



R/V Kairei Cruise Report

KR13-08



Cruise Proposal 1

“The Survey and Observation for Earthquakes and Tsunamis off the Pacific Coast of Tohoku”

Cruise Proposal 2

“Research of the fault slip process using the temperature observation at the JFAST site”

21 April 2013 (Yokosuka) – 9 May 2013 (Shiogama)

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Acknowledgements

We would like to thank Captain Mr. Ukekura and all ship crew of R/V KAIREI for their safe cruise. We are grateful to Commander Mr. Miura and the operation team of a ROV KAIKO7000 II for their operations in serious condition. We are pleased to MARITEC/JAMSTEC staff for their supports during our cruise.

This cruise report is a preliminary documentation as of the end of the cruise.

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KR13-08 Cruise report contents

1. Objectives and Cruise summary of KR13-08 cruise
2. List of Participant
 - Scientists
 - KAIKO Team
 - Ship Crew
3. Ship Log
4. Instruments
 - 4.1 OBEs
 - 4.2 JFAST site
5. Operation and Dive summary
 - 5.1 LBL transponder operation
 - 5.2 Dive 595
 - 5.3 Dive 596
 - 5.4 Dive 597
 - 5.5 Dive 598
 - 5.6 Dive 599
 - 5.7 Dive 600
 - 5.8 Dive 601
 - 5.9 Dive 602
6. Shipboard data

Appendix

Explanatory notes

1. Objectives and Cruise summary of KR13-08 cruise

Cruise information

Cruise number	KR13-08
Name of the cruise	R/V KAIREI
Chief scientist	Takafumi Kasaya (IFREE, JAMSTEC)
Representative of the Science Party 1	Takafumi Kasaya (IFREE, JAMSTEC)
Title of the cruise 1	The Survey and Observation for Earthquakes and Tsunamis off the Pacific Coast of Tohoku
Representative of the Science Party 2	Shuichi Kodaira (IFREE, JAMSTEC)
Title of the cruise 2	Research of the fault slip process using the temperature observation at the JFAST site
Cruise period	21 April 2013 – 9 May 2013
Ports of call	Yokosuka port – Sendai-Shiogama
Research Area	Japan trench off Tohoku (Fig.1)

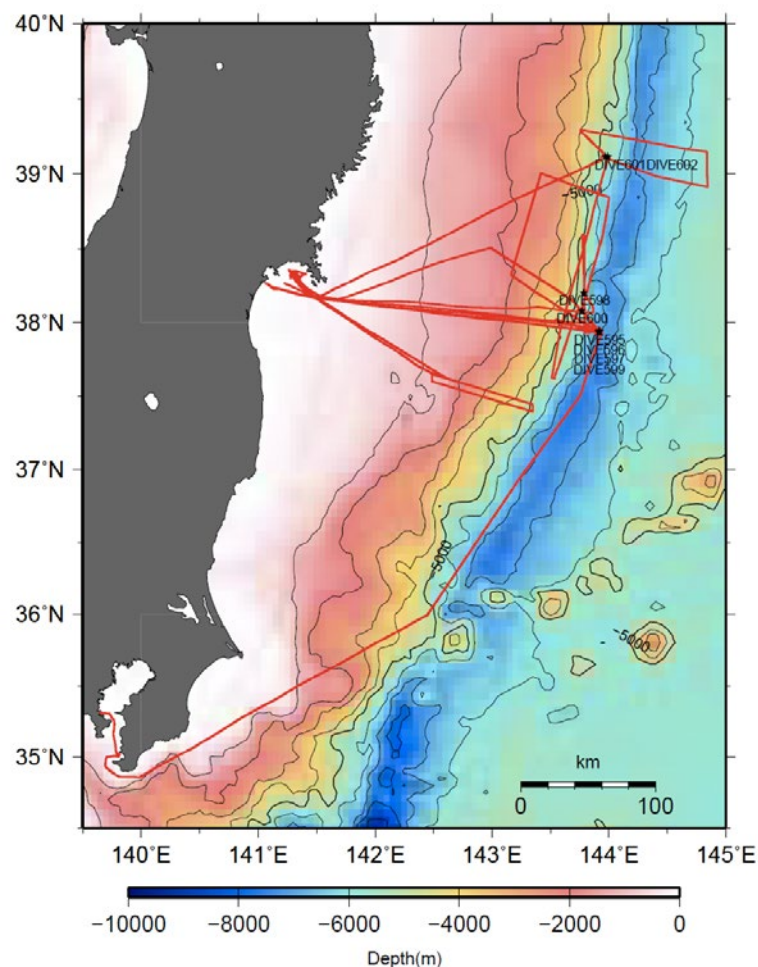


Fig.1 Ship track of this cruise.

Cruise summary

Cruise proposal 1

”The Survey and Observation for Earthquakes and Tsunamis off the Pacific Coast of Tohoku”

On 11 March 2011, Tohoku, northeast Japan, experienced a great earthquake (Mw 9.0, Mt 9.1) called the 2011 off the Pacific coast of Tohoku earthquake. Seismic and tsunami inversion analyses have shown that tsunami waves with a maximum run-up height of 38 m were generated after the main shock by topographic changes on the seafloor in the toe region of the Japan Trench slope off Sendai. These inversion analyses and bathymetric surveys (Fujiwara et al., 2011) indicate that the toe region slipped about 50 m along the thrust.

To investigate many phenomena related with the earthquake, research program supported by MEXT has been started. Our main task of this cruise is to survey the bathymetric and geophysical data around off Tohoku area. Moreover, we used a sub bottom profiler (SBP) system on a Kaiko Launcher to obtain high resolution sub bottom structure. We carried out three Kaiko dives (dive #600, 601 and 602) to obtain detailed subsurface structures for sedimentary images. We do not launch the vehicle from the launcher in these dives because acoustic sonars can keep stable posture for acoustic sounding survey. We could detect very clear sub-surface images with about 30 - 50 ms penetration. Moreover, we carried out the recovery operation of a super deep depth OBS, sea floor observation around the JFAST site and the recovery operation OBE's system at a depth of 5800 meters.

Reference

T. Fujiwara, S. Kodaira, T. No, Y. Kaiho, N. Takahashi, Y. Kaneda, The 2011 Tohoku–Oki earthquake: Displacement reaching the trench axis. *Science* 334, 1240 (2011).

Cruise proposal 2

“Research of the fault slip process using the temperature observation at the JFAST site”

The main scientific goal of JFAST is to understand the physical mechanisms and dynamics of large slip earthquakes (Chester et al., 2012). The site for JFAST was chosen to penetrate the plate boundary fault that had large slip during the 2011 Off the Pacific Coast of Tohoku earthquake. One of the objectives of JFAST is estimating the frictional heat and stress within and around the fault zone by measurement of temperature across the fault. During the JFAST expeditions (Integrated Ocean Drilling Program [IODP] Expedition 343 from April to May 2012 and IODP Expedition 343T in July 2012), five holes were drilled using the D/V Chikyu. Three holes penetrated the plate boundary. In Hole C0019D, the miniature temperature logger (MTL) autonomous observatory was installed. The wellhead was installed on the seafloor close to the Japan Trench at a water depth of about 6900 m. The ROV KAIKO 7000 II was used to retrieve the MTL observatory on this cruise.

