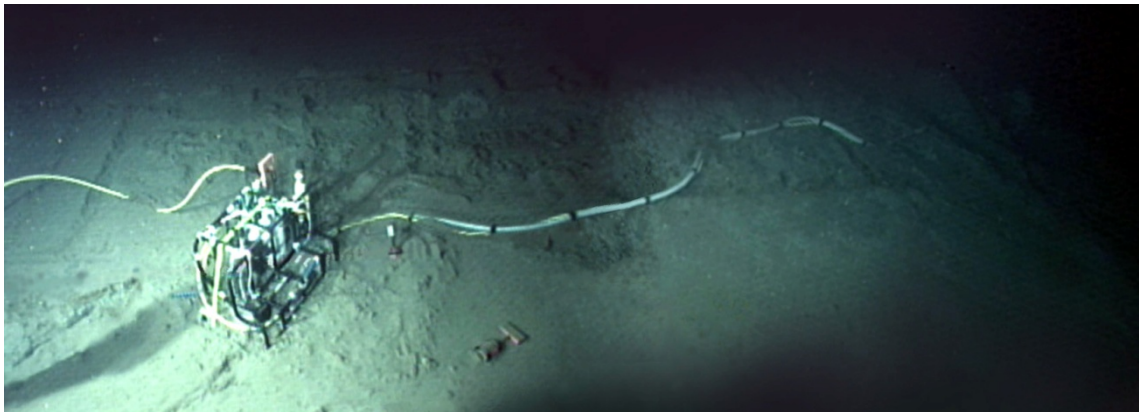


NT10-04 Cruise Report
KUMANO-NADA
DONET Node Installation & Observatory
Construction



March 2010

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1. Overview

A unique development program of submarine cabled real-time seafloor observatory network named DONET is put into practice in Japan. This program has aimed to establish the technologies of large scale real-time seafloor research and surveillance infrastructure for earthquake, geodetic and tsunami observation and analysis. The first phase of this program has been carried out since 2006 to settle on To-Nankai region in Nankai trough as the target of observation. The initial plan scheduled to install twenty sets of complex cabled observatories to cover the active seismogenic zone of To-Nankai earthquakes. A precise earthquakes monitoring infrastructure that has the performance equal with the earthquakes observation network on land can be prepared when there are observatories of this number on the seafloor at To-Nankai region.

