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CRUISE REPORT

KY12-11

R/V “Kaiyo”

September 2012

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. We have already developed seven cabled observatories 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 sucha s 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 network system by using sub-marine cable off Kii-peninsula, where the last mega-thrust earthquake named Tonankai earthquake was took place in 1944. The Headquarters for Earthquake Research Promotion in the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has estimated that the probability of the next Tonankai earthquake is 60 to 70 % in the next 30 years, because the recurrent interval of the plate boundary earthquake is approximately 100 to 150 years there. Thus, the offshore seismic monitoring system for the forthcoming Tonankai earthquake is urgently needed to mitigate future disasters form the earthquake and resulting tsunami.

The system to be developed contains twenty seismometers, twenty 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 postulated 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, in addition to developing the network system itself.

Natural events such as slumps, slides and turbidity currents on steep, sediment covered slopes, and earthquake events are risks to the network system in the deep-sea area in its lifetime. In the shallow area, on the other hand, the potential risks to the network system are from human related activities, specifically from bottom contact fisheries and large ships' anchors. There is also a smaller danger that dumping or dredging operations could harm a submarine cable. For the first step in the network system development, an in-situ survey and a risk assessment is necessary in order to find better observatory's sites and safer submarine cable route.

In the present R/V Kaiyo KY12-11 cruise, we carry out piston core sampling, bottom casing deployment, and the deep tow dive as a pre-survey for DONET construction off Kii-suido.

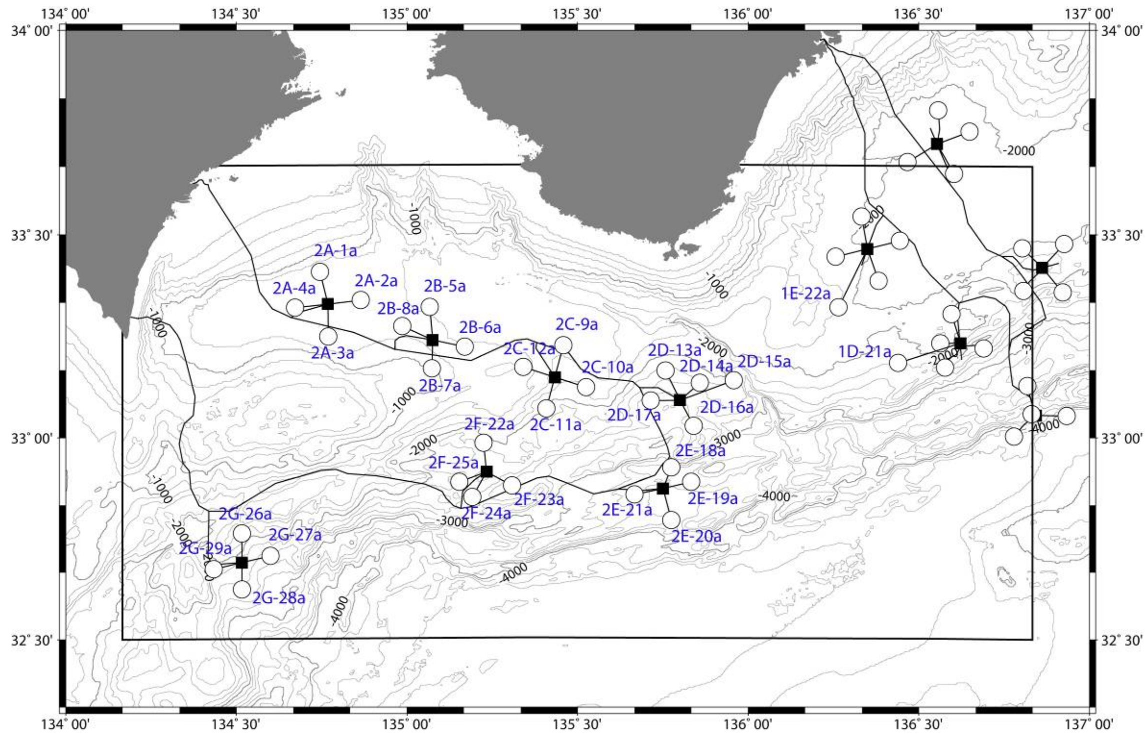


Figure 1 Map showing the deep-sea network observatory to be deployed off Kii-Peninsula. Circles and dots represent the observatories and the science nodes, respectively

References

Matsumoto, H. and Mikada, H. (2005), "Fault Geometry of the 2004 Off the Kii Peninsula Earthquake Inferred from Offshore Pressure Waveforms", Earth Planets Space, 57, 161-166.

Mikada, H., Mitsuzawa, K., Matsumoto, H., Watanabe, T., Morita, S., Otsuka, R, Sugioka, H., Baba, T., Araki, E., and Suyehiro, K. (2006), "New Discoveries in Dynamics of an M8 Earthquake -Phenomena and their Implications from the 2003 Tokachi-oki Earthquake Using a Long Term Monitoring Cabled Observatory-", Tectonophysics, 426, 95-105.

2. SURVEY EQUIPMENTS

2.1 Piston corer system

Piston corer system is sediment sampler that a core-pipe let be piled into the ocean bottom in order not to disturb the sedimentation. In the case that the pipe is piled into the ocean bottom, it disturbs the sample due to the friction between pipe and wall, and it would not be piled into deep layer. Piston corer, which is applied by free fall and inner piston makes us possible to pile the pipe deeper layer by means of the balance between busting into the sediment and suction of the sediment. Schematic figure of piston corer system is shown in Fig. 1.

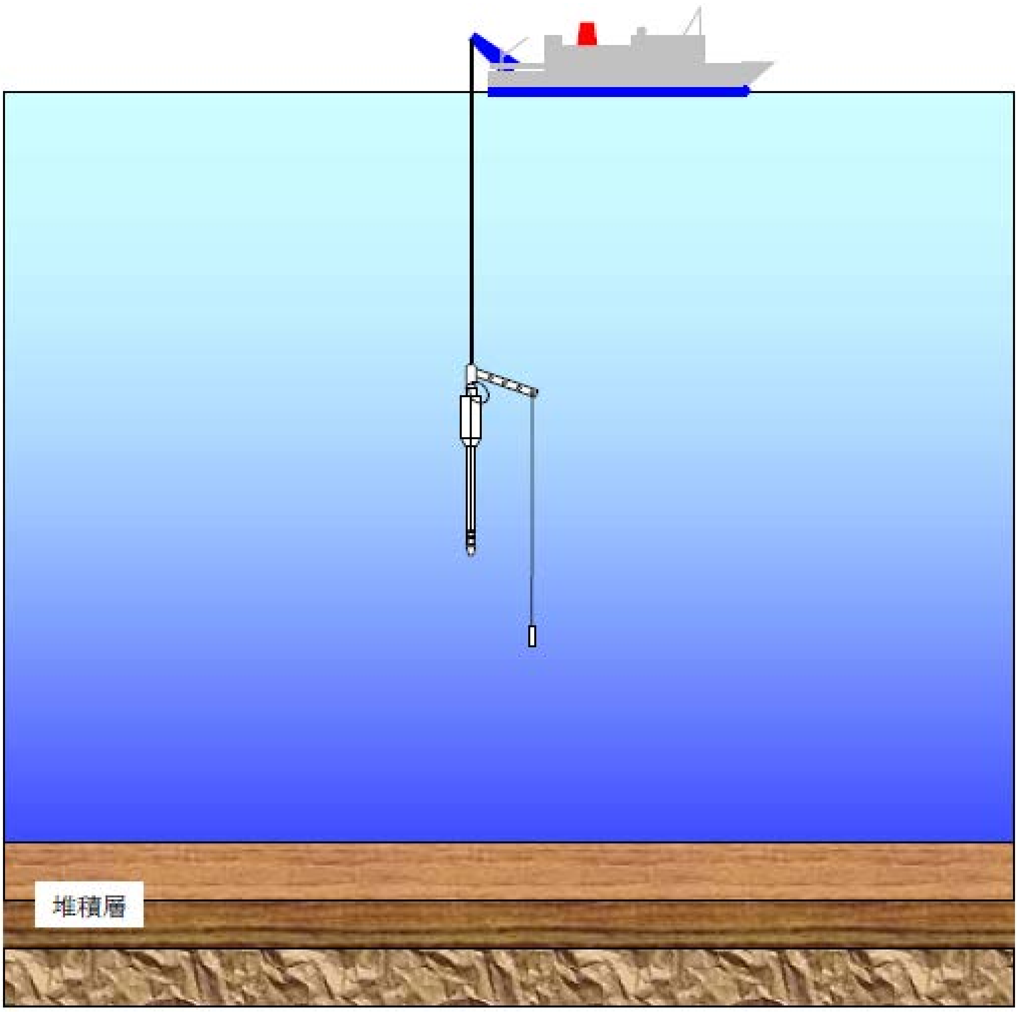


Figure 2.1 Schematic figure of piston corer system (source: JAMSTEC)