During Dives 595 and 596 of the KR13-08 cruise, we searched for and located Hole C0019D and retrieved the MTL observatory by ROV KAIKO 7000 II. In Dive 595, a survey was

made of the area surrounding the hole using side scan sonar (SSS) and sub-bottom profiler (SBP) of the vehicle in order to help locate the hole. In Dive 596, the wellhead of Hole C0019D was located and the MTL observatory was retrieved. The recovered sensors of MTL observatory records temperature along with the hole for about 9.5 months, which will be used to estimate the frictional heat.

Reference

Chester, F.M., Mori, J.J., Toczko, S., Eguchi, N., and the Expedition 343/343T Scientists, 2012. Japan Trench Fast Drilling Project (JFAST). IODP Prel. Rept., 343/343T. doi:10.2204/iodp.pr.343343T.2012

2. List of Participant

Chief Scientist

TAKAFUMI KASAYA JAMSTEC

Onboard Scientists

MASANORI KYO	JAMSTEC
YASUHIRO NAMBA	JAMSTEC
SHURO YOSHIKAWA	JAMSTEC
YASUYUKI KANO	Kyoto University
PATRICK MICHAEL FULTON	University of California Santa Cruz
HIDETOSHI OKANO	Power House

Marine Technician

HIROAKI MURAKI	Marine Works JAPAN
HISANORI IWAMOTO	Nippon Marine Enterprises, LTD.

R/V KAIREI Crew

Captain	EIKO UKEKURA
Chief Officer	HIROYUKI KATO
2nd Officer	KAZUKI MIYAKE
3rd Officer	YUKI DEGURA
Jr. 3rd Officer	SATORU YOSHIDA
Chief Engineer	KIYONORI KAJINISHI
1st Engineer	KAZUNORI NOGUCHI
2nd Engineer	RYOZO MIKAMI
3rd Engineer	KOTA KATAOKA
Chief Electronics Operator	HIROYASU SAITAKE
2nd Electronics Operator	MISATO HATA
3rd Electronics Operator	TAKAYUKI MABARA
Boat Swain	YOSHIAKI KAWAMURA
Able Seaman	KATSUHIKO SATO
Able Seaman	HATSUO ODA
Able Seaman	HIROAKI MURASE
Able Seaman	SAIKAN HIRAI
Sailor	HIDEO ITO
Sailor	SHINYA KOJIMA
No.1 Oiler	KAZUAKI NAKAI
Oiler	SHINYA SUGI
Oiler	MASAYUKI FUJIWARA
Assistant Oiler	KAZUO MURASE

Assistant Oiler	RYO MATSUUCHI
Chief Steward	TOMIHISA MORITA
Steward	SHINSUKE TANAKA
Steward	KIYOTAKA KOSUJI
Steward	RYU KUBOTA
Steward	KANA YUASA

KAIKO 7000II operating team

Operation Manager	ATSUMORI MIURA
1st ROV Operator	HOMARE WAKAMATSU
1st ROV Operator	TOMOE KONDO
2nd ROV Operator	KIYOSHI TAKISHITA
2nd ROV Operator	TETSUYA ISHITUKA
2nd ROV Operator	SEIJI SHIGETAKE
2nd ROV Operator	SHOTA IHARA
2nd ROV Operator	YUDAI SAKAKIBARA
3rd ROV Operator	TAKUMA GOTO
3rd ROV Operator	YOICHI YASUE

3. Ship Log

Date	Local Time	Description	Note	Position/Weather/Wind/Sea condition
21-Apr-13	08:00	scientists onboard		4/21 12:00 (UTC+9h)
	09:00	departure from JAMSTEC		34-01.3N,139-49.3E
	10:30-11:00	lecture for life of shipboard life and safety		rain
	11:00	arrived at TATEYAMA-WAN bay		North-5 (Fresh breeze)
	16:40-17:00	pray to KONPIRASAN for safety cruise		3 (Sea slight)
				2 (Low swell long)
				Visibly: 4'
22-Apr-13	04:00	left off TATEYAMA-WAN bay for research area		4/22 12:00 (UTC+9h)
	09:00-09:40	KAIKO pre-dive meeting for search J-FAST		35-31.7N,141-24.0E
				fine but cloudy
				NNW-5 (Fresh breeze)
				3 (Sea slight)
				4 (Moderate long)
				Visibly: 8'
23-Apr-13	06:00	arrived at research area		4/23 12:00 (UTC+9h)
	06:26	released XBT		37-56.0N,143-55.0E
	07:49	deployed 1-A transponder		fine but cloudy
	08:38	deployed 2-B transponder		West-5 (Fresh breeze)
	09:19	deployed 3-C transponder		4 (Sea moderate)
	10:45-13:06	carried out transponder location calibration		4 (Moderate long)
	16:34	Launching KAIKO (7K#595Dive)		Visibly: 8'
	19:13	KAIKO arriveing at the depth (6,900m)		
	21:37	com'ced KAIKO lancer SSS survey		
24-Apr-13	05:16	finished KAIKO lancer SSS survey		4/24 12:00 (UTC+9h)
	05:18	KAIKO leave the depth (6,725m)		38-03.5N,142-51.2E

	08:00	KAIKO come up to the surface		overcast
	08:30	proceeding to ISHINOMAKI-WAN bay		South-6 (strong breeze)
	17:30	arrived at ISHINOMAKI-WAN bay		5 (Sea rough)
				4 (Moderate average)
				Visibly: 8'
25-Apr-13	18:00	left off ISHINOMAKI-WAN bay for research area		4/25 12:00 (UTC+9h)
				38-20.5N,142-18.7E
				fine but cloudy
				WNW-6 (strong breeze)
				4 (Sea moderate)
				2 (Low swell long)
				Visibly: 8'
26-Apr-13	06:00	arrived at research area		4/26 12:00 (UTC+9h)
	7:04	Launching KAIKO (7K#596Dive)		37-56.4N,143-55.0E
	10:31	KAIKO landing (6,924m)		fine but cloudy
	11:51	KAIKO leave the bottom (6,925m)		SSE-5 (fresh breeze)
	17:57	KAIKO come up to surface		3 (Moderate short)
	18:41-19:07	recovered thermistor string		2 (Low swell long)
	19:45	proceeding to ISHINOMAKI-WAN bay		Visibly: 8'
27-Apr-13	08:30	let go anchor at ISHINOMAKI-WAN bay		4/27 12:00 (UTC+9h)
				38-21.4N,141-15.8E
				fine but cloudy
				WNW-7 (near gale)
				4 (Sea moderate)
				2 (Low swell long)
				Visibly: 8'
28-Apr-13	08:30	practiced boat station drill		4/28 12:00 (UTC+9h)
	16:15	heaving anchor, com'ced heave to		38-21.4N,141-15.8E
				fine but cloudy
				WNW-7 (near gale)
				4 (Sea moderate)