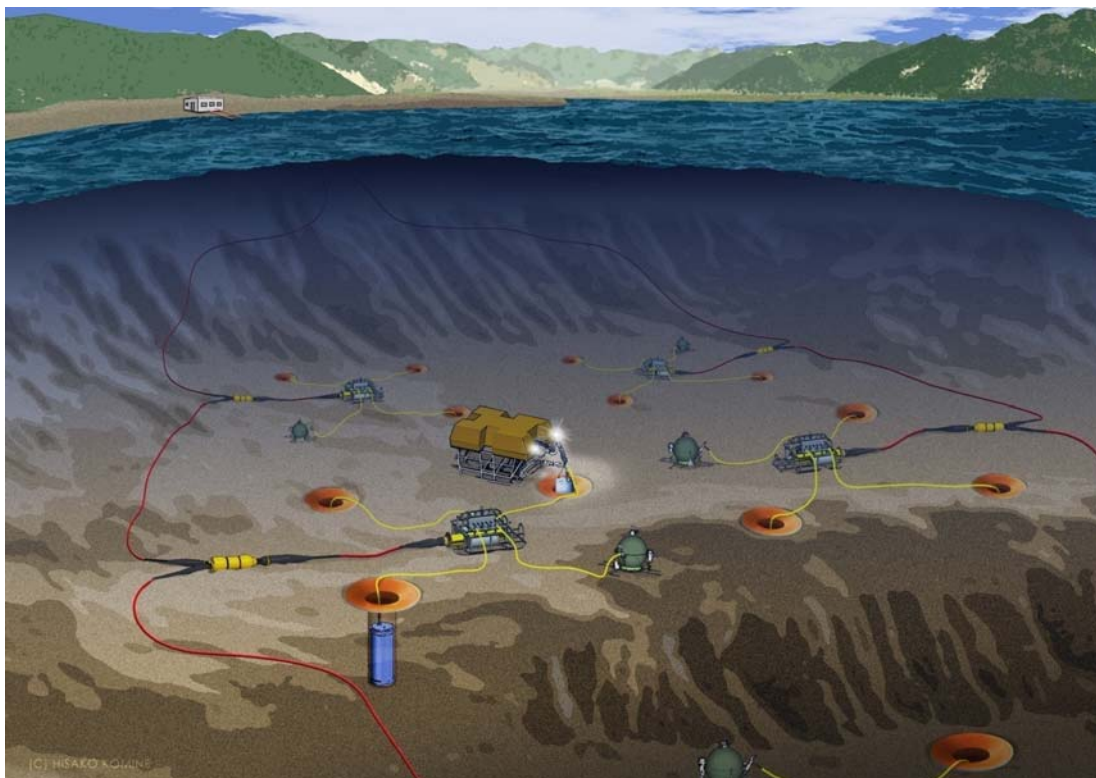


Figure 1 An Image of DONET cable observatory

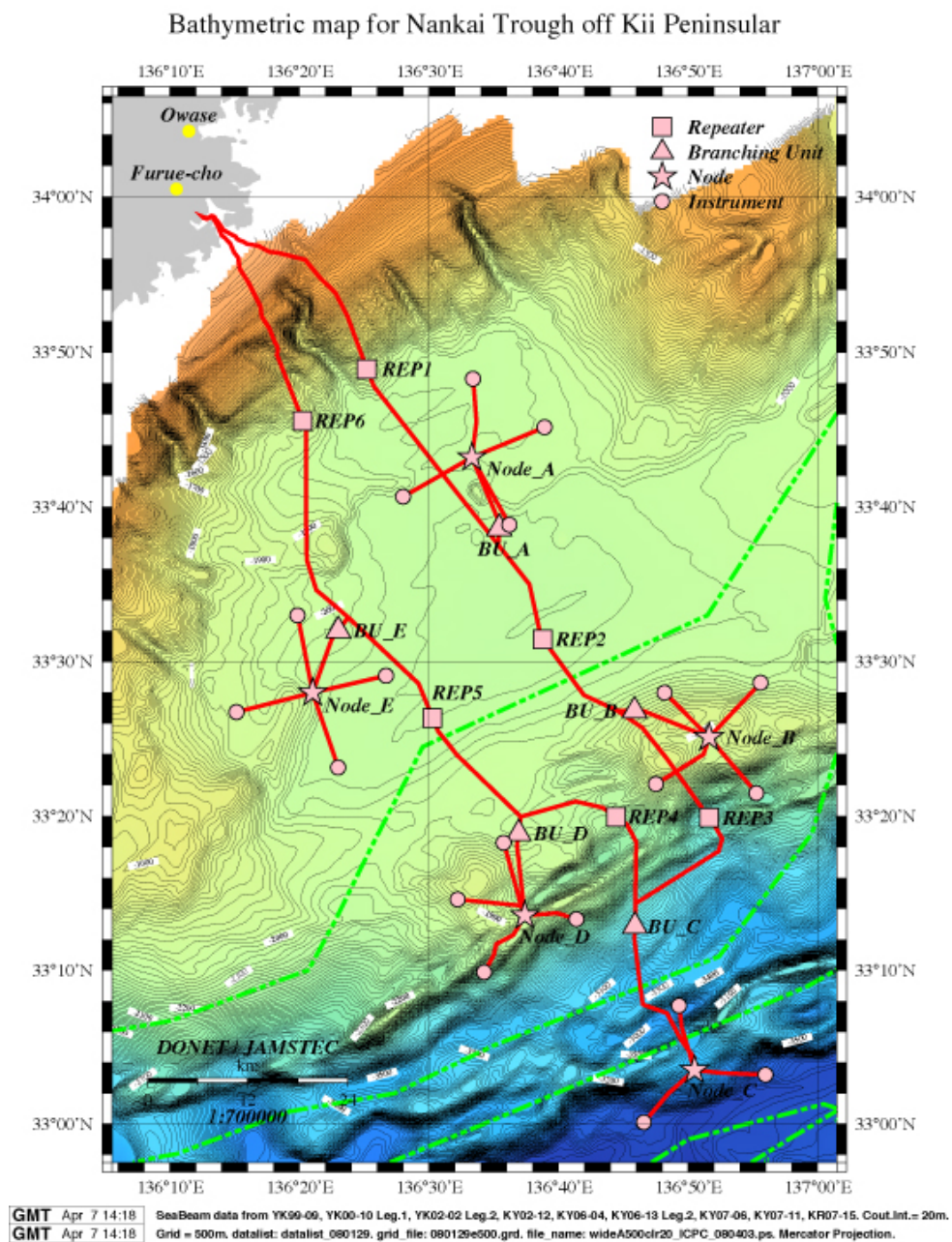


Figure 2 DONET backbone cable route and observatory & node position

The observatories deployed on the seafloor are connected to one of the five hub systems (science node) in backbone submarine cable system as star formed topology. An originally designed thin submarine cable (extension cable) will be secured the point-to-point power distribution and communication channel between observatory and science node. The electrical and fiber optical hybrid underwater mate-able connectors fitted up the both end of the thin submarine cable make possible the maintenance or replacement of observatories on the seafloor without difficulty. Approximately 10km length of extension cable is essential for each point-to-point connection to acquire proper observatory arrangement. In addition, it is necessary to connect the two accurate locations on deep seafloor with only several to a few tenth meters position error margin. Because of the conventional cable laying method by laying ship is not fit for this kind of operation requirement, a ROV (Remotely Operated Vehicle) based thin submarine cable laying method is contrived for seafloor observatory construction.