2.2. Bottom casing system

Seismic sensors attached with the network system will be buried below the seafloor. The platform for the seismic sensors is designed as a borehole. We call the platform the bench mark. Although pelagic sediments such as mud or silt are predominant in the deep-sea area, we should evaluate how deep the bench mark can be deployed below the seafloor. Therefore, detailed sediment types are classified by recovering marine sediment by using a piston corer.

A piston corer consists of a heavy weight and a long pipe to collect the sediment core samples. We used 6 meters pipe with 0.8 tons weight. Recovery of marine sediment could be done at 11 observatories by two cruises so far. All collected samples suggest that it is soft enough to deploy 4 meters bench mark at the observatory. Shear strength was also measured in terms of torque force.

Then, a couple of bench mark, with short and long pipes, have been deployed at the central Kumano Trough by using piston corer during Kairei cruise (Fig. 4). A procedure to deploy the bench mark below the seafloor is as follows. A piston corer covered with a bench mark pipe penetrates into sediment layer as usually done. After landing a piston corer at the seafloor, an outer bench mark pipe is released. And only a piston corer pipe is recovered with remaining the bench mark below the seafloor. Finally, the bench mark is simply deployed. In the same cruise, we observed the deployed bench mark by Kaiko. The bench mark is buried completely in the sediment layer (Fig. 4).

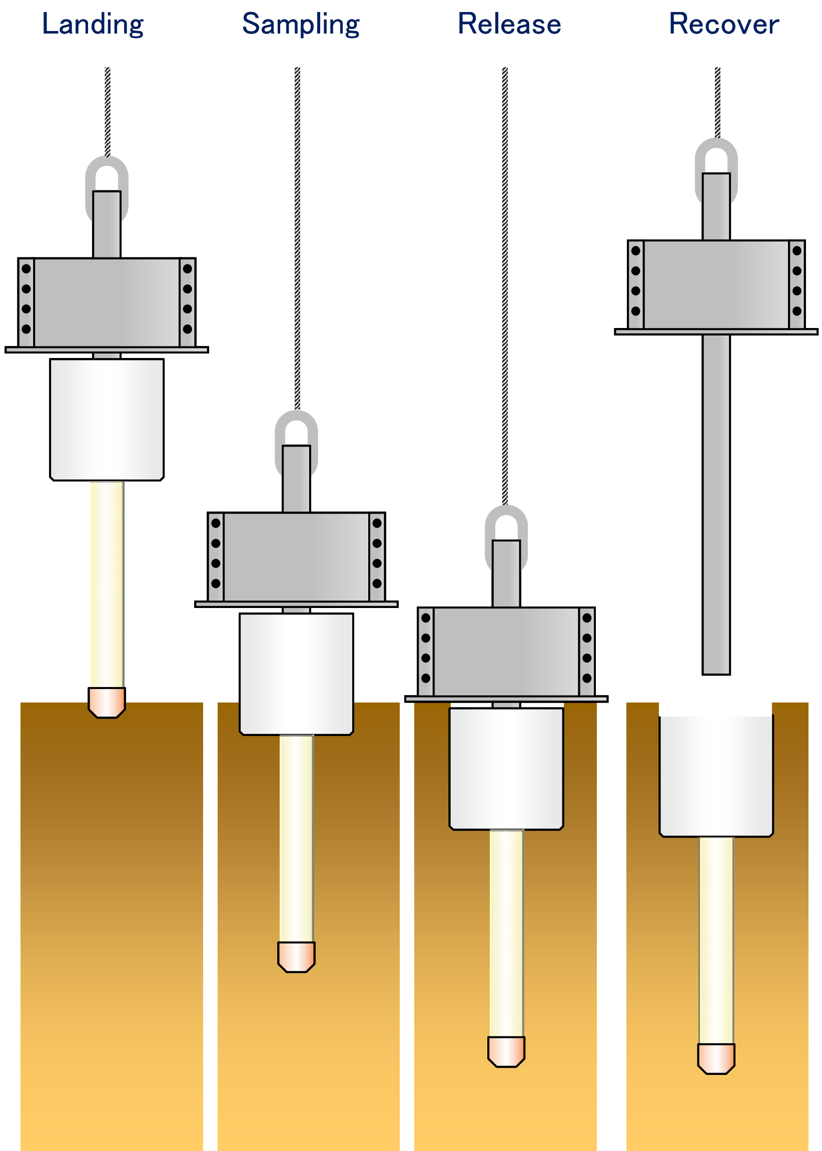


Figure 2.2.1　Schematic figure of bottom casing installation

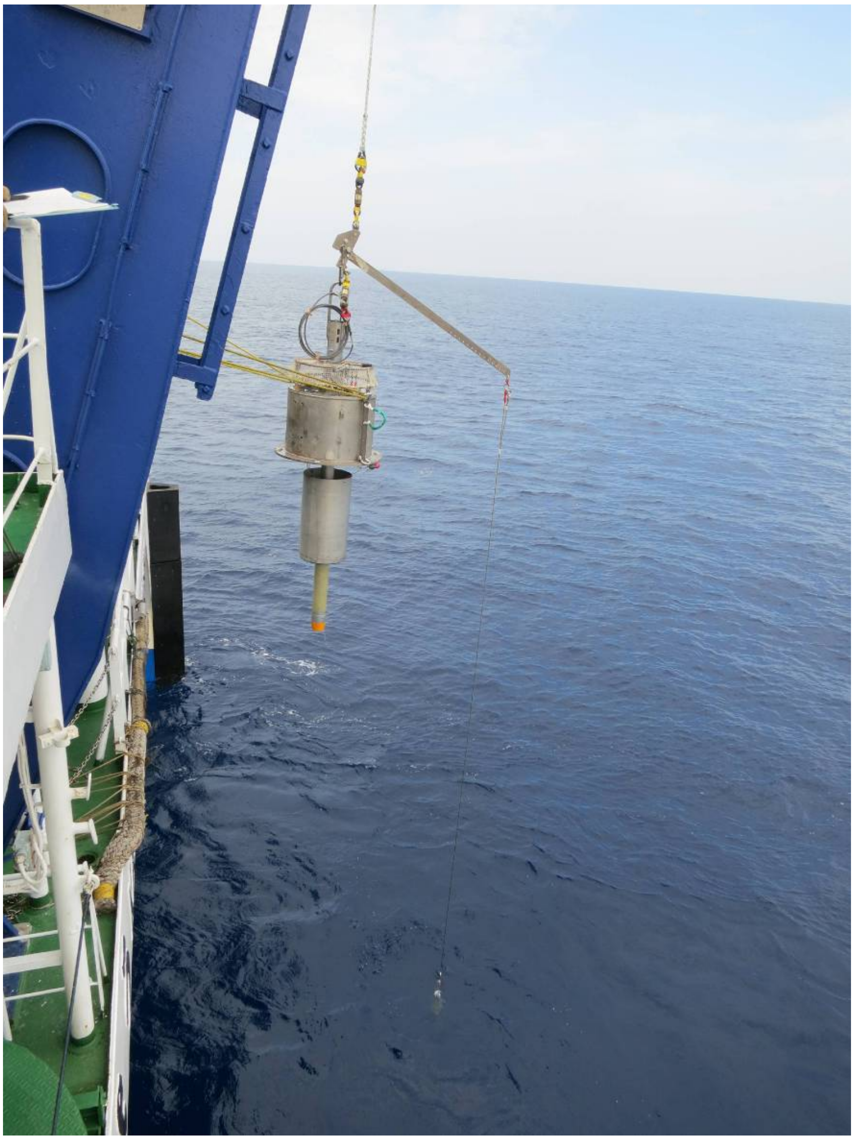


Figure 2.2.3 Installation of the bottom casing attached with the piston corer from the vessel (left)

2.3. Deep Tow system

1) 6,000m-class Deep Tow camera system

The JAMSTEC 6,000m-class Deep Tow camera system consists of the underwater unit, the onboard unit, the double armored 8,000 m optical cable and the positioning system.