			2 (Low swell long)
			Visibly: 8'
29-Apr-13	04:00	left off ISHINOMAKI-WAN bay for research area	4/29 12:00 (UTC+9h)
	09:00	arrived at research area	38-20.4N,143-19.1E
	09:17-15:09	carried out MBES and SBP survey	fine but cloudy
	16:36-16:50	send interrogate command to UDOBS	WSW-5 (Fresh breeze)
	17:58	Launching KAIKO (7K#597Dive)	3 (Sea slight)
	21:02	KAIKO landing (6,971m)	2 (Low swell long)
	23:55	KAIKO leave the bottom (6,993m)	Visibly: 8'
30-Apr-13	02:49	KAIKO come up to surface	4/30 12:00 (UTC+9h)
	02:54	recovered ultra deepOBS	38-11.3N,141-20.4E
	03:30	proceeding to ISHINOMAKI-WAN bay	overcast
	14:00	arrived at SENDAI-KO port	West-4 (Moderate breeze)
	14:00-14:35	Used traffic boat 6 scientists disembarked	2 (Sea smooth)
		left off SENDAI-KO port for research area	2 (Low swell long)
			Visibly: 6'
01-May-13	06:00	arrived at research area	5/1 12:00 (UTC+9h)
	08:30	Launching KAIKO (7K#598Dive)	38-12.4N,143-47.1E
	11:11	KAIKO landing (5,810m)	overcast
	14:19	KAIKO leave the bottom (5,802m)	NE-6 (strong breeze)
	16:48	KAIKO come up to surface	4 (Sea moderate)
	17:02	recovered 2 OBE	4 (Moderate average)
	17:07	released XBT	Visibly: 8'
	20:24	com'ced MBES and SBP survey	
02-May-13	03:00	finished MBES and SBP survey	5/2 12:00 (UTC+9h)
	07:35	Launching KAIKO (7K#599Dive)	37-56.4N,143-54.5E
	10:32	KAIKO landing (6,975m)	cloudy
	13:14	KAIKO leave the bottom (6,838m)	WSW-5 (Fresh breeze)
	16:08	KAIKO come up to surface	3 (Sea slight)

	17:21	send release command to LBL transponder C	4 (Moderate average)
	18:57	recovered transponder C	Visibly: 8'
	20:54	com'ced MBES and SBP survey	
03-May-13	00:31	finished MBES and SBP survey	5/3 12:00 (UTC+9h)
	04:00	send release command to LBL transponder A and B	37-56.9N,143-54.7E
	09:40	recovered transponder A	fine but cloudy
	11:59	recovered transponder B	West-5 (Fresh breeze)
	15:18-21:58	carried out MBES and SBP survey	4 (Sea moderate)
			4 (Moderate average)
			Visibly: 8'
04-May-13	00:11-02:18	carried out MBES and SBP survey	5/4 12:00 (UTC+9h)
	06:03	released XBT	38-05.1N,143-45.6E
	08:36	Launching KAIKO (7K#600Dive)	fine but cloudy
	10:54	KAIKO statrted towing survey (5,505m)	West-5 (Fresh breeze)
	13:52	KAIKO finished towing survey (5,468m)	4 (Sea moderate)
	16:07	KAIKO come up to surface	4 (Moderate average)
	19:02-21:56	carried out MBES and SBP survey	Visibly: 8'
05-May-13	06:06	released XBT	5/5 12:00 (UTC+9h)
	08:27	Launching KAIKO (7K#601Dive)	39-07.0N,143-59.0E
	10:45	KAIKO statrted towing survey (5,352m)	overcast
	13:50	KAIKO finished towing survey (5,145m)	North-3 (Gentle breeze)
	16:00	KAIKO come up to surface	2 (Sea smooth)
	17:52	com'ced MBES and SBP survey	2 (Low swell long)
			Visibly: 8'
06-May-13	02:25	finished MBES and SBP survey	5/6 12:00 (UTC+9h)
	07:29	Launching KAIKO (7K#602Dive)	39-07.0N,143-56.9E
	09:43	KAIKO statrted towing survey (5,152m)	fine but cloudy

	12:50	KAIKO finished towing survey (5,257m)		SSW-6 (strong breeze)
	15:01	KAIKO come up to surface		4 (Sea moderate)
	15:45	proceeding to ISHINOMAKI-WAN bay		2 (Low swell long)
				Visibly: 8'
07-May-13	02:00	arrived at ISHINOMAKI-WAN bay		5/7 12:00 (UTC+9h)
	10:00-10:40	onboard seminar		38-19.5N,141-17.3E
				cloudy
				NW-4 (Moderate breeze)
				3 (Sea slight)
				3 (Moderate short)
				Visibly: 8'
08-May-13	07:00	arrived at research area		5/8 12:00 (UTC+9h)
	07:17	released XBT		37-32.5N,142-57.8E
	8:06-23:34	carried out MBES and SBP survey		fine but cloudy
	23:40	proceeding to SHIOGAMA-KO port		North-4 (Moderate breeze)
				2 (Sea smooth)
				4 (Moderate average)
				Visibly: 8'
09-May-13	09:00	attived at SHIOGAMA-KO port, MIYAGI		5/9 12:00 (UTC+9h)
				SHIOGAMA

4. Instruments

4.1 OBE system

Long term OBE system was based the pop up type OBE system (Kasaya et al., 2006; Kasaya and Goto, 2009). Table 4.1.1 shows a their specifications. To detect an anomalous change of a cold water seep, we used a horizontal and vertical electrode configuration, in the KR12-16 cruise (show Fig. 4.1.1.). The electrodes are Ag-AgCl equilibrium type made by Clover Tech. For electric field, four voltage differences between the electrodes on the tip of the pipes and the ground electrode are measured. The electrodes were measured their self-potentials in advance of the seafloor observation and pairs that the coherence is high enough were selected, in order to reduce the noise due to the voltage drift of electrodes themselves.

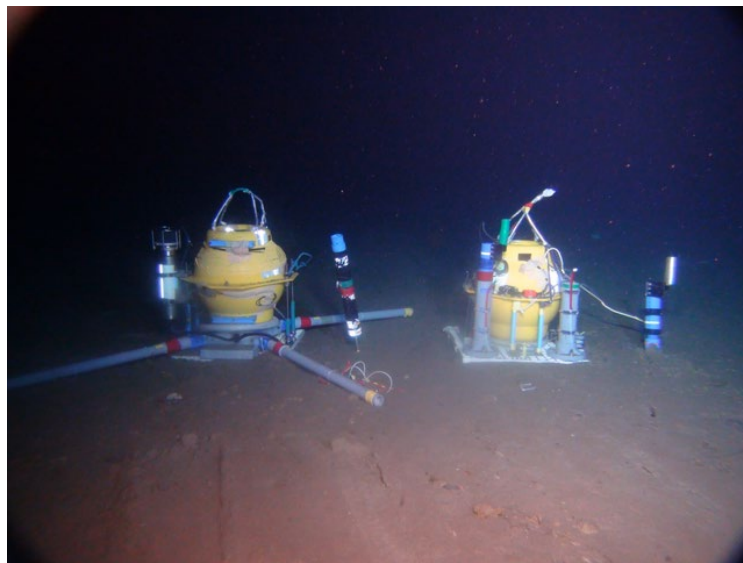


Fig. 4.1.1 OBEs and heat flow measurement system (SAHF) were set up on the seafloor in KR12-16 Cruise.

Table 4.1.1 Specification of OBE system

Sampling rate	1Hz
AD converter	24bit
Resolution	0.0000019mV/LSB
Memory	Compact flash memory (Max 1GB)
Communication port	RS-232C

References

- Kasaya, T., T. Goto, and R. Takagi, Marine electromagnetic observation technique and its development –For crustal structure survey-, *BUTSURI-TANSA*, **59**, 585-594 (in Japanese with English abstract), 2006.
- Kasaya, T., and T. Goto, A small OBEM and OBE system with an arm folding mechanism, *Exploration Geophysics*, **40**, 41-48, 2009.

4.2 JFAST site

Fig.4.2.1 shows a schematic diagram of the observatory system installed during IODP Expedition 343T at the JFAST site, Hole C0019D. An 8.5" open hole was drilled to a total depth of about 850 meters below seafloor (mbsf). The hole penetrated two fault zones. The miniature temperature logger (MTL) autonomous observatory was loaded in a 4.5" tubing, which was then emplaced in the 8.5" hole.