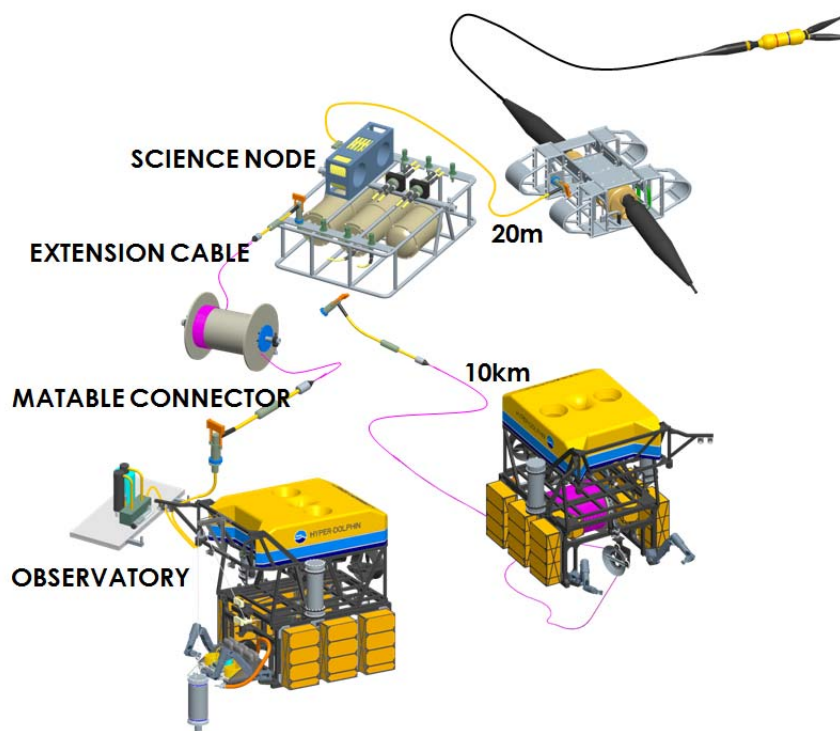


Figure 3 A Scenario of DONET Observatory Construction

The cable laying ROV is remodeling of ROV Hyper Dolphin for loading 10km length of extension cable and make possible to laying a cable between any two points on seafloor. The cable laying system is composed of three main components these are cable bobbin elevator, tension controlled extension cable pay out system, and VBCS (variable buoyancy control system). The cable bobbin elevator make possible to equip and release the cable bobbin together with 10km length of extension cable in air and water. The elevator works by the supplied hydraulic power from ROV. It is generate one ton of pulling torque that is a sufficient power to lift the cable bobbin of 650kgf in air. The cable bobbin is fixed to the chase of cable laying system with the pair of stab rod when operating.

The cable payout system can control the cable payout speed voluntarily to manage the reasonable cable slack correspond to laying course or undulated seafloor terrain. The slip roller and bobbin break mechanically managed the cable payout tension 30kg constant. It is suits for the 100kg that is a designed value of extension cable breaking strength to prevent unexpected restrict of ROV on seafloor with extension cable.

The ROV hyper-dolphin has the 100kg of buoyancy compensate capability in water using vertical thrusters. However, this number is not sufficient for the cable laying operation which buoyancy variation during the cable pay out and wind up operation is 180kg. The VBCS is composed of a pair of 50L volume pressure resist water tank to compensate the up to 100kg of buoyancy variation in water to maintain the mobility of the ROV in operation.

In addition to these main components, cable laying ROV comes to be able to conduct cable recover operation by equipping it with a cable traverse actuator. Each component actuated by the hydraulic pressure distributed by the ROV hyper dolphin hydraulic interfaces for user payload.

