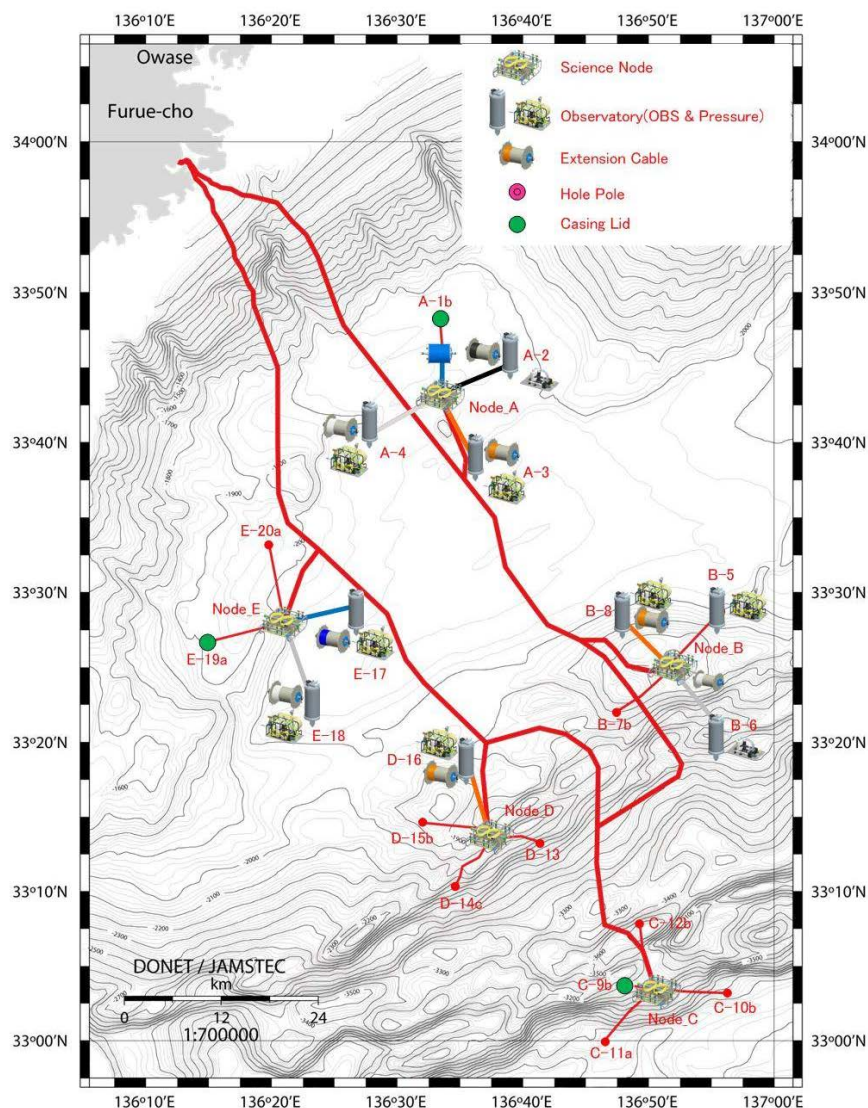


Figure 2 Status of DONET observatory after KY10-15 expedition

End of Report.