The MTL observatory system consisted of a sinker bar, 8 ropes, 55 MTL sensors, 3 weak links, an MTL hanger and an ROV hook ring. The sensors are represented by several types of symbols in Fig 4.2.1. There are two types of temperature sensors, expressed as "Temperature-1" and "Temperature-2" and the total number of the sensors was 45. There were also ten other sensors that measure pressure for depth in addition to temperature. The wet weight of the MTL observatory was about 80 kg. Because it was possible that the faults were still slipping, three weak links were employed to avoid losing the whole system within the hole during retrieval.

Measured data were being stored in the sensors and the MTL observatory system was recovered during this cruise (See 5.3). As shown in the upper right of Fig.4.2.1, the upper end of the 20" casing and a running tool connector exist on the seafloor. The MTL observatory had an ROV hook ring at its upper most end and was retrieved by hooking and pulling up on this ring.

To evaluate the tension of the rope from KAIKO after hooking the MTL string, we deployed a loadcell and spring measure on the payload KAIKO. The rope could be cut for safety of KAIKO if the load became extremely large because of problems with the MTL string.

5. Operation and Dive summary

5.1 LBL transponder operation

Long Base Line (LBL) system consists of three 7 kHz transponder units. In April 24, three transponder units were deployed from R/V KAIREI to make triangle arrangement around JFAST. The base line for each transponder horizontal length was 3,500 m, and descending speed about 100 m/min.

We had carried out position calibration from the ship, which are calculated slant range from each transponder to ship and base line for each transponder by using the least square analytical method. The calibrated positions of transponder were shown in Table 4.2.1.2.

In May 2nd and 3rd, three transponder units were recovered from ocean bottom. It was very hard to accept the release command to the transponder. We tried to send command about 3 hours and to change ship position above transponder to far from transponder. Finally, we found the best sending position; about 4 km northeast from transponder. The ascending speed of transponders about 65 to 70 m/min. 2 of 3 transponders were straggled top buoy and following float buoy before arriving at the sea surface.

Table 5.1.1 Specification of 7 kHz transponder

Max depth	11000m	
Battery capacity	more than 100000 interrogation	
Max release load	500 kgf	
Weight	108 kg (in air), 74 kg (in sea)	
TX frequency		
Transponder code	RX from ship (6.3 kHz)	RX from submersible (6.6 kHz)
X-POND A(#1)	6.8 kHz	6.9 kHz
X-POND B(#2)	7.1 kHz	7.2 kHz
X-POND C(#3)	7.4 kHz	7.5 kHz

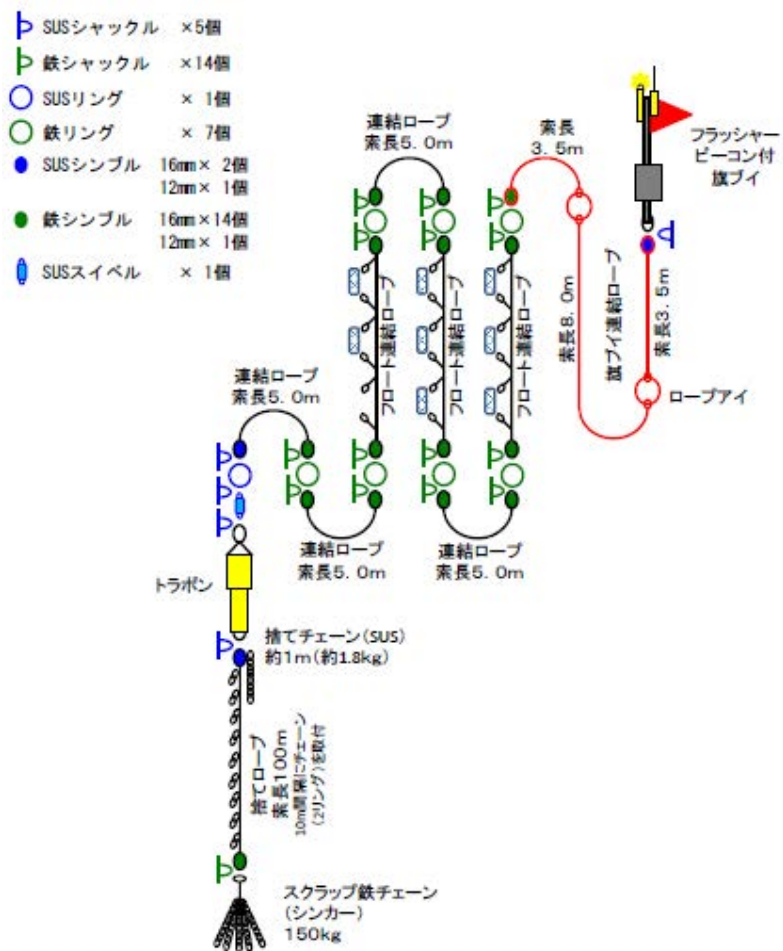


Fig. 5.1.1 Mooring system of LBL transponder

Table 5.1.2 Transponder position

Transponder code	deploy latitude	deploy longitude	calibrated latitude	calibrated longitude
X-POND A(#1)	37-55.7000N	143-56.0000E	37-55.4324N	143-55.9182E
X-POND B(#2)	37-57.4000N	143-54.8000E	37-57.1158N	143-54.7211E
X-POND C(#3)	37-55.7000N	143-53.7000E	37-55.4100N	143-53.5887E
calibrated base line horizontal length				
A-B	3573.8 m			
B-C	3564.9 m			
C-A	3413.5 m			

5.2 Dive 595

During dive 595, a survey was made of the area surrounding the wellhead of C0019D placed by D/V Chikyu during IODP Expedition 343 and 343T. The side scan sonar (SSS) and sub-bottom profiler (SBP) were used to obtain the topography around the site. The tracks of the R/V KAIREI and ROV KAIKO 7000II are shown in Figure 5.2.1. We adopted Long Base Line (LBL) acoustic navigation for precise location of the wellhead.

The data of SSS reveal a hill south of line 1, which is close to the position of D/V Chikyu during the drilling of Hole C0019D. The data of SBP and trend of water depth show that the topography is relatively flat along line 1 and uneven along line 2 (Figure 5.2.2). The wellhead of Hole C0019D was previously located during Dive 579 of cruise KR12-16 south in a flat area and on a slope dipping to the south or southwest. Together this data and information allowed us to narrow down the target search area for the wellhead.