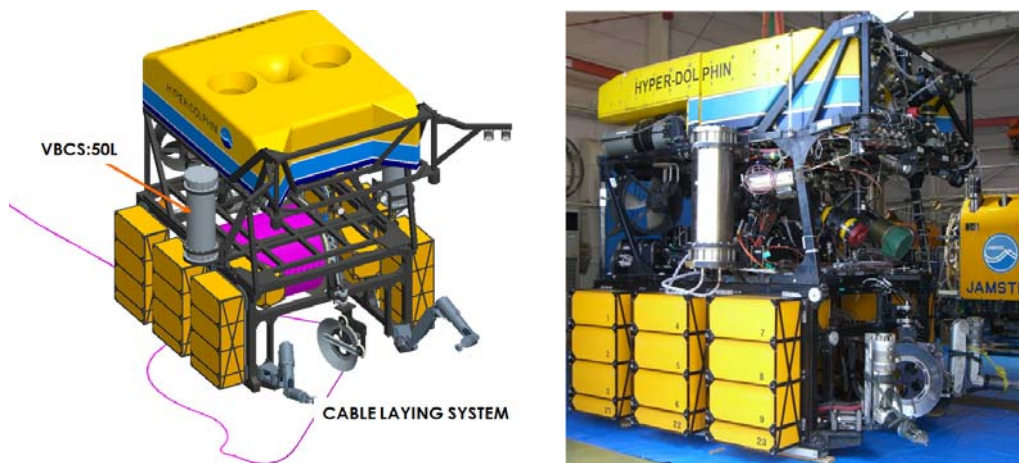


Figure 4 Cable Laying ROV

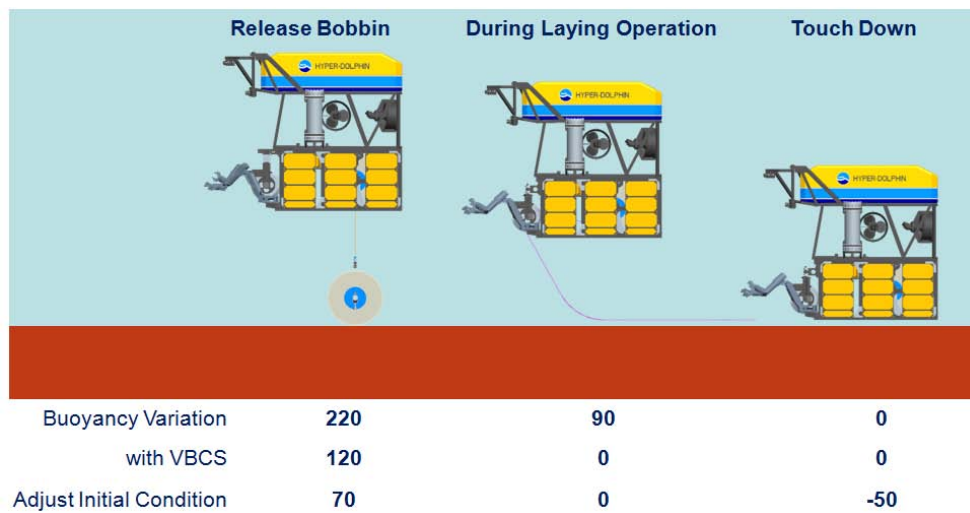


Figure 5 Estimation of Buoyancy Variation

As the pre cruise operation of NT10-04, the cable ship KDDI Pacific Link (KPL) conducted DONET backbone cable system installation from January to early March 2010. Approximately 300km length of submarine cable, six repeaters, five branching unit (BU), and five termination unit (TU) were installed to the seafloor in the construction. The final major component of backbone cable system in installation schedule was touchdown on the seafloor on February 23th 13:47 (JST). Four hours later on the touchdown, all functions and performance of backbone cable system were tested and confirmed from DONET landing station at Furue-cho Owase, Mie prefecture. The submarine cable laid on the up to 1,000m depth of shallow water area was buried into the sedimentary layer by the ROV (MARCAS III on KPL) after the installation (PLIB: post lay inspection and burial). The KPL complete the PLIB on March 8th and announced the end of DONET backbone system construction.



Photo 1 Loading of DONET backbone cable system



Photo 2 Landing a cable end at Kata-bay, Furue-cho Owase



Photo 3 Installation of Termination Unit



Photo 4 Repeater on Drum Cable Engine



Photo 5 Branching Unit on Deck

2. Schedule

In NT10-04, eight ROV dives were originally scheduled for the first DONET node installation and observatory construction. The time window of this cruise was March 4th to 14th 2010. The summary of NT10-04 is listed the table below.

Table 1 Summary of NT10-04 Cruise

Date	Place	Action
4-Mar	Yokosuka	Embark at JAMSTEC Yokosuka HQ
5-Mar	Suruga-bay	Evading Navigation
6-Mar	Kumano-Nada	Dive #1083: Science Node Installation
7-Mar	Kumano-Nada	Dive #1084: Dorothy operation test at Owase deep seawater sampling facility site.
8-Mar	Mikawa-Bay	Evading Navigation
9-Mar	Mikawa-Bay	Evading Navigation
10-Mar	Mikawa-Bay	Evading Navigation
11-Mar	Kumano-Nada	Dive #1085: Observatory Construction
12-Mar	Kumano-Nada	Dive #1086: Cable Laying Operation
13-Mar	Singu port	ROV Maintenance
14-Mar		Disembark at Singu Port

3. Dive Summary

Dive 1083

March 6th 2010. The first DONET science node installation was conducted in this dive. The science node is fixed to the chase of cable laying system with the pair of stab rod as [photo 6](#). The weight of the science node is 420kg in air / 189kg in pure water. The assistance of VBCS (buoyancy control) is indispensable for the UMC (underwater mateable connector) mating operation after install the node on seafloor. The target site for node installation is area “A”. The target touchdown point was TU-A (termination unit A: 33-43.20N, 136-33.300E, [ROV homer ID: 23](#)), it is a position estimate by the cable laying ship KPL when she install the equipment on the seafloor. The dive started 10:30 and arrived at 2027m depth of seafloor 11:34. The ROV towed the target touchdown point but could not found the TU at the position. We found that the information from cable ship has large position error that we not expected. The ROV homer ID: 23 indicate 300m distance at the target point, Hyper Dolphin approach to the TU-A using this homer information ([Photo 7](#)). 11:53, the vehicle found the submarine cable on the seafloor and finally found the TU-A at 11:54. The ROV make a landing 16m away from the TU-A, fill up the water in the VBCS then release the science node from cable laying system at 12:34 ([Photo 8](#)).

The position of science node is

[ID: Node-A010: 33-43.349N, 136-33.209E, 2009m](#)

After release the science node, the vehicle carried out the high voltage UMC on the node and connected it to the TU-A UMC interface at 13:37 ([Photo 9](#)). Immediately after the connected operation, the physical condition of installed science node was tested from the node control interface in landing station at Owase. The DONET engineering development group and HPD operation team succeeded in installing the first DONET science node on seafloor.



