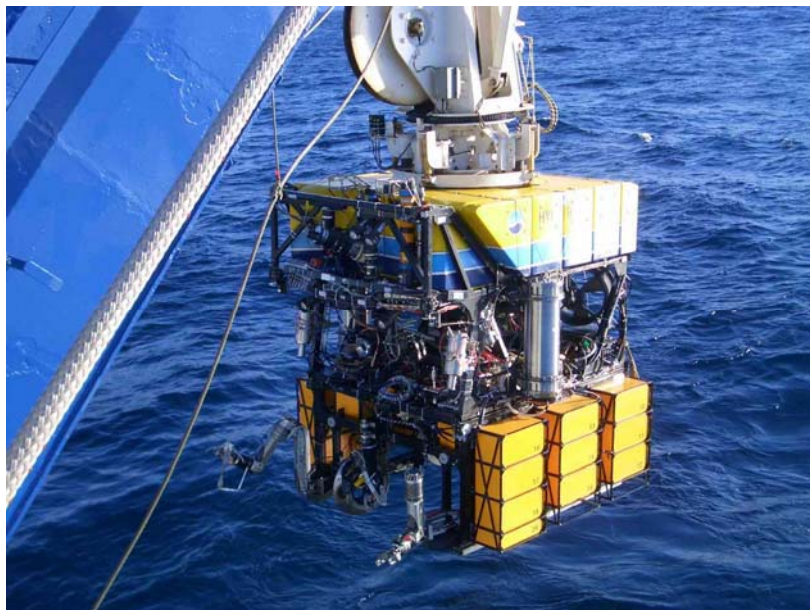


NT09-21 Cruise Report
SURUGA-BAY
Cable Laying Experiment / VBCS Function Test



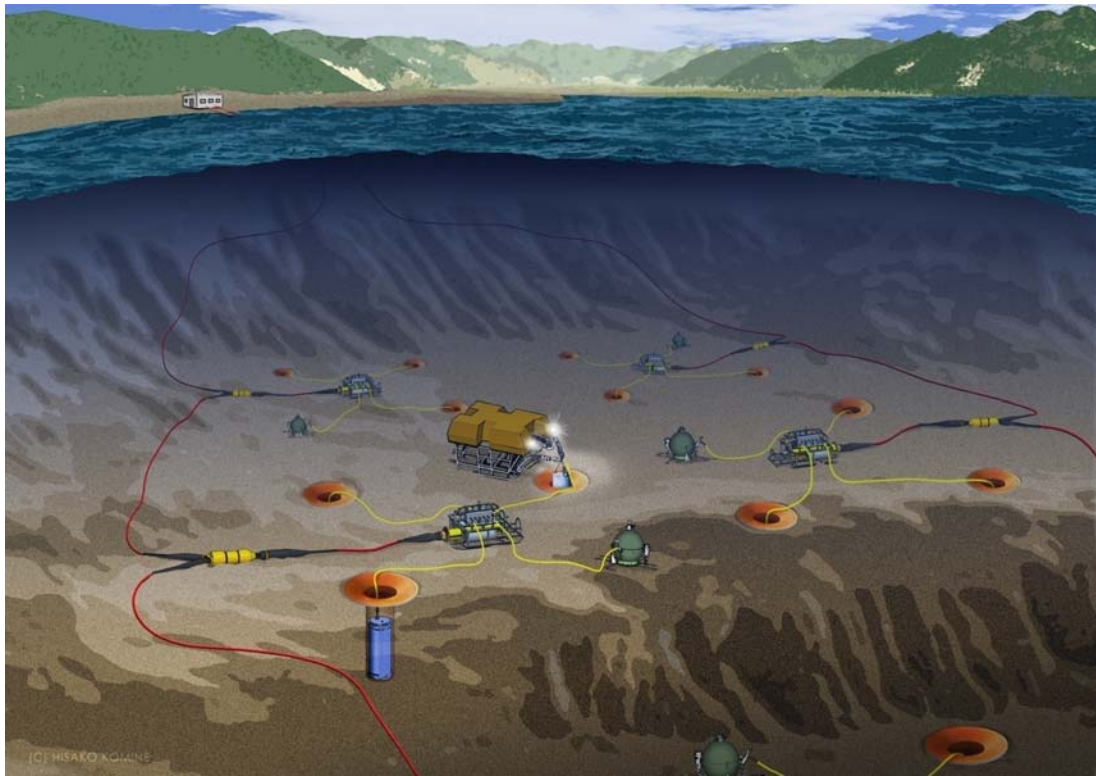
December 2009

Table of Contents

1. Overview
2. Schedule
3. Dive Summary
4. Concluding Remarks

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 monitoring 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.