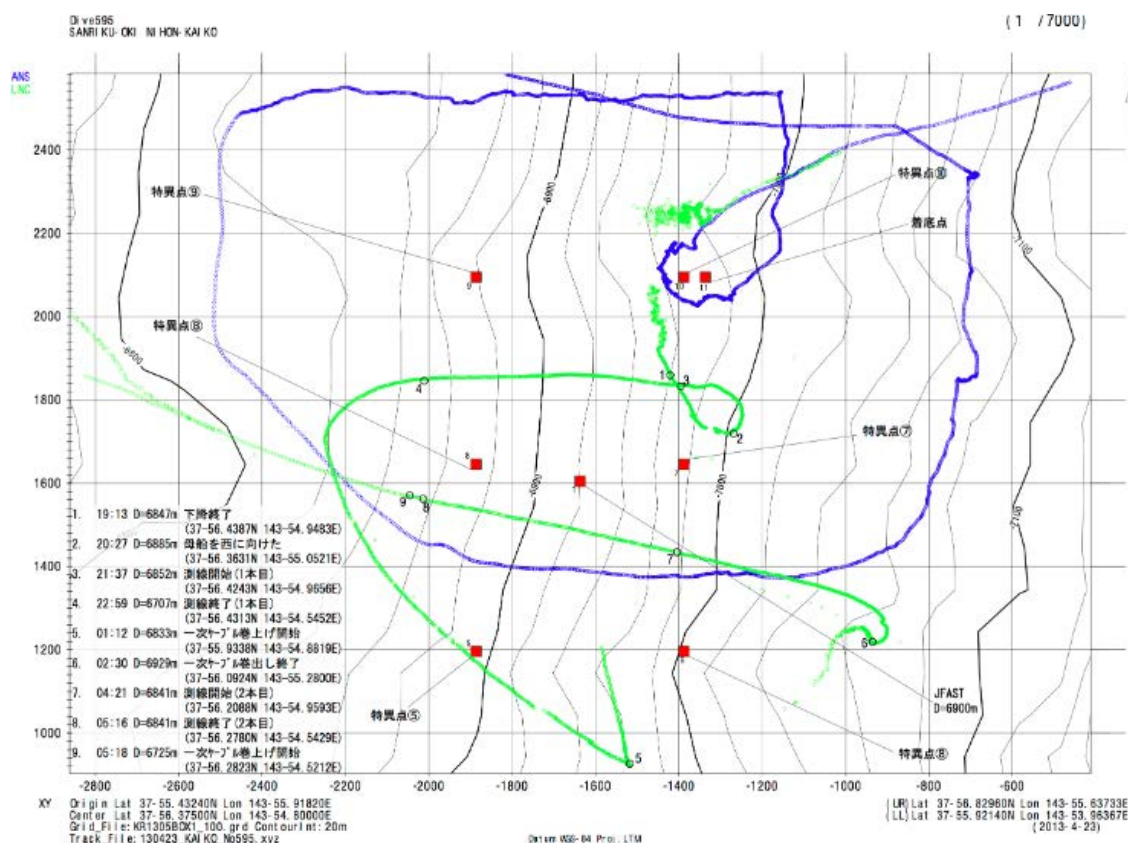


Figure 5.2.1 Map shows tracks of R/V KAIREI (blue) and ROV KAIKO launcher (green). The survey Line 1 is from event numbers 3 to 4 and Line 2 is from event numbers 7 to 8. A sharp bend of the track of launcher after event number 5 is artificial.

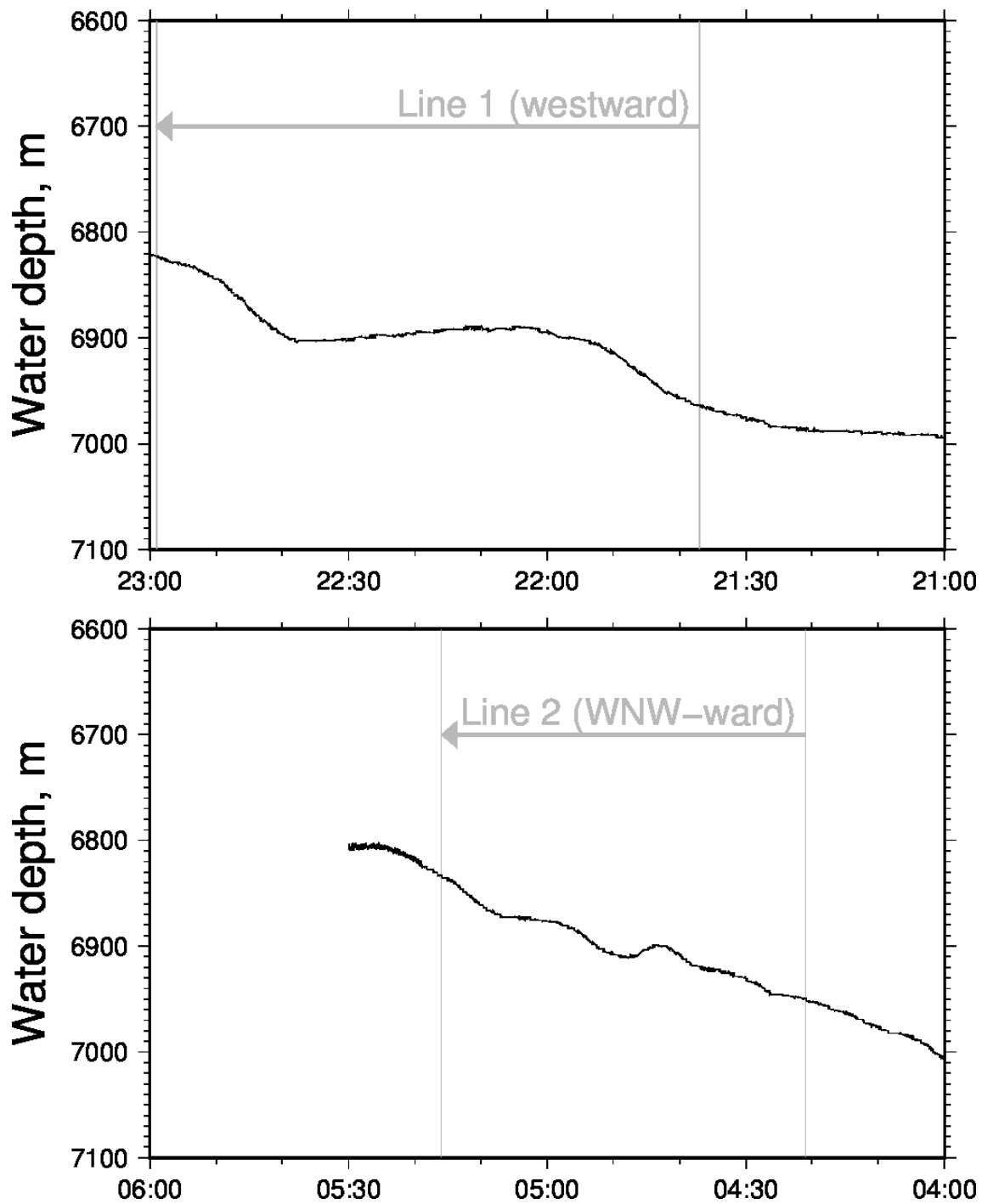


Figure 5.2.2. Trend of water depth along survey lines obtained by summing the CTD depth and SBP altitude of the launcher. The horizontal axis is time flipped to show the direction of surveys from east to west.

5.3 Dive 596

Integrating the information obtained during multiple cruises including IODP Expedition 343/343T of D/V Chikyu, KR12-08, KR13-04 and this cruise, we decided the target point for dive 596 to search for the observatory wellhead (Figure 5.3.1). Both wellheads (Hole C0019D and Hole C0019C) appeared promptly on Obstacle Avoidance Sonar (OAS) after the vehicle arrived the sea bottom. The vehicle of ROV KAIKO approached from the south to Hole C0019D (Figure 5.3.1 and Figure 5.3.2). Table 5.3.1 shows the location of Hole C0019D. The position located during Dive 579 of cruise KR12-16 was shifted to the south by about 200 m because of inherent positioning error of Super Short Base Line acoustic navigation (SSBL). The sea floor around the hole seemed to become lower than that observed during KR12-16 by about 0.5 m relative to the wellhead. Along the approach to Hole C0019D, the wellhead of Hole C0019C was also located (Figure 5.3.3).