Photo 6 ROV HPD loaded Science Node

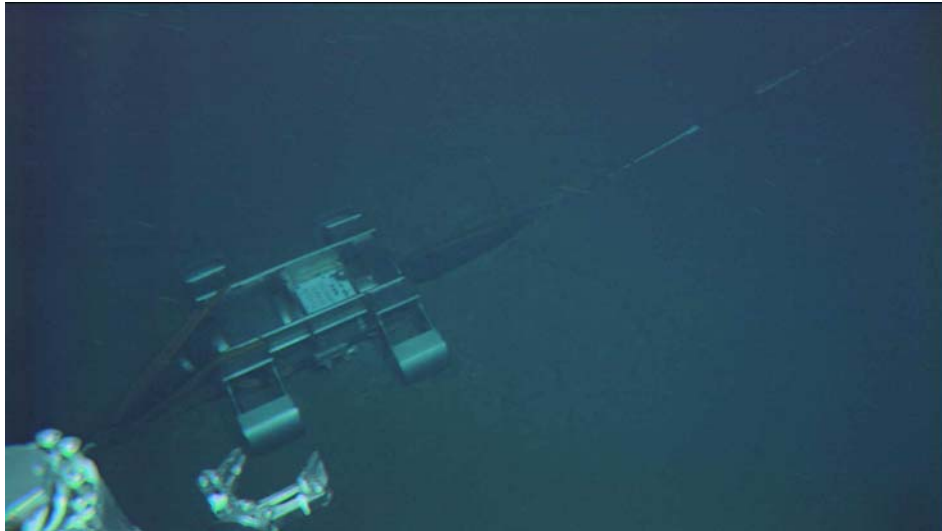


Photo 7 TU-A on the seafloor

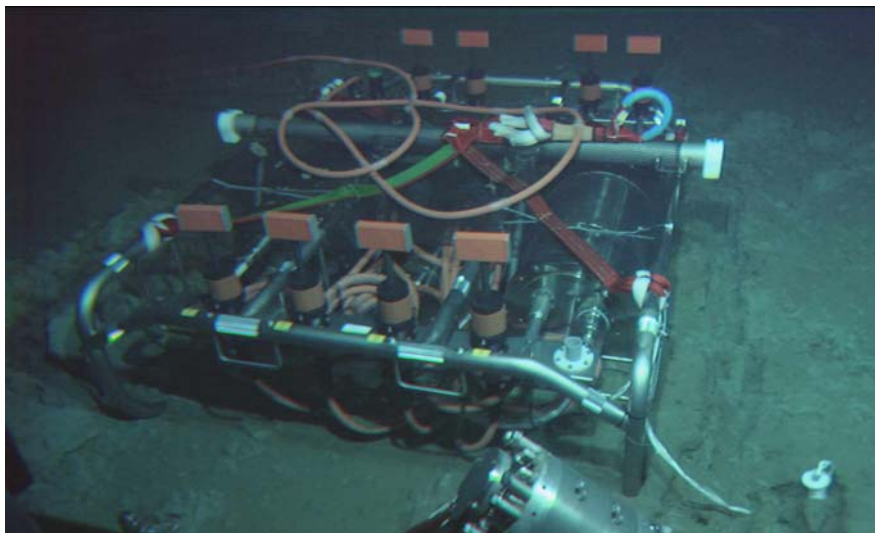


Photo 8 Installed science node on the seafloor

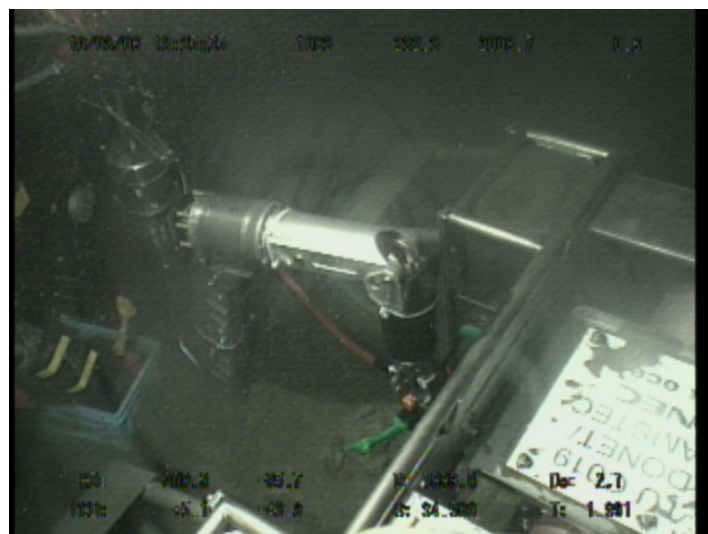


Photo 9 Science node and TU connecting operation

DIVE 1084

March 7th, this is a preliminary dive to check the DOROTHY pump system is operational. The original dive schedule (observatory installation) was postponed by spring storm. The mother ship R/V Natsushima shifts the location to the coastal area and looking for the site to fit for the experiment. The water intake of deep seawater sampling facility (33-54.279N, 136-18.194E, 415m) was selected the target point of this dive. The HPD landed the surface at 10:19 and arrived at the seafloor 10:47. 11:09 HPD found the water intake by the obstacle avoidance sonar and touchdown in front of the structure (Photo 10,11).

The location is

33-54.289N, 136-18.190E, 411m

The DOROTHY test run was conducted few minute beside the structure (Photo 12). After the test run HPD observed the condition of the water intake and pipe line of deep seawater sampling facility as photo 13 then leave the seafloor at 12:51.