Figurer 1 An Image of DONET cable observatory

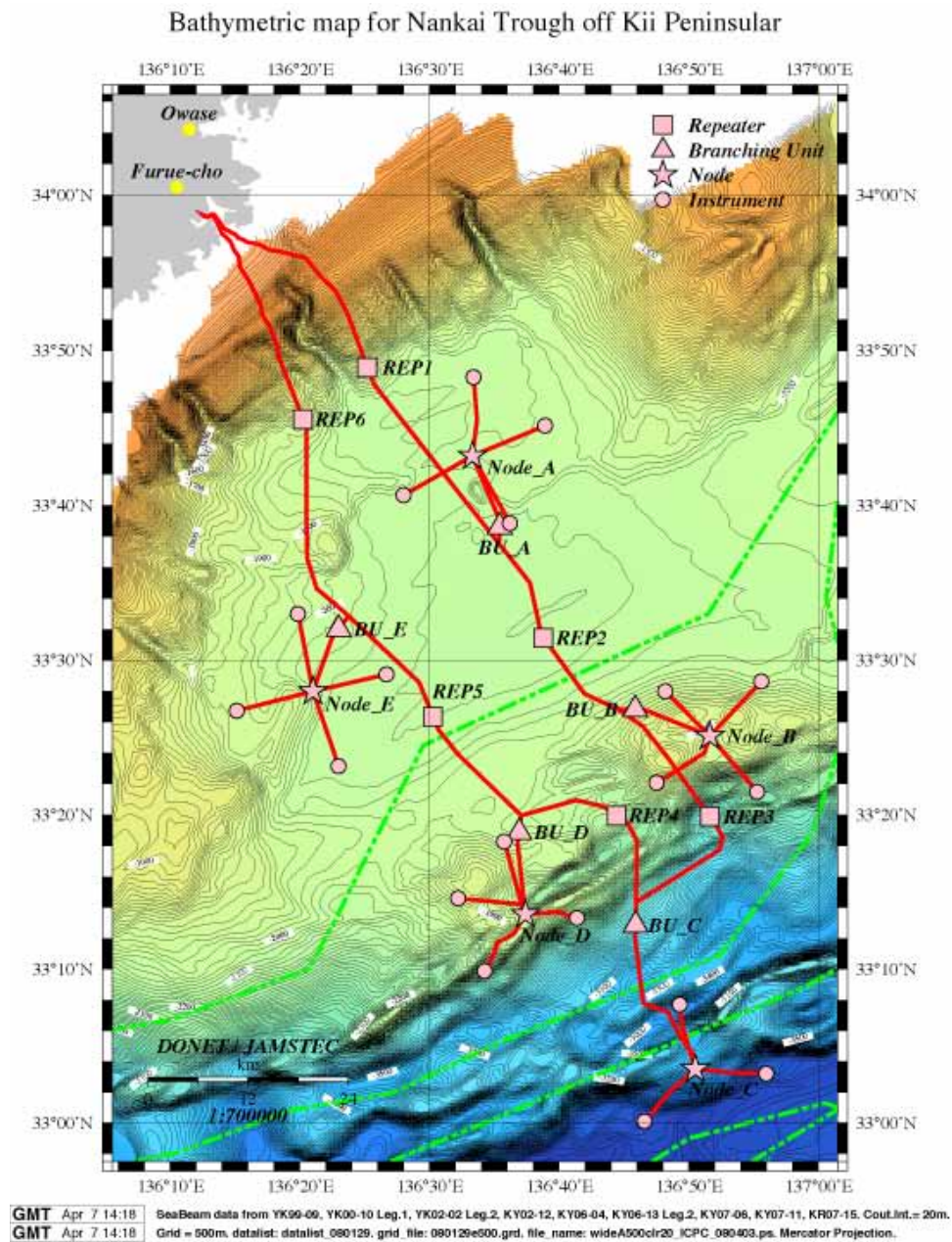


Figure 2 DONET backbone cable route and observatory & node position

The observatories deployed on the seafloor are connected to one of the five hub systems (science node) in backbone submarine cable system with a point-to-point link as star formed topology. An originally designed thin