The operation of retrieving the MTL observatory sensor string was started when R/V KAIREI and launcher and vehicle of KAIKO were aligned vertically. The alignment is essential to raise the MTL sensor string straight and to avoid excess tension to the MTL sensor string and KAIKO. The ROV hook eye at the top of the MTL observatory (Figure 5.3.2) was hooked to a retrieval rope connected to the vehicle using the manipulator. Once the eye was hooked, the observatory sensor string was raised by winching the primary cable of KAIKO, keeping the vertical distance of 20 m between the launcher and vehicle. The line speed of the primary cable was kept to 5 m per minute until the vehicle ascended to 5951 m where the total length of the observatory sensor string was certainly pulled out entirely of the hole (Figure 5.3.4). The vertical alignment of KAIREI, launcher, and vehicle of KAIKO was kept with LBL navigation. An OAS directed to the bottom was also used to monitor the sea floor. The load on the retrieval rope was measured by load cell and springs measure to monitor the condition of the retrieval (Figure 5.3.4). The oscillation of load became small at 15:03 (depth of 6102 m), which may correspond to pulling out the total length of the observatory.

After the docking of the vehicle and launcher at a depth of 5951 m, KAIKO ascended at regular sequence. The MTL observatory was on deck at 19:10.

Table 5.3.1 Location of Hole C0019D.

Cruise (Position)	Latitude	Longitude	Water depth mbsl
Chikyu (vessel)	37-56.3224 N	143-54.8008 E	6897.5
KR12-16, Dive 579 (Launcher; SSBL)	37-56.1886 N	143-54.7827 E	6903
KR13-08, Dive 596 (Launcher; LBL)	37-56.2861 N	143-54.7989 E	6924

SSBL: Super Short Base Line acoustic navigation

LBL: Long Base Line acoustic navigation

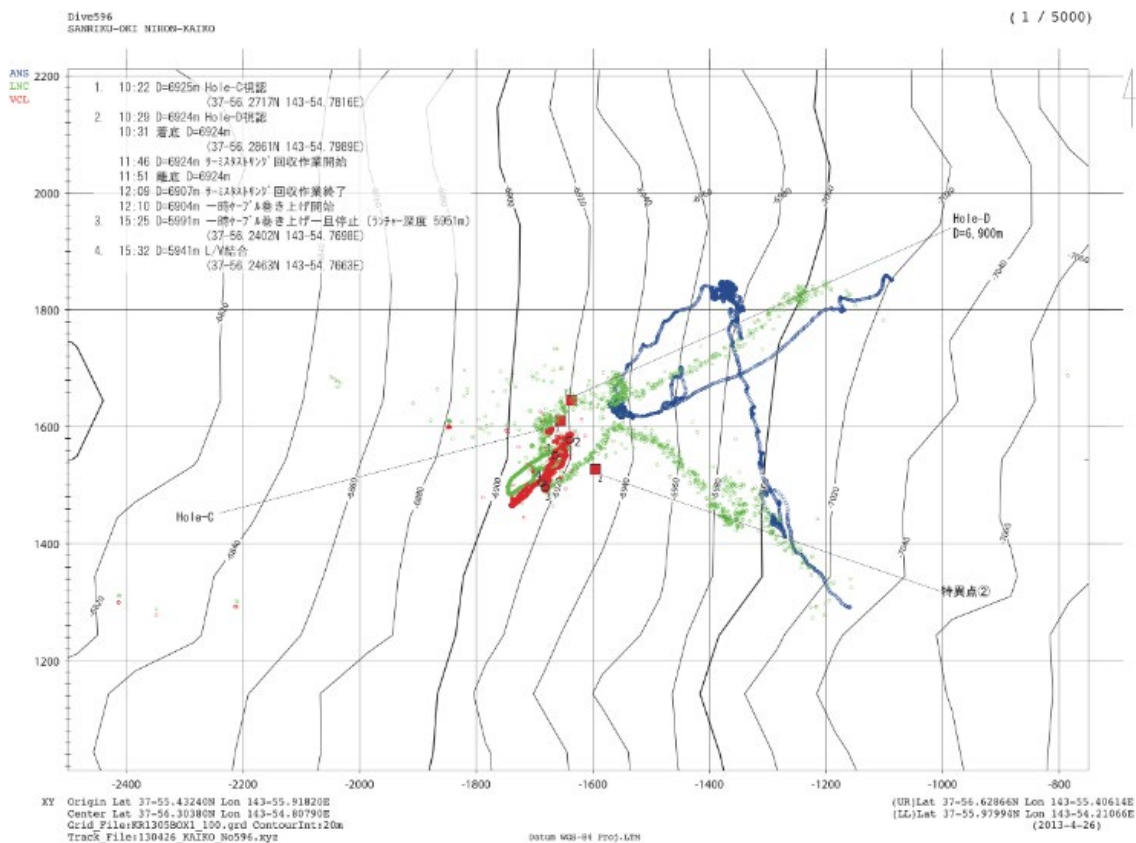


Figure 5.3.1 Map shows tracks of R/V KAIREI (blue), ROV KAIKO launcher (green) and vehicle (red). The survey line 1 is from event numbers 3 to 4 and 2 is from 7 to 8. Sharp bend of the track of launcher after event number 5 is artificial.



Figure 5.3.2 Wellhead of Hole C0019D and ROV hook eye.

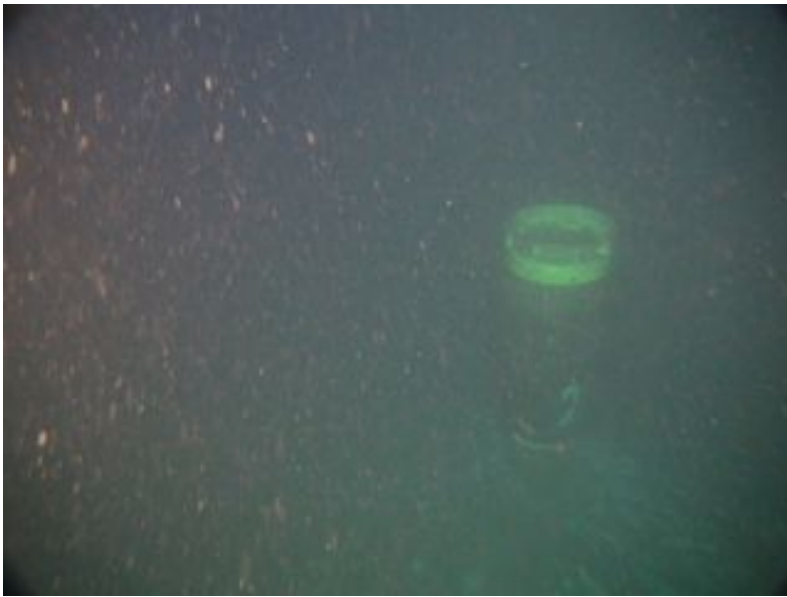


Figure 5.3.3 wellhead of Hole C0019C.