2) Underwater unit

The underwater unit is towing by ship and takes video images, photographs and seawater data. This unit include color CCD cameras, one black and white CCD cameras, seven underwater lights (DEEPSEA, Inc./ 250W), one digital still camera (KOWA, Corp./ model: KI17098), one film still camera (Benthos, Inc./ model: 372A), two strobe lights (Benthos, Inc./ model: 382), one CTD (Sea-Bird Electronics, Inc./ model: SBE 9plus), one DO-sensor (Sea-Bird Electronics, Inc./ model: SBE 43), one transmissometer (Alphatracka, Inc./ model: MK), one altimeter (Data Sonics, Inc./ model: PSA-9000), one releaser (InterOcean, Inc./ model: MR5000-B), one power-telemetry unit and one acoustic transponder (Benthos, Inc./ model: XT-6000).

The color CCD camera is used to monitor the vertical direction, usually to watch for bottom material and geological structures and biological. The black and white CCD camera is used to monitor the forward direction, usually to watch for obstacles.

The maximum operation depth of each unit is 6,000 m. This unit is installed on an open frame made of iron pipe. The weight of underwater unit is 500 kg in water, 700kg in air. The dimensions of underwater unit are 3.6m in length, 1.2m in width, 1.6m in height.

General view of underwater unit is shown Photo-1, system diagram of underwater unit is shown figure-1

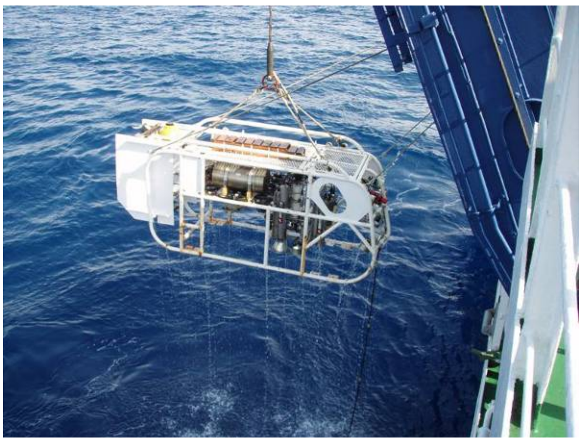


Photo-2.3.1 6,000m-class Deep Tow camera system (underwater unit)

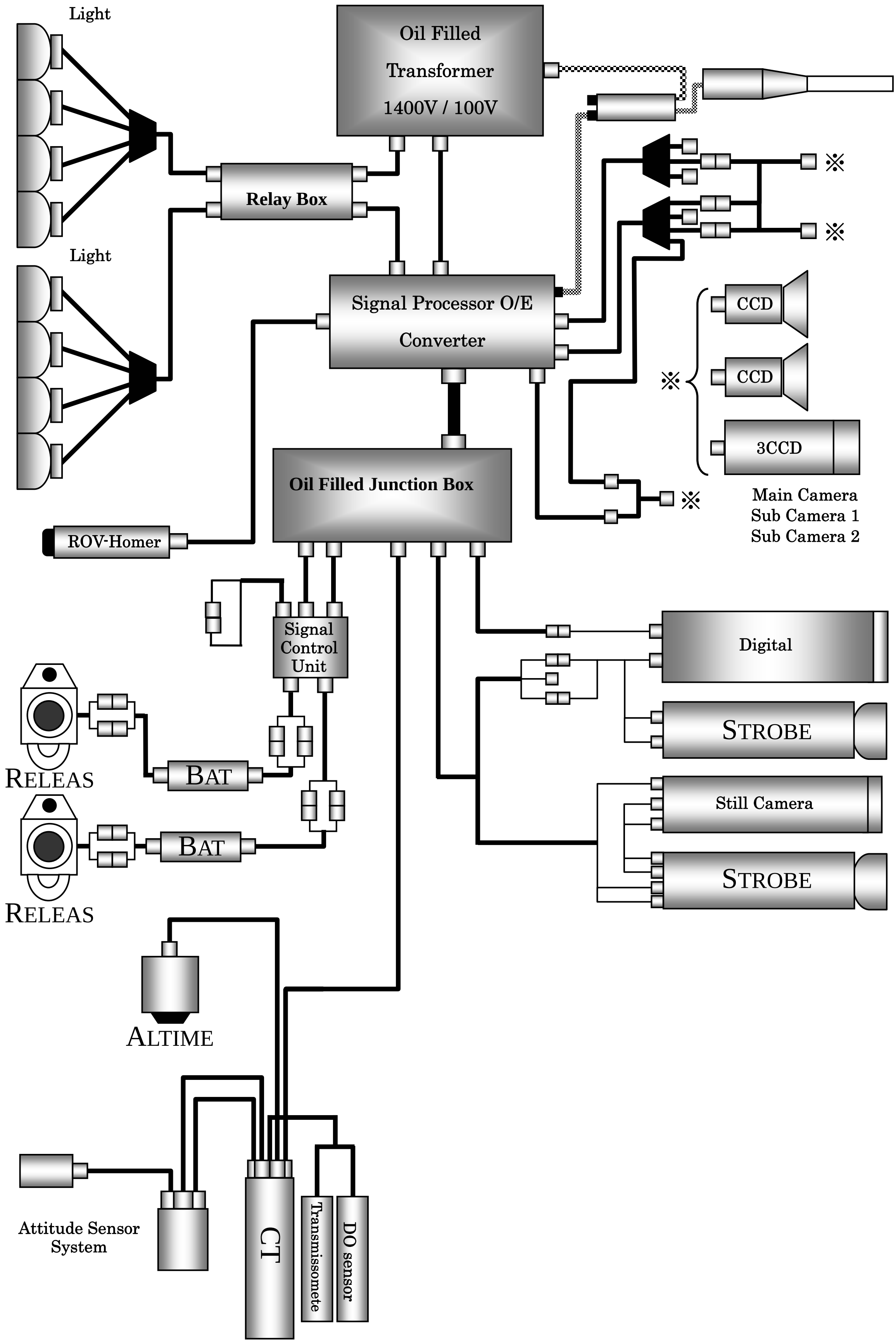


Figure 2.3.1 System diagram of underwater unit

3) Onboard unit

Video images and data taken by the underwater unit are displayed and recorded in the onboard unit. The onboard unit consists of an electric communication unit, power supply unit, CTD controlling unit, super impose unit, TV monitors, three HDD-DVD recorders, cable length meter, multi-pen-recorder, tow supporting computer and 8,000m optical cable and traction winch. These device are installed in one special container expect for winch. Video watching, electric power adjustment, and CTD unit operation takes place in this container.

HDD-DVD recorder records the video images. The super impose system can display 9 items (cruse number, survey line number, date, time, CTD depth, temperature, salinity, altitude and photo number) overlaid on the video image.

Cable length meter, multi-pen-recorder and tow supporting computer are used for watching ship and the underwater unit position, and towing cable data (tension, length and distance).