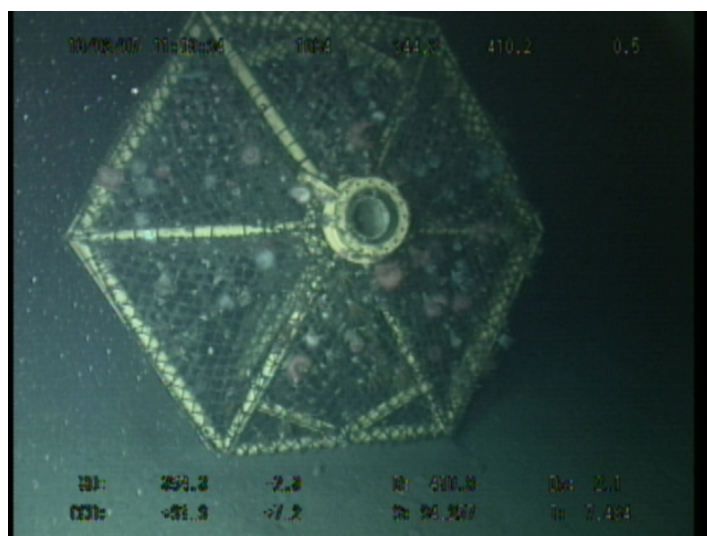


Photo 10 Front view of water intake of deep seawater sampling facility



Photo 11 Close up of water intake

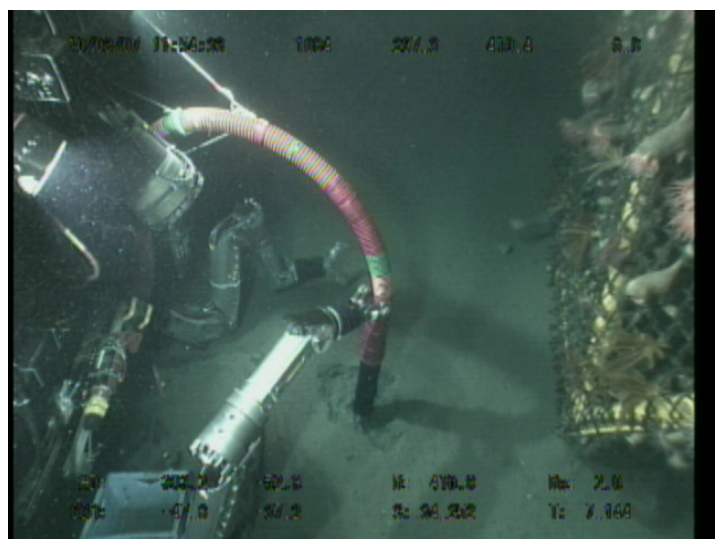


Photo 12 DOROTHY test run



Photo 13 Side view of water intake

DIVE 1085

March 11th, after the spring storm go through the Kumano-nada, DONET observatory construction was conducted in HPD dive 1085. The target site is A-3a where is a place installing the casing by R/V Kaiyo KY10-03

A-3a: 33-38.904, 136-36.227E, 2065m, HomerID: 65.

The observatory (ground motion sensing system and pressure sensing system), six sand bags for fix the ground motion sensing system in burial casing, and DOROTHY pump system are fixed to the chase of cable laying system as [Photo 14](#). The weight of the install components are ground motion sensing system: 156kg in air / 70.5kg in pure water, pressure package: 61kg in air / 22kg in pure water, sand bag (6): 90kg in air / 30kg in pure water. The HPD start to descent 8:16 and arrived at 2060m depth of seafloor at 9:30. 9:52, HPD approached the casing A-3a following the homer ID 65 and sat beside of the homer. From 10:01, HPD start to open a burial hole using DOROTHY ([Photo 15](#)) and complete to open the hole at 12:02 ([Photo 16](#)). 12:25 HPD adjusted the relative position between ground motion sensing system and burial hole then completed to install the system into the hole at 13:56 ([Photo 17](#)). The pressure sensing system was extended 10m north from burial hole and set it on the seafloor as [Photo 18](#) (14:30).

The final position of A3 observatory is;

Ground motion sensing system: 33-38.905N, 136-36.220E, 2063m, HomerID: 65

Pressure sensing system: 33-38.911N, 136-36.210E, 2063m, HomerID: 54

The HPD had not enough time to bury the ground motion sensing system using fine sand in this dive. The 6 sand bags carried by the HPD placed to the next of ground motion sensing system for future burial operation. The HPD confirmed the condition of constructed observatory and ascent to surface at 15:35.



Photo 14 DONET observatory on HPD



Photo 15 Burial hole maintenance by DOROTHY



Photo 16 Condition of burial hole

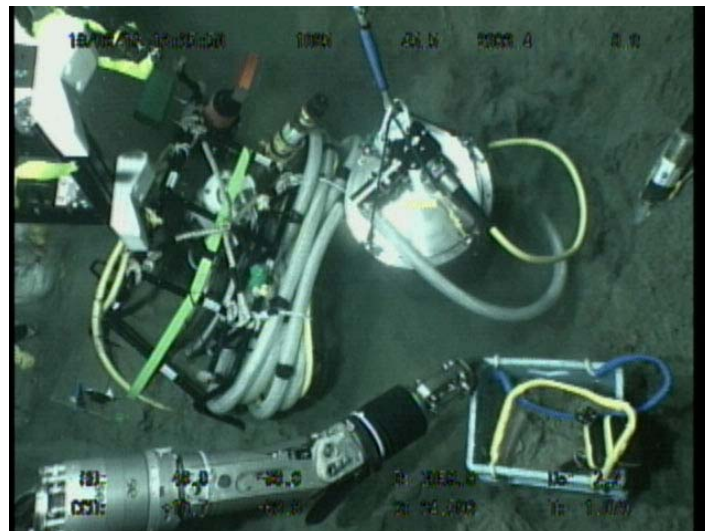


Photo 17 Ground motion sensing system installation



Photo 18 Pressure sensing system installation

DIVE 1086

March 12th, the day after the observatory construction, HPD conducted extension cable laying operation between node A and observatory A3. 10.6km length of extension cable was wound up into the cable bobbin and set in the cable laying system (Photo 19). The weight of each component is extension cable: 501.4kg in air / 182kg in pure water, cable bobbin: 137.4kg in air / 47.1kg in pure water, UMCs: 26.3kg in air / 13.6kg in pure water. The distance from node A to observatory A3 is approximately 9452m calculated by horizontal cross section of bathymetric data. The start and the end point of this operation is listed follows,