submarine cable (extension cable) will be secured the point-to-point power distribution and communication channel. 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.

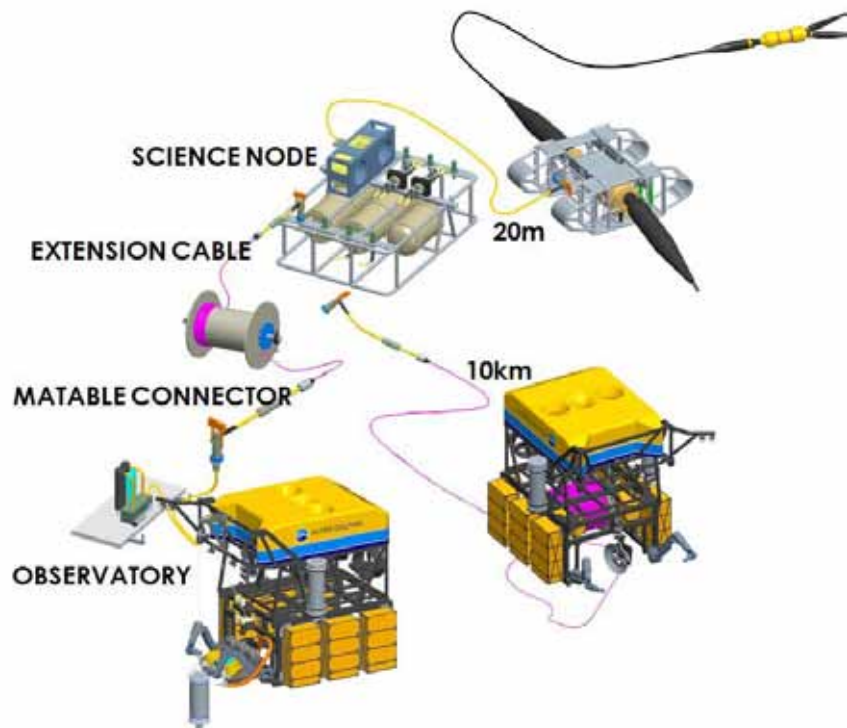


Figure 3 A Scenario of DONET Observatory Construction

The cable laying ROV is remodeling of Japanese research 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