4) Double armored optical cable

The underwater unit are connected the onboard unit with the double armored optical cable. This cable is used to power supply, electric communication, and tow the underwater unit. This cable has a diameter of 17.2 mm, and a total length of 8,000 m. All data are sent by one fiber line, and a parallel communication (Up link: 1.3 micro m, 420 Mbps, Down link: 1.55 micro m, 2.2 Mbps) is carried out. And, power supply which is from high voltage equipment (3kVa) to A.C. 1,400 V (2.0 A) is performed by four electric lines. Power reduced by an oil filled trans is provided to each underwater unit.

Characteristic of the double armored optical cable is shown table-1.

Table 2.3.1 The characteristic of double armored optical cable

The item		The characteristic value
The conductor resistance	The inside conductor	Equal to or less than 3.49Ω/km
	The outside conductor	Equal to or less than 4.06Ω/km
The insulation resistance	Among in and outside the conductors	Equal to or more than 5,000MΩ·km
	Among outside conductor and the exterior	Equal to or more than 5,000MΩ·km

The durable voltage	Among in and outside the conductors	AC 9,100V
	Among outside conductor and the exterior	AC 3,800V
The capacitance (1kHz)		125.4nF/km
The standard attenuation quantity (1kHz)		6.7dB/km (max 7.71dB/km)
The characteristic impedance (1kHz)		$40 \pm 3\Omega$
The cutting load		Equal to or more than 15tonf
The weight		1,050kg/km (in air), 830kg/km (in water)

5) Positioning system

A determination of the position of the underwater unit is used acoustic positioning system (SSBL: Super Short Base Line) which use D-GPS installed on the research vessel and an acoustic transponder (Tx: 13.5kHz, Rx: 13.0kHz).

3. SURVEY SCHEDULE AND RESULTS

3.1 Schedule

Actual schedule of the KY12-11 cruise was listed in Table 1. Our cruise started from JAMSTEC and returns to JAMSTEC via Kumano-nada and off Kii-channel in order to carry out "Deep-Tow" survey and multi-beam bathymetry survey.

Table 3.1 Schedule of KY12-11 cruise

Date	Area at noon	Operation	Remarks
03 September		Departure	9:00 departured from Yokosuka port
04 September	off Shionomisaki 2D area	Piston corer sampling	2D-15a and 2D-16a
05 September	off Shionomisaki 2E area	Piston corer sampling	2E-18a and 2E-19a
06 September	off Shionomisaki 2E area	Piston corer sampling	2E-20a and 2E-21a
07 September	off Shionomisaki 2F area	Piston corer sampling	2F-22a and 2F-23a
08 September	off Shionomisaki 2F area	Piston corer sampling	2F-24a and 2F-25a
09 September	off Muroto 2G area	Piston corer sampling	2G-26a and 2G-27a
10 September	off Muroto 2G area	Piston corer sampling	2G-28a and 2G-29a
11 September	off Muroto 2A area	Piston corer sampling	2A-1a and 2A-3a
12 September	off Shionomisaki 2B area	Piston corer sampling	2B-5a and 2B-7a
13 September	off Shionomisaki 2C area	Piston corer sampling	2C-11a and 2C-12a
14 September	Kumano-nada 1E and 1D area	Piston corer sampling	1E-22b and 1D-21b
15 September	off Shionomisaki 2D and 2C area	Piston corer sampling	2D-17a and 2C-10a

16 September	off Han-nan port out of expedition		
17 September	off Han-nan port out of expedition		
18 September	off Han-nan port out of expedition		
19 September	off Shionomisaki 2F and 2B area	Free fall and Piston corer sampling	
20 September	Kumano-nada 1D and 1E area	Bottom bench mark installation	
21 September	off Shingu port	Switching PC to Deep Tow Deep Mogera's training	
22 September	Kumano-nada 1D area	Deep Tow survey	C0002G bore-hole
23 September	off Muroto 2A area	Deep Tow survey	2A-4a route
24 September	off Muroto 2G area	Deep Tow survey	Backborn cable route
25 September	shift Mikawa port	cancelled	
26 September	Mikawa port out of expedition	Deep Mogera's training	
27 September	Mikawa port out of expedition		
28 September	Mikawa port out of expedition		
29 September	shift Yokosuka		
30 September		Arrive	9:00 arrived at JAMSTEC

3.2 Piston core sampling

25 piston core sampling of 2 – 3meters long have been carried out in the KY12-11 cruise, whose locations are presented in Figure 3.2.1. For obtained samples, we measured the share stress as for the depth directions. The results are shown in Figure 3.2.2 to Figure 3.2.8. 1.6 meters' bottom casing can be applicable for less than 30 kN/m² share stress sediment to be deployed in term of our experience. Most sites can be acceptable as DONETobservatories, but 2G-26a site seems to be difficult to deploy conventional bottom casing. 2B-7a, 2C-11a, and 2F-22a has slightly strong share stress, but it seems possible to deploy by using the ROV water hammer.