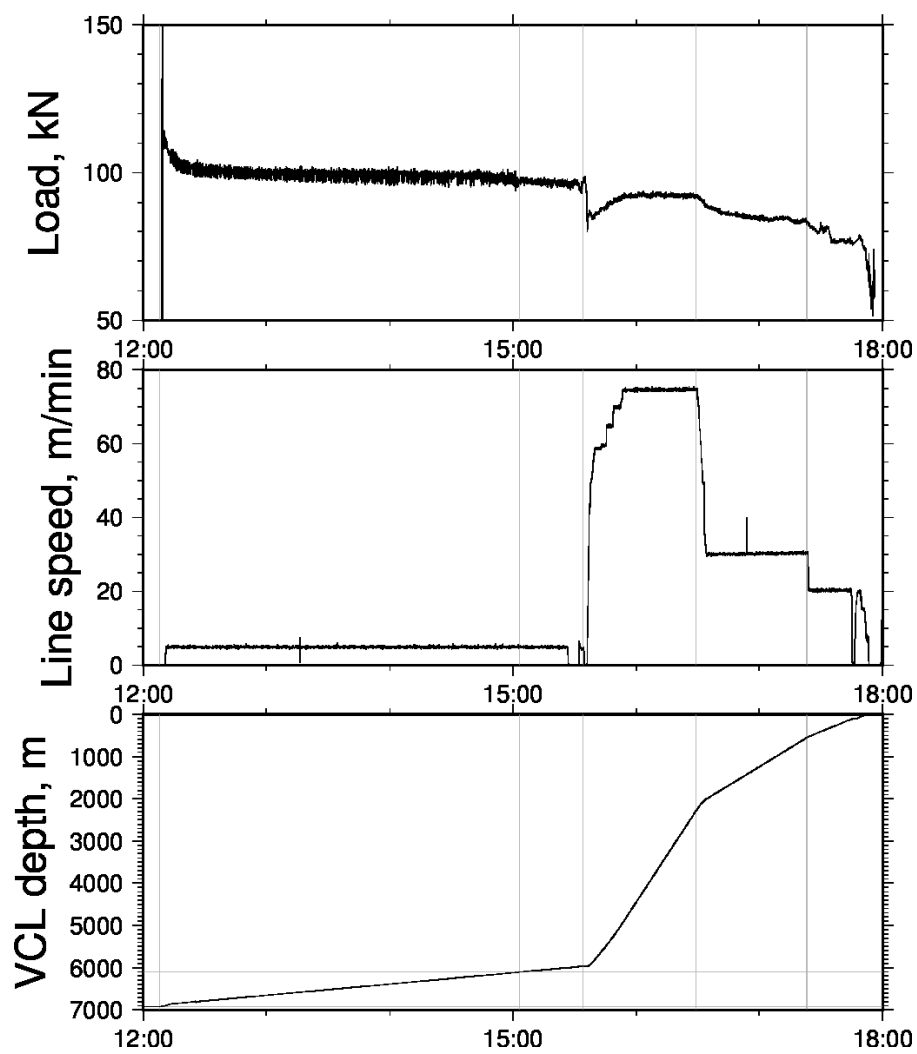


Figure 5.3.4 Load, line speed of primary cable, and depth of vehicle during the retrieval of the MTL observatory.

5.4 Dive 597

The objective of this dive is to recover the super deep OBS that have not recovered because of acoustic release system trouble. Because rough weather would be forecasted until tomorrow morning, we decided the overnight dive. The LBL acoustic navigation system was also used for precise position during this dive.

The ROV Kaiko landed at 21:02 (JST) on April 29 around the event no. 1 in Fig. 5.4.1, and a push core was sampled. We moved to the estimated OBS position after sampling to seek it. Then some clear reflective objects were detected by an acoustic sonar, and we could find the super deep-sea OBS in the end (Figure 5.4.2). A part of the anchor was buried in soft mud in a fissure.

After discovery, we tried to continue a sea floor observation. Because the direction of sea floor current was not good for observation, we gave up an observation. Before the recovery operation, second push core was also sampled near the OBS. The Kaiko hooked a recovery line to a ring attached to the OBS for recovery smoothly and we could recover it on deck.

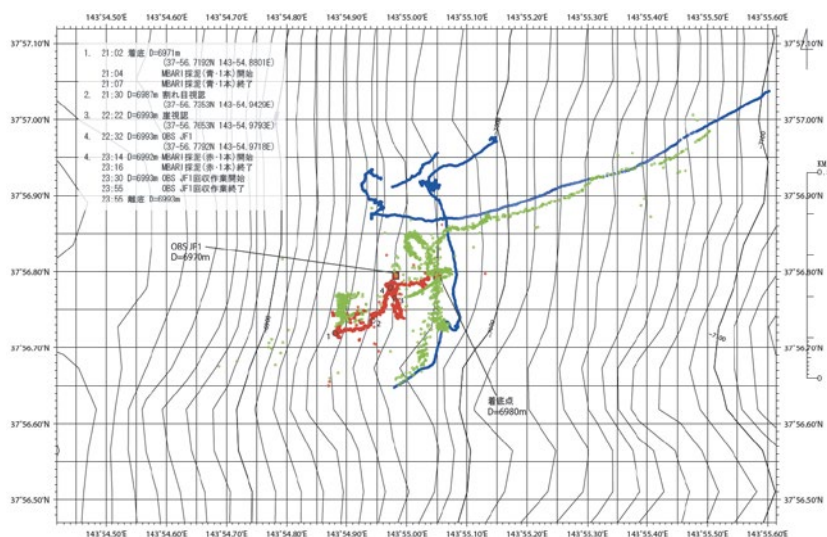


Figure 5.4.1. Track lines of R/V KAIREI (blue), and launcher (green) and vehicle (red) of the ROV KAIKO. Numbers 1 and 4 in red circle indicate the sample location of the push cores.



Fig. 5.4.2 Discovered a deep-sea OBS. A part of the anchor was buried in soft mud in a fissure.

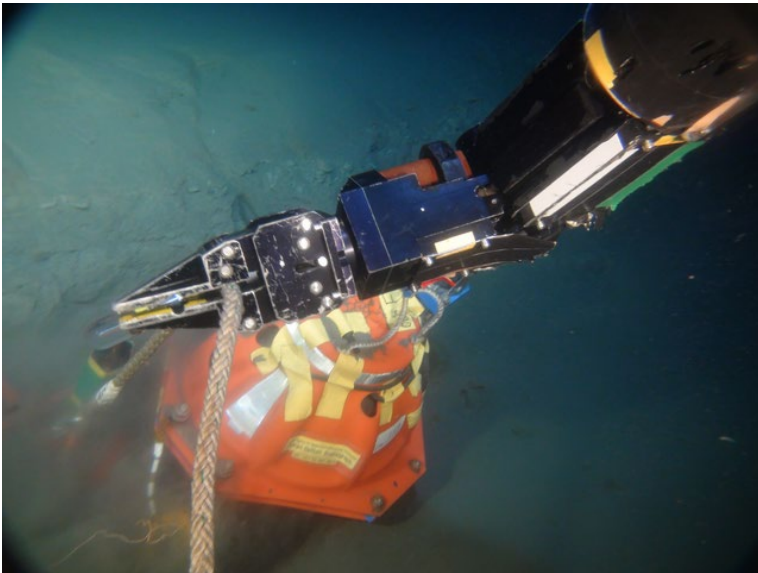


Fig. 5.4.3 Photo of recovery operation. A recovery line was hooked to a ring attached to the OBS.

5.5 Dive 598

The purpose of this dive is to recover the OBE's and measure some heat flow data. Kaiko dove to around 400m southern area of OBE site and start to search our OBE's. Before arriving at an OBE site, we carried out heat flow measurements at event mark 2 and 3 (Figure 5.5.1). We moved to the estimated OBE position after heat flow measurements. Then clear reflective object was detected by an acoustic sonar, and we could find them. Before the recovery operation, we observed the condition around OBE's (Fig. 5.5.2). As a result of the observation, the horizontal type OBE has been moved to the SAHF and a weight put on it fell to a sea floor. Then, an ROV-Homer fell beside vertical type OBE system. Before a recovery operation, we took two core sample beside OBE system. We recovered SAHF and ROV-Homer at first. Then the Kaiko hooked recovery lines to each OBE and started to ascend from a sea floor at 14:19 (JST).