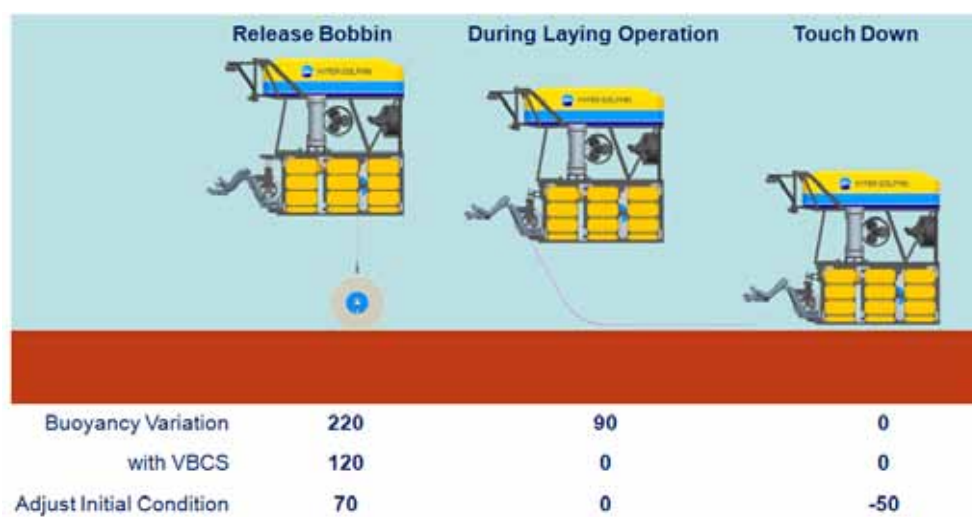


Figure 5 Estimation of Buoyancy Variation

2. Schedule

NT09-21 is a four times dive cruise for engineering experiment of ROV cable laying system and VBCS. R/V Natsushima leave JAMSTEC at 21st December. Originally, researchers schedule to dive from 22 to 25th at the Suruga Bay, but unfortunately it has a heavy weather day in this duration. R/V Natsushima can arrange only 3 days for four dives schedule. On board researchers make a change in original schedule to minimize the experimental item list as following table.

Table 1 Summary of NT09-21 cruise

Date	Place	Actions
Dec. 21	Departure from JAMSTEC	—
Dec. 22	Suruga Trough	Hyper-Dolphin Dive #1070: Cable laying operation
Dec. 23	Suruga Bay	Cancelled due to heavy weather Overhaul of VBCS
Dec. 24	Suruga Trough	Hyper-Dolphin Dive #1071: Cable bobbin recovery
Dec. 25	Suruga Trough	Hyper-Dolphin Dive #1072: Confirm the condition of cable laying start position. #1073:VBCS performance test
Dec. 26	Enter Shimizu port	—

3. Dive Summary

Dive 1070

Cable laying experiment was conducted in the dive 1070. ROV Hyper Dolphin (HPD) equipped cable laying system, VBCS and a cable bobbin that loaded 7km length of extension cable. The weight of cable bobbin was adjusted 666kgf in air and 228kgf in seawater (Specific Gravity: 1.034) by using steel weigh, that is a number of actual 10km laying operation. In this dive, HPD landing on the 900m depth of seafloor in the middle of the Sagami Bay (34-43.99N, 138-38.20E) at 09:13. After the landing, HPD set the cable end anchor to the seafloor at 09:36 and start the cable laying face to west at 10:09. HPD kept the cable payout speed approximately 900m/h constant and close the operation at 14:47. During the operation HPD successfully payout the 4km length of extension submarine cable on the seafloor and confirm the stable performance of cable laying system. After the operation, HPD release the cable bobbin on the seafloor (34-43.986N, 138-35.221E) then complete the experiment 15:57.

HPD originally schedule to adjust the buoyancy using VBCS when the vehicle releases the cable bobbin in this dive. However, it is not work certainly on the 1800m depth of seafloor this time. Because of the wrong fitting arrangement of VBCS, the canister of water filter had damaged when the HPD test the behavior of VBCS at the 900m depth during the descent operation. The problem is very clear to observe the HPD on deck, a countermeasure was work out for next HPD dive.