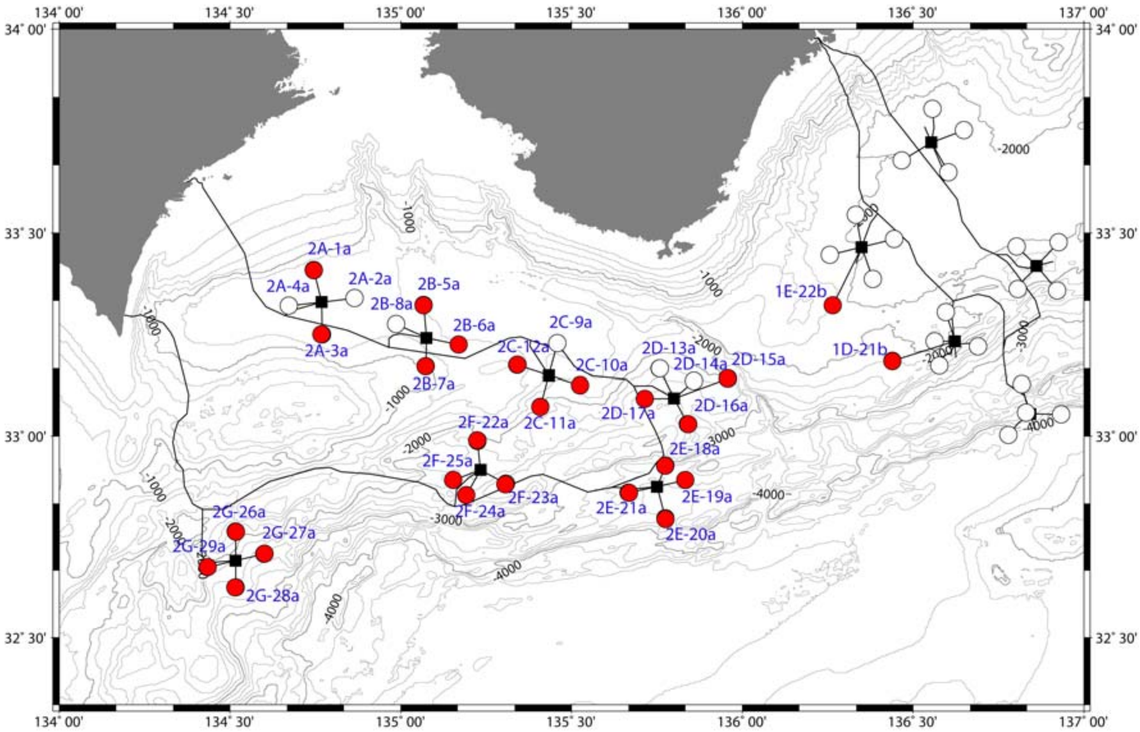


Figure 3.2.1 Location of piston core sampling of DONET2

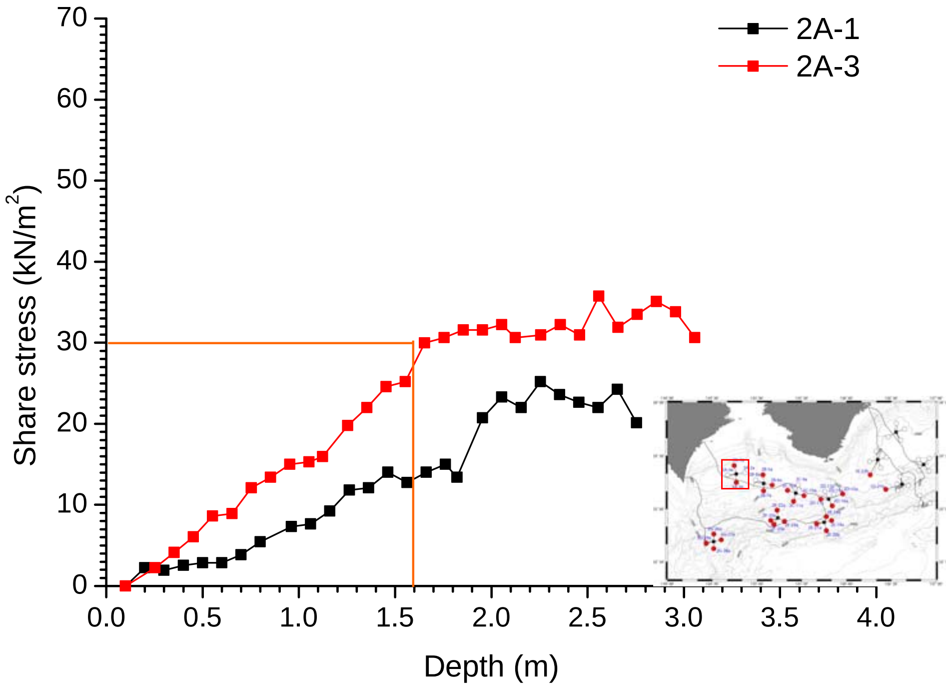


Figure 3.2.2　Share stress of the Node-A area

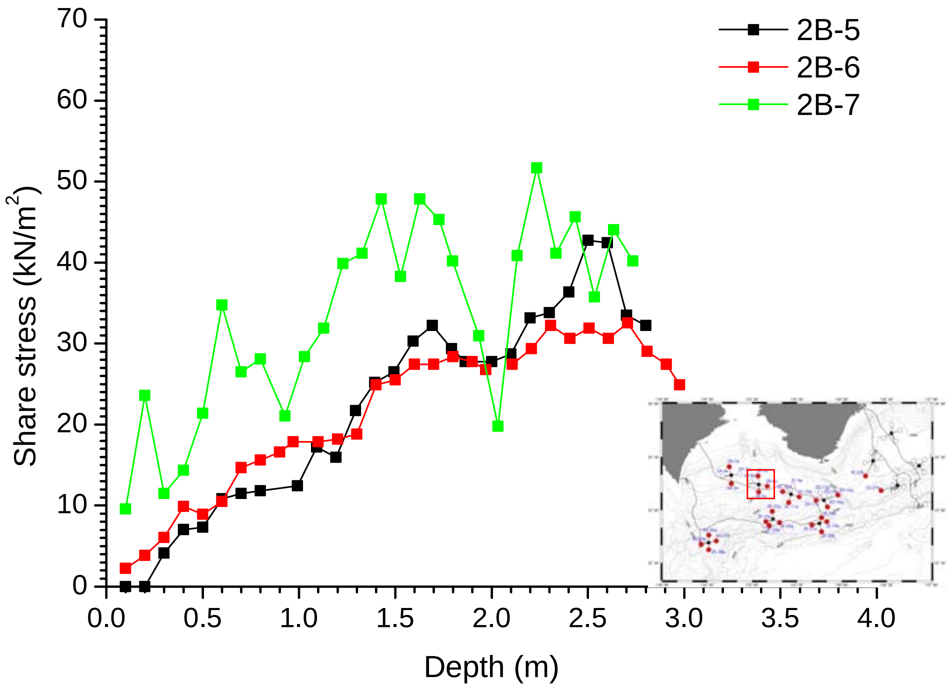


Figure 3.2.3　Share stress of the Node-B area

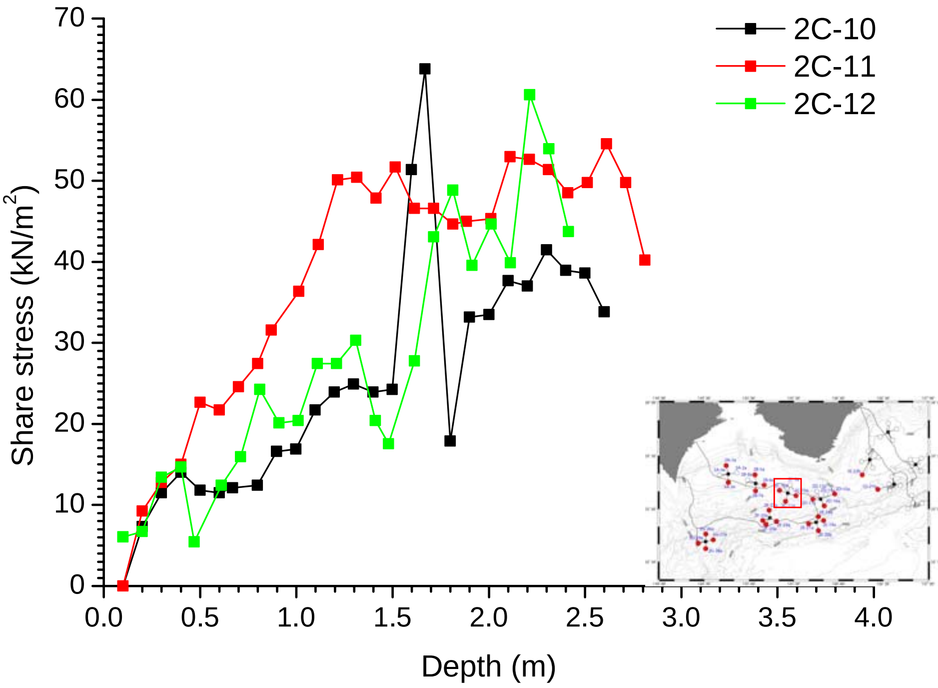


Figure 3.2.4   Share stress of the Node-C area

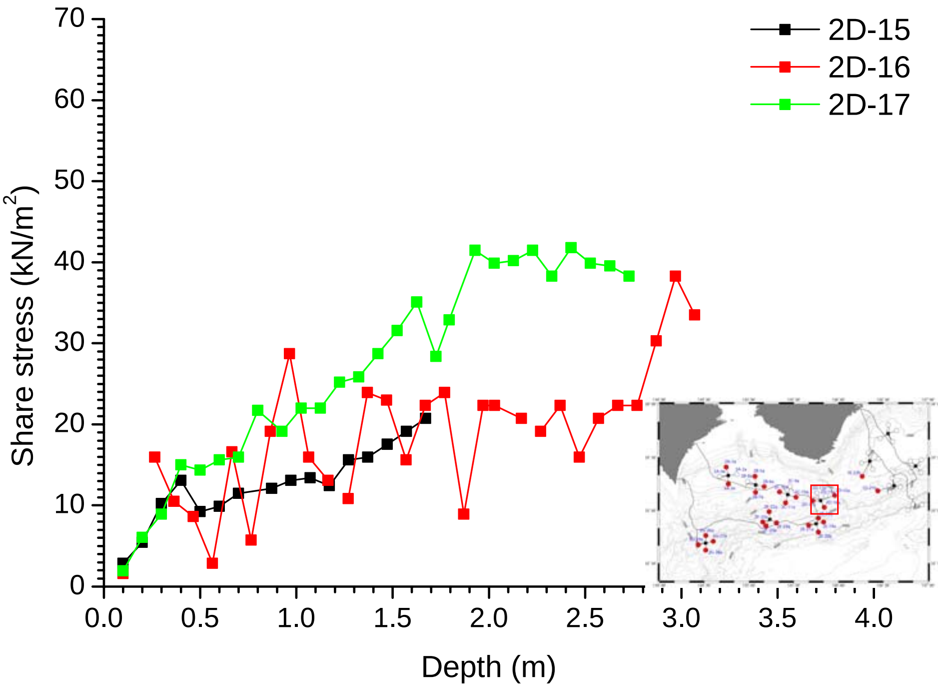


Figure 3.2.5   Share stress of the Node-D area

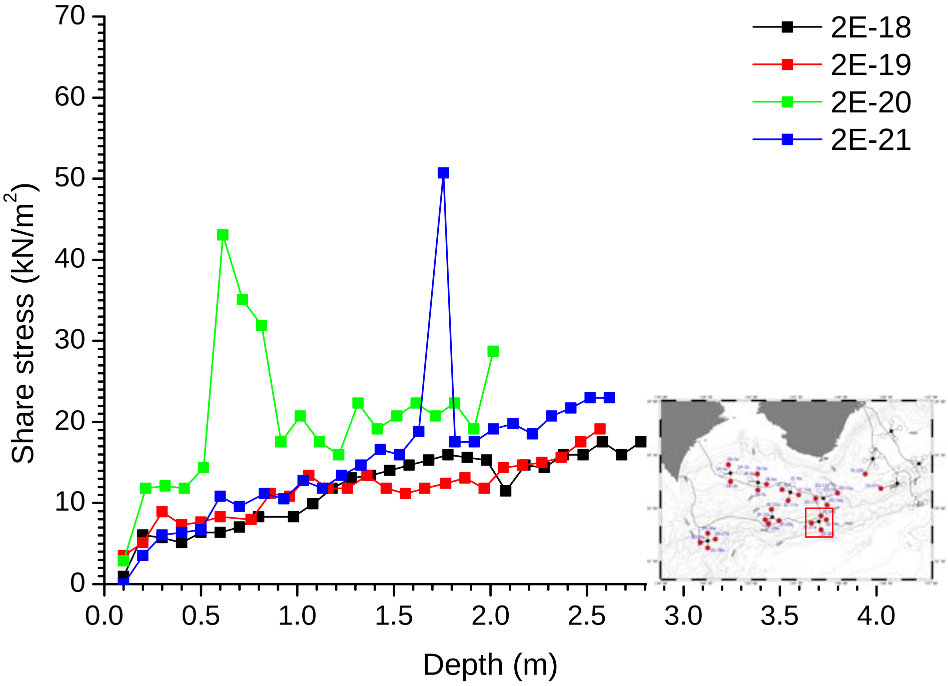


Figure 3.2.6　Share stress of the Node-E area

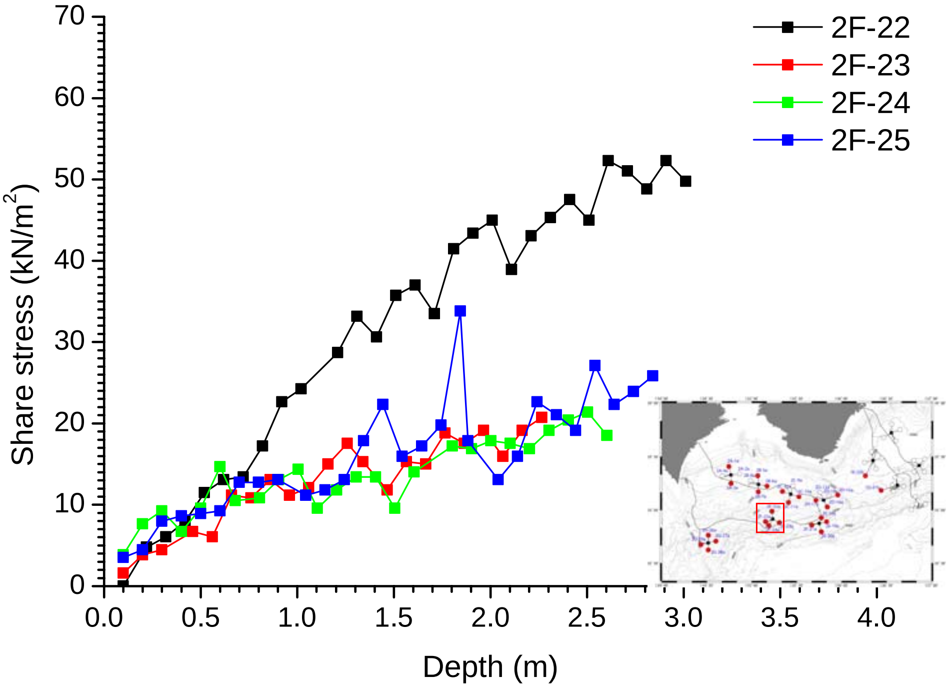
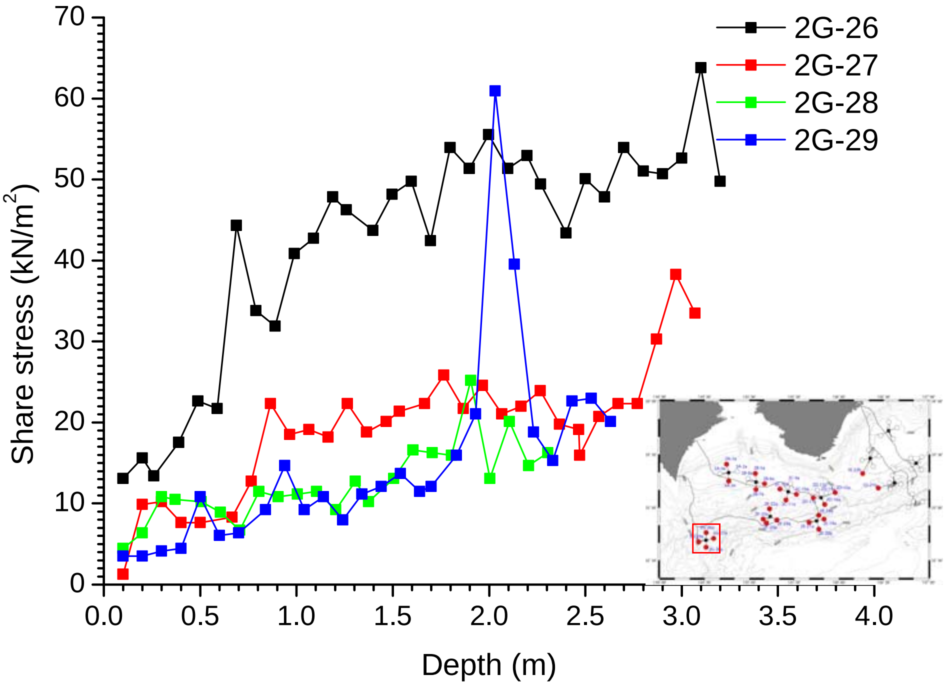


Figure 3.2.7　Share stress of the Node-F area

Figure 3.2.6　Share stress of the Node-G area



3.3 Bottom casing installation

Two bottom casing were deployed for two observatory of DONET2; one is for 1D-21b and the other is for 1E-22b as BM01 and BM02, respectively. Status of bottom casing installation for 1D-21b is good by means of acoustic signals, i.e., installation tilt is within 10 degree and touchdown of corer was done. For 1E-22b, on the other hand, tilt is within 10 degree, but touchdown of corer was not confirmed. Final deployed coordinate of bottom casing are as follows,

Table 3.1 Bottom casing installation coordinates

	Latitude	Longitude	Depth	Homer ID
1D-21b	33° 11.2002′ N	136° 26.9087′ N	2,161 m	66
1E-22b	33° 19.8000′ N	136° 16.2000′ N	1,837 m	24