Start point (Node A): 33-43.344N, 136-33.215E, 2009m

TU-A (16m from Node A): 33-43.344N, 136-33.209E, 2009m, Homer ID: 23

End point (Pressure sensing system A3): 33-38.19N, 136-36.210E, 2063m, Homer ID: 54

The HPD start to descent 6:44 and arrived at TU-A 7:51. At 8:00 HPD landing the next of node A and connected extension cable end UMC to the user port No.3 in node A (Photo 20). The HPD step back 30m to pay out the initial extension of cable end and then start the 10km length of extension cable laying operation face to observatory A3 at 9:01 (Photo 21). HPD used VBCS to compensate the buoyancy variation from 3000m extension cable payout at 12:08 (to 50%) and 8000m payout at 15:55 (to 70%). 18:12, the vehicle fill up the VBCS 100% at the final destination of observatory A3 and release the cable bobbin to the seafloor from cable extension system (Photo 22, 23). The final extension of extension cable was took out from the side wall of cable bobbin and connected the observatory interface on pressure sensing system as Photo 24 (19:10). Right after the connection, the observatory was successfully boot up from landing station and start to acquire a data set of initial condition (Photo 25). The result of laid cable length is 9800m it has the 4% of cable slack in average the operation.

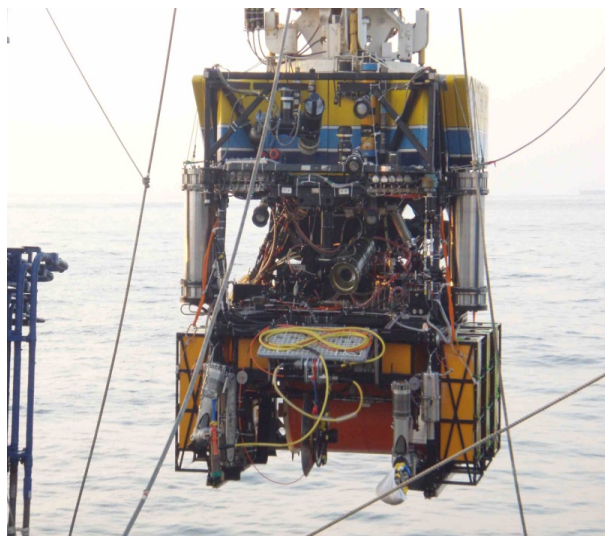


Photo 19 HPD equipped 10km length of extension cable in cable extension system

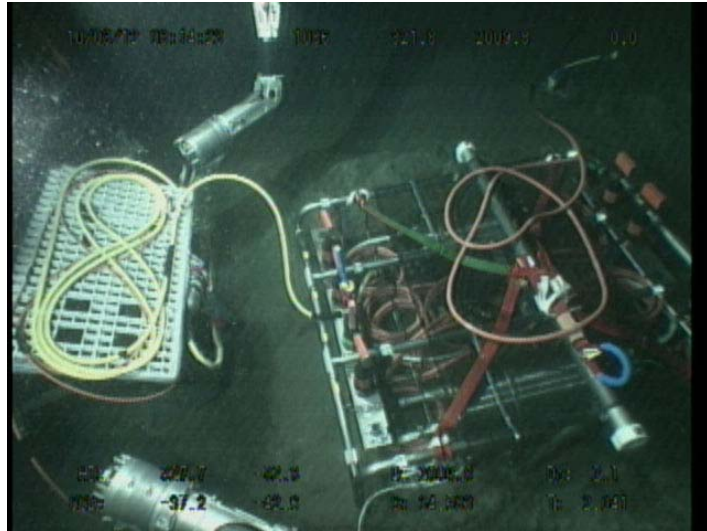


Photo 20 Connected extension cable end UMC to the user port No.3

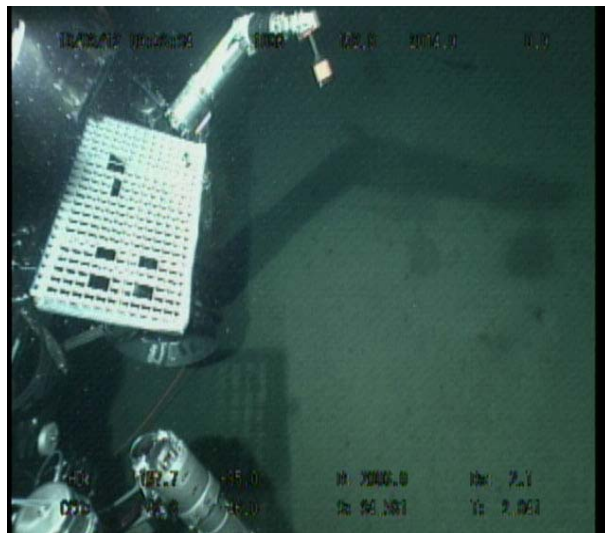


Photo 21 Cable extension in operation

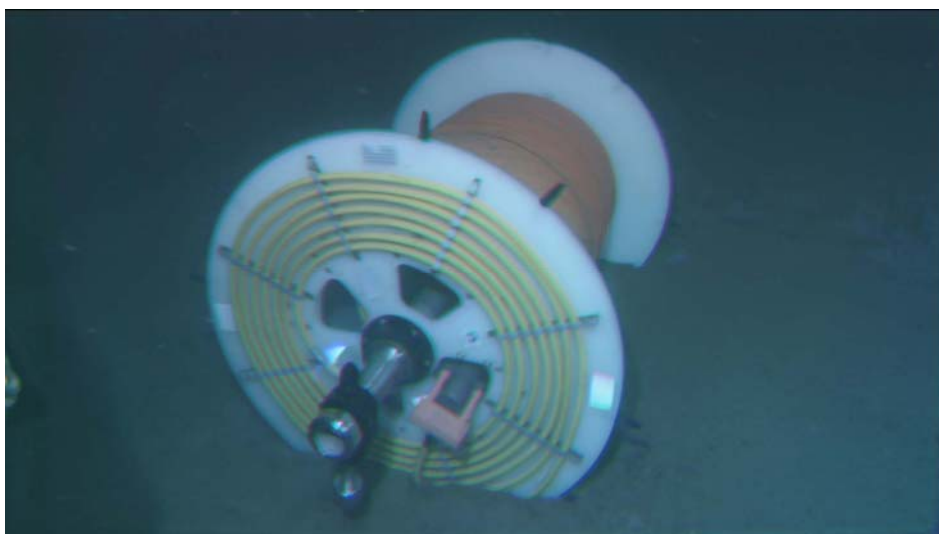


Photo 22 Release the cable bobbin to the seafloor

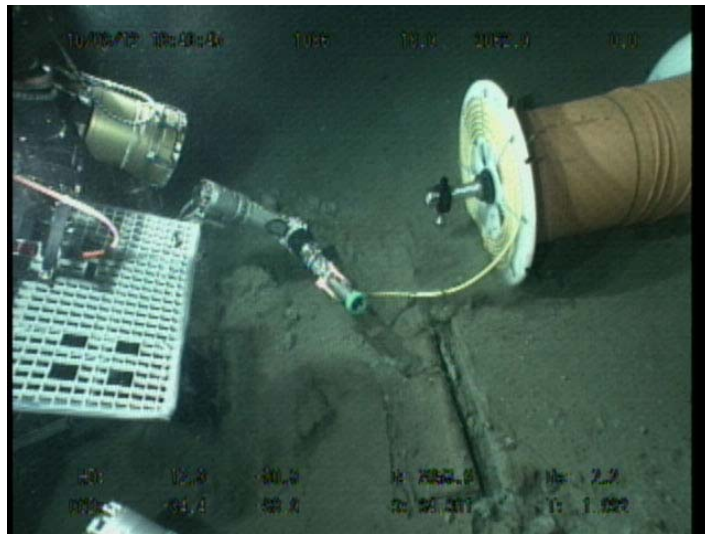


Photo 23 Take out final extension of extension cable from bobbin



Photo 24 Connected extension cable end UMC to the pressure sensing system

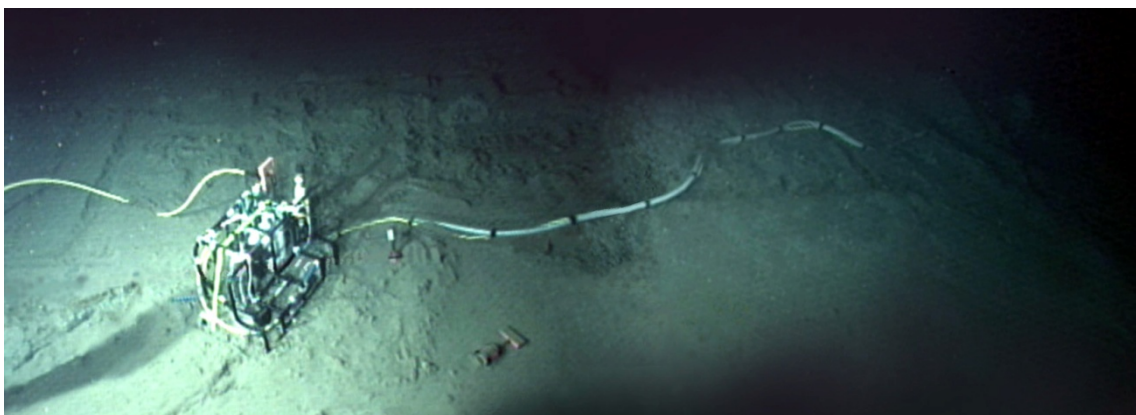


Photo 25 Completion of first DONET observatory

4. Concluding Remarks

NT10-04 originally scheduled 8 ROV dives but only 3 dives were able to be conducted in the stormy spring weather at Kumano-nada. The expedition became to an end by the dive#1086 March 12th. However, researchers successfully demonstrate the observatory construction method of DONET in this short duration and also the qualities of the initial data were contents that satisfied the researchers sufficiently.

The construction of other science nodes and observatories are scheduled in the ship time of JAMSTEC research fleet in coming fiscal year.

End of report....