Photo 1 Cable Laying System



Photo 2 Cable End Anchor

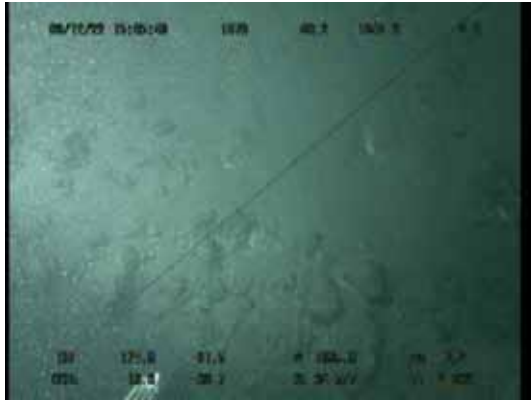


Photo 3 Extension Submarine Cable



Photo 4 Cable Bobbin on the Seafloor

Dive 1071

Cable recovery operation was conducted in this dive. The cable laying system was modified to recovery operation setup (added cable traverse actuator on the system) and descent to the end point of dive 1070. It takes about 30 minute to search the cable bobbin on seafloor and ROV landed by the side of cable bobbin at 11:27. HPD capture the cable bobbin shaft using quick catch and release mechanism of cable bobbin elevator. Because of the end point of dive 1070 has an unexpected complicated terrain, the cable bobbin tumbling on the slop and the extension cable itself got entangle in cable bobbin in the accident. It is assumed to take time to solve the accident, cable recovery was giving up during this dive. Only cable bobbin was recovered in this dive. The extension cable that remains at the seafloor can be recovered later using same cable laying system setup. The HPD leaved the seafloor 13:30 and accent to surface. Using this time widow, VBCS performance test was conducted 1750, 1000, 500 and 100 depth pressure environment.



Photo 5 cable traverse actuator

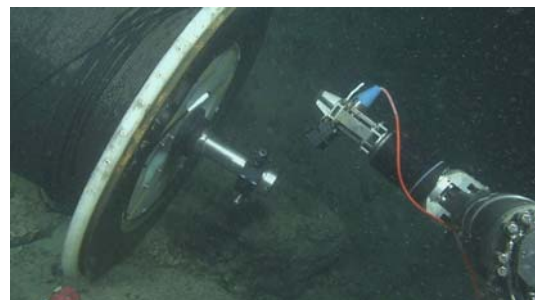


Photo 6 quick catch and release mechanism



Photo 7 Recovery cable bobbin

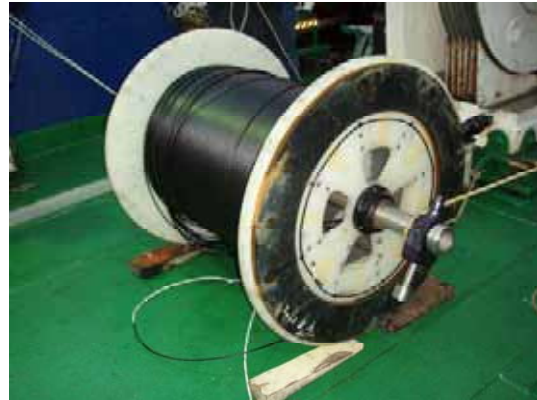


Photo 8 Recovery cable bobbin -2

Dive 1072

It is difficult to make a time to do the 4km length of extension cable recovery operation, the determination of laid cable route position was indispensable operation in this cruise. The dive 1072 is a half day dive to find and mark the cable laying start position carried out Christmas 2009. The extension cable on the seafloor was easily found by HPD and put a marker beside the cable end anchor.

The location is

[34-44.008N, 138-37.768E](#)

After the marking of cable end point, the performance of prototype mini-transponder was tested short time in addition. On the way back to the surface, a VBCS performance test was implemented at 500m depth mid water column.

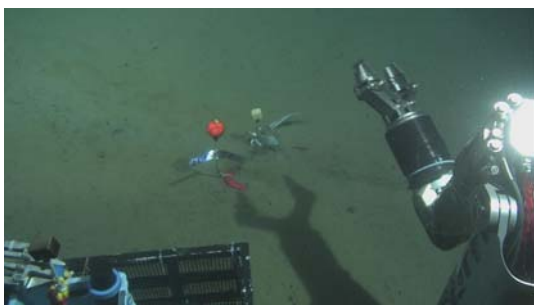


Photo 9 Cable End Anchor and Marker



Photo 10 Mini-transponder prototype

Dive 1073

Dive 1073 was a half day dive for VBCS deep water performance test. Right after the dive 1072, R/V Natsushima take a ship to southern part of Suruga Bay that water depth is 2300m. The HPD landed on the water at 13:01. The target point on the map is

34-38.1N, 138-35.3E. The VBCS pump in / out water test was conducted at 500, 1400, and 2300m water depth water column in this dive. The performance curve for VBCS buoyancy control can be draw by this experimental result as following figures