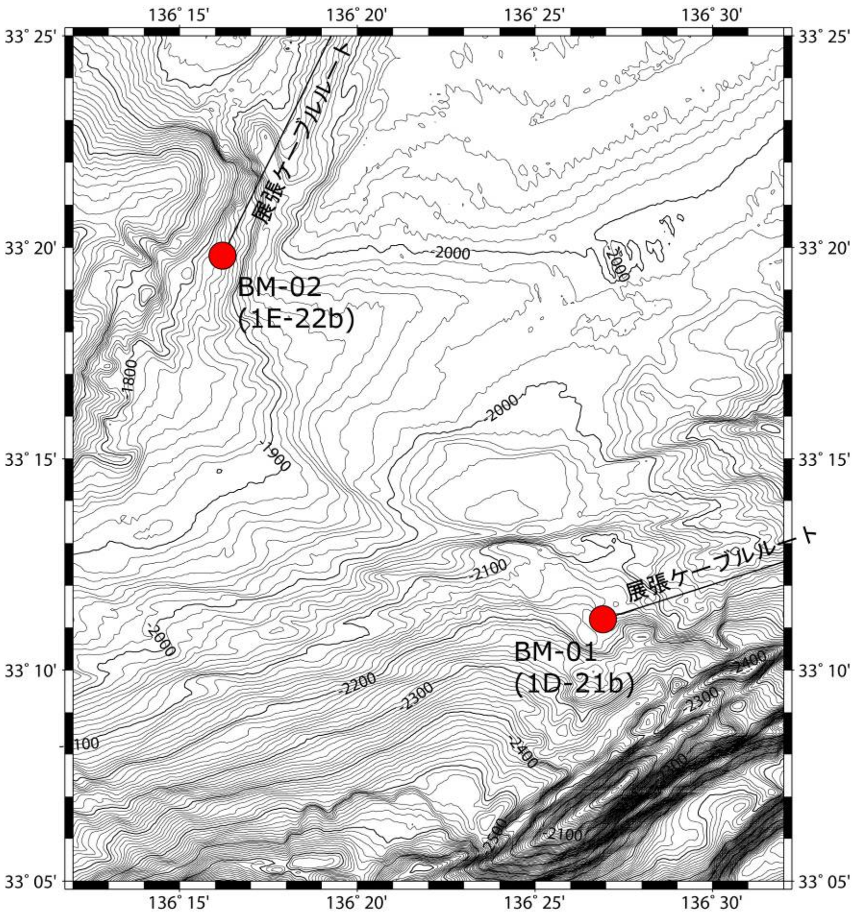
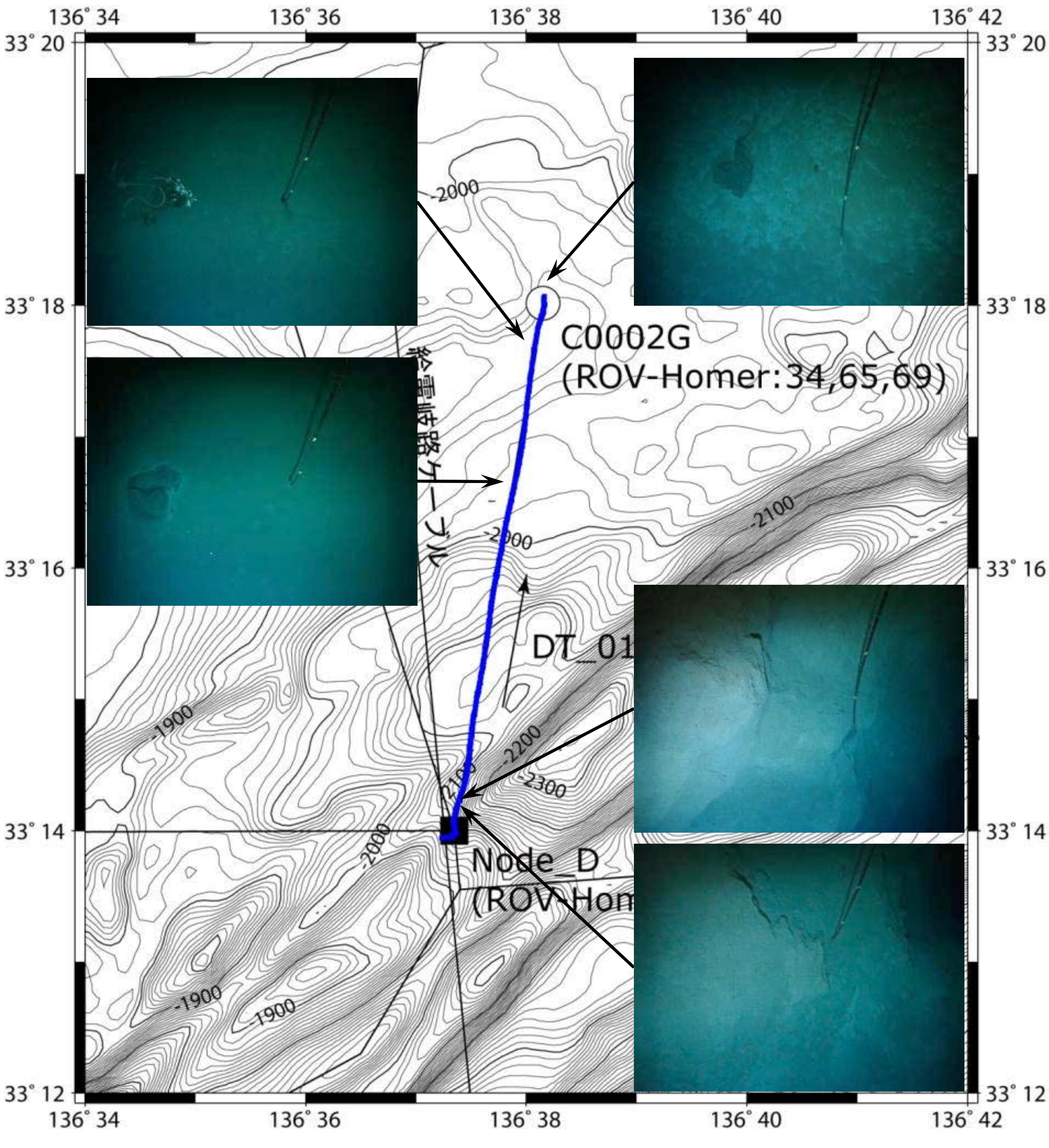