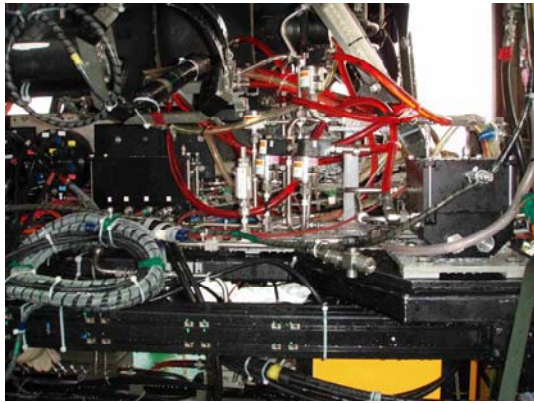


Photo 11 VBCS Actuator

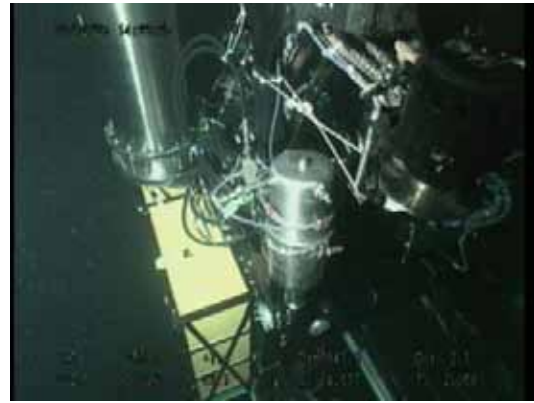


Photo12 VBCS in water



Photo 13 Outlet Flow Meter



Photo 14 Vehicle on surface

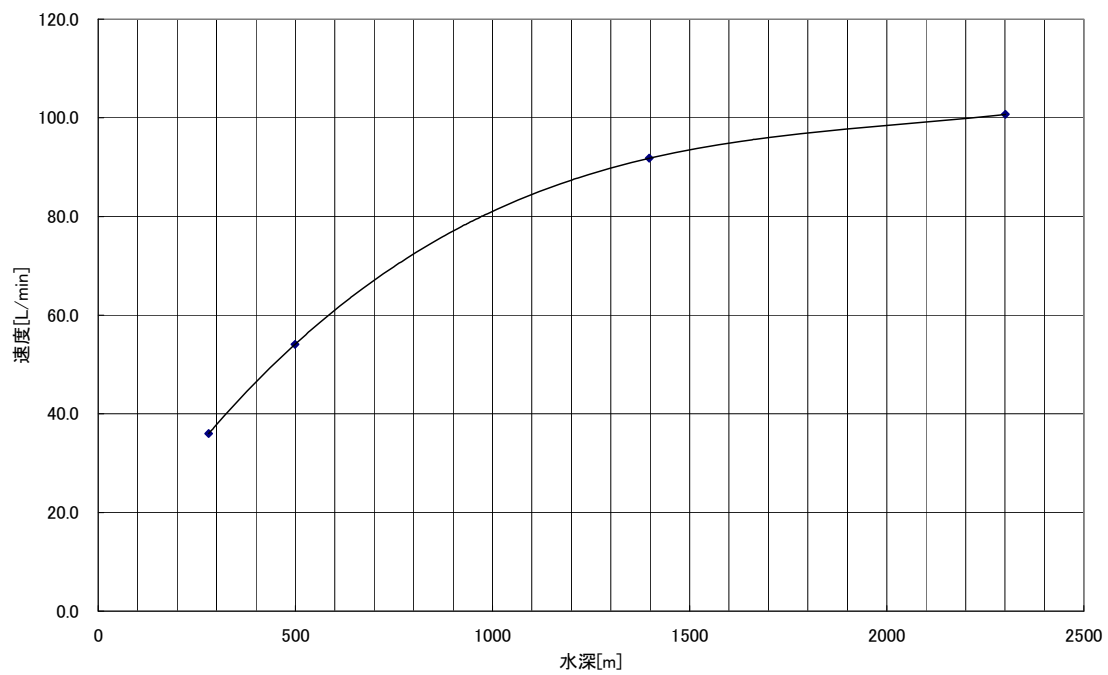


Figure 1 VBCS Pour Water Curve

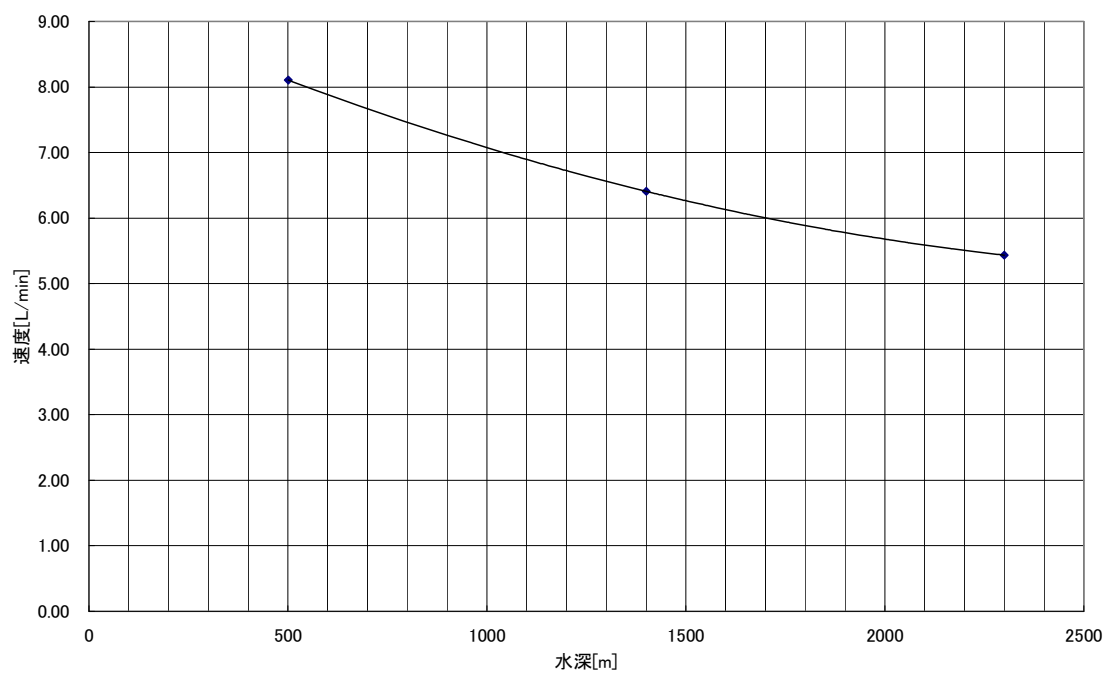


Figure 2 VBCS Drain Curve

4. Concluding Remarks

We conducted engineering experiment for ROV cable laying system and VBCS on the NT09-21 Cruise from Dec. 21-26, 2009. Following action item is confirmed in this experiment.

ROV cable laying system:

- * has a good performance to conduct extension cable laying on seafloor.
- * initial weigh in water setup and CG location set up need more consideration before actual DONET operation.
- * need to modify the operating oil pressure for stab pin actuator for cable bobbin and DONET node installation.
- * poor insulating resistance of DOME pan / tilt camera.
- * need to modify the shape of bobbin elevator guide
- * need to modify the bobbin elevator orange rope guide
- * need to repair orange rope surface scratch.

VBCS need to consider

- * modification of water filter design
- * make an addition of inlet flow regulator
- * poor insulating resistance of pressure sensor
- * poor insulating resistance of solenoid coil
- * consideration of flow meter setting
- * confirm the reliable action of solenoid valve
- * need to confirm the performance to 4500m depth

And additionally think about the

- * secure transfer of heavy weigh items on deck
- * reliability of vehicle lift-up actuator
- * HPD CG location on land and in water.
- * back stock of system component for actual DONET operation

-End of Report-