Figure 3.3 Location of bottom casing installation

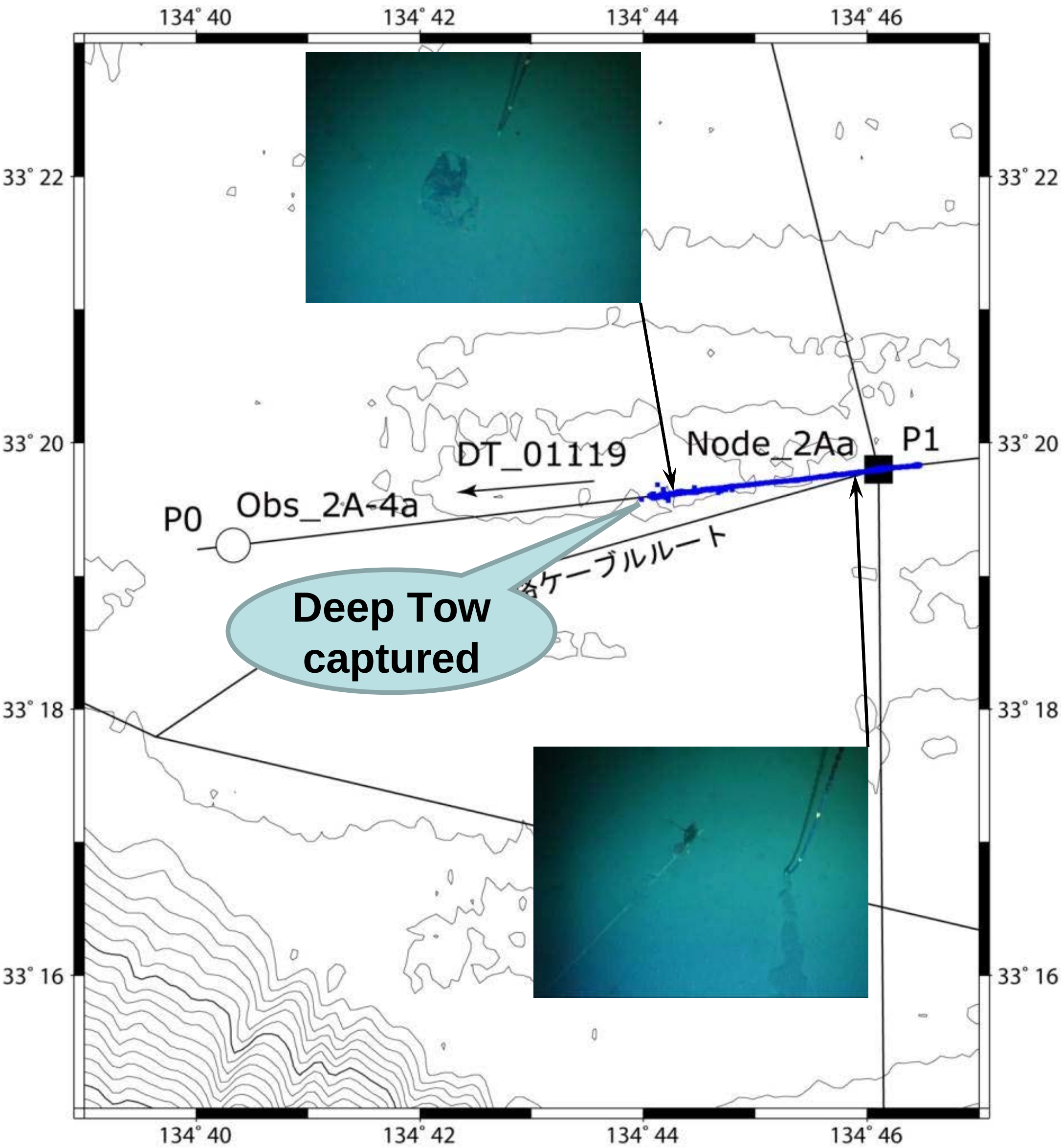
3.4 Deep Tow survey

Three Deep Tow dives were done in the present KY12-11 cruise. The first one (dive DT_01118) was for long-term borehole observatory to be connected with DONET in 2013. The second one (dive DT_01119) was for extension cable of 2A-4a observatory. The last one (dive DT_01120) was for main cable near the node 2G. The present three dives tracks are shown below. Note that Deep Tow has been captured by something in the sea in the second survey, hence the survey must be halt on the way. Route clear should be done before the ROV dive operation in this route.

(1) DT_01118

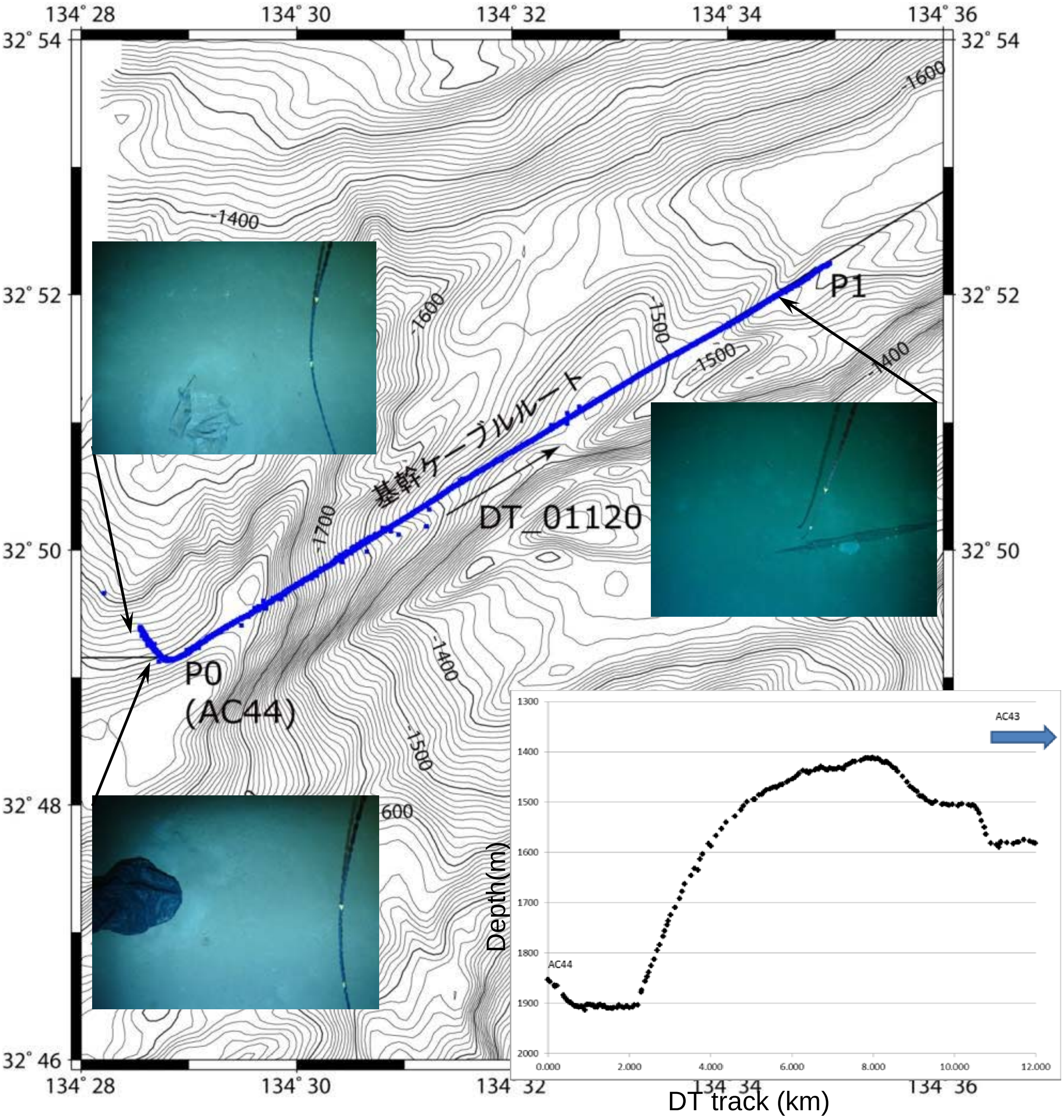


(2) DT-01119



134° 40
134° 42
134° 44
134° 46
33° 22
33° 20
33° 18
33° 16
DT_01119
Node_2Aa
P1
P0
Obs_2A-4a
ケーブルルート
Deep Tow captured

(3) DT_01120



134° 28
134° 30
134° 32
134° 34
134° 36
32° 54
32° 52
32° 50
32° 48
32° 46
-1400
-1500
-1600
-1700
P1
P0
(AC44)
基幹ケーブルルート
DT_01120
AC43
AC44
Depth(m)
DT track (km)
1300
1400
1500
1600
1700
1800
1900
2000
0.000
2.000
4.000
6.000
8.000
10.000
12.000

4. CONCLUDING REMARKS

We carrid out KY12-11 cruise by using R/V Kaiyo for one month in which the piston core sampling, the bottom casing deployment, and the route clear have been done before deployment of the DONET2. Following the desktop study, we carried out route and site surveys off Kii-suido last year. 25 piston core sampling have been obtained that can predict the difficulties of the bottom casing deployment. Our survey suggests that the most site is easy to deploy the bottom casing, but some site is not applicable for the conventional bottom casing. On the other hand, the route clear by Deep Tow has been done for three route. One is for long-term observatory, others are for DONET2 construction. One route could not be cleared, whish would be erased in the future survey.