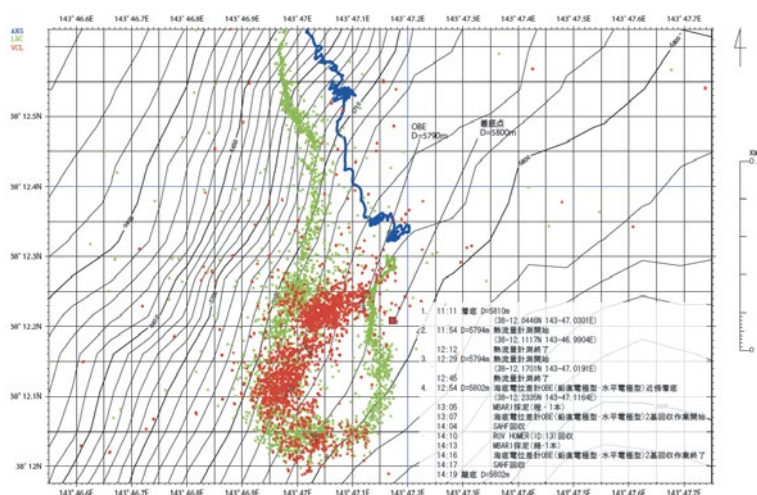


Figure 5.5.1 Track lines of R/V KAIREI (blue), and launcher (green) and vehicle (red) of the ROV KAIKO. Numbers 2 and 3 in red circle indicate the heat flow data measurement position. Number 4 is the OBE site.

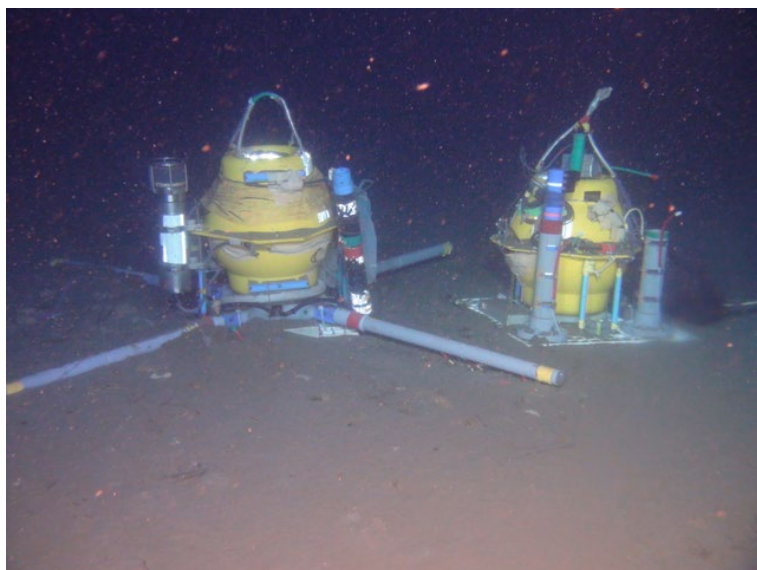


Fig. 5.5.2 OBE system before the recovery operation.

5.6 Dive 599

During dive 599, seafloor observation was conducted to reveal the detailed fracture system, and seabed material and morphology related to recent sediment transport near the JFAST site (Hole C0019D). The tracks of the R/V KAIREI, and vehicle and launcher of ROV KAIKO 7000II are shown in Figure 5.6.1. The LBL acoustic navigation system was adopted for precise position during this dive. A lot of fine-scale fractures (width: < approx. 2 m) were clearly recognized along this line.

In this dive, three push cores (length: 20–30 cm) were also sampled to detect the sediment transport caused by recent earthquake events. The sample locations are shown in Figure 5.6.1. It is note that the sediment core obtained at number 7 in the red line is probably unsuitable for detailed analysis of the sediment transport. Sedimentary structure of uppermost part (0–5 cm below the seafloor) of this core was destroyed while the core was stored in the sample bucket. A rock sample obtained at number 2 in the red line was lost while the KAIKO moved up to the sea surface after the observation.

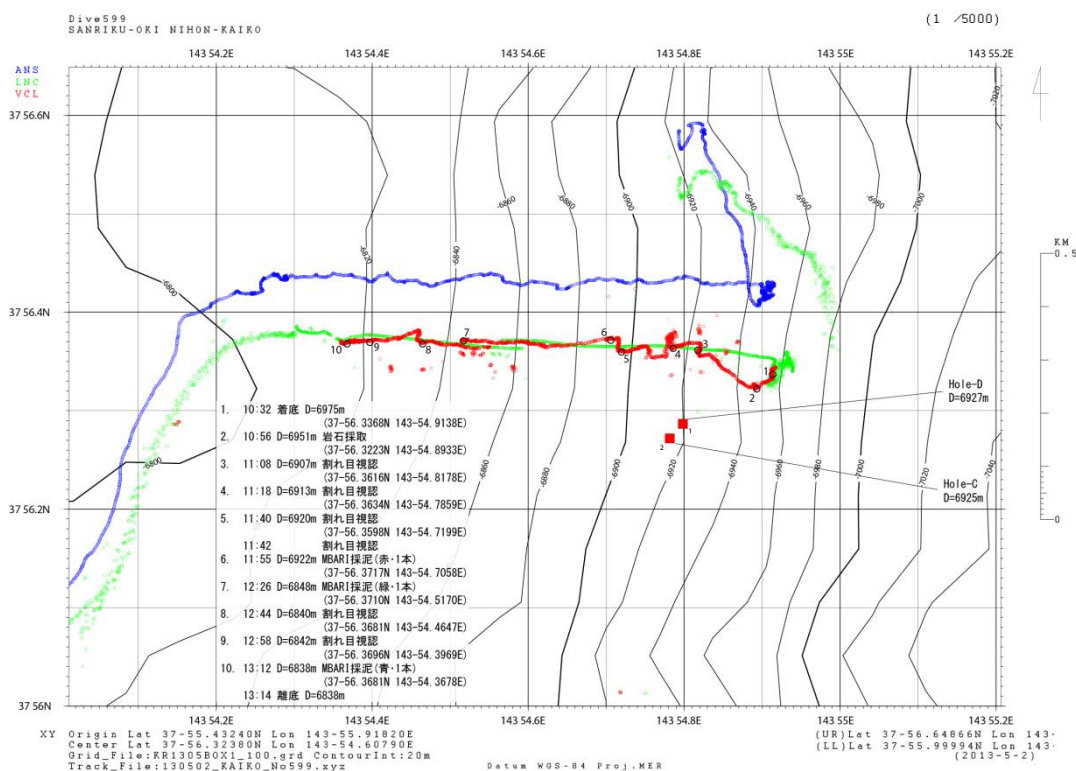


Figure 5.6.1. Track lines of R/V KAIREI (blue), and launcher (green) and vehicle (red) of the ROV KAIKO. Numbers 6, 7, and 10 in red line indicate the sample location of the push cores.

5. 7 Dive 600

During dive 600, bathymetry and subsurface structure were investigated by the SSS and the SBP. The tracks of the R/V KAIREI and ROV KAICO 7000II are shown in Figure 5.7.1. The position of the KAICO was determined by SSBL acoustic navigation system. Altitude of the launcher was 96–106 m above the seafloor during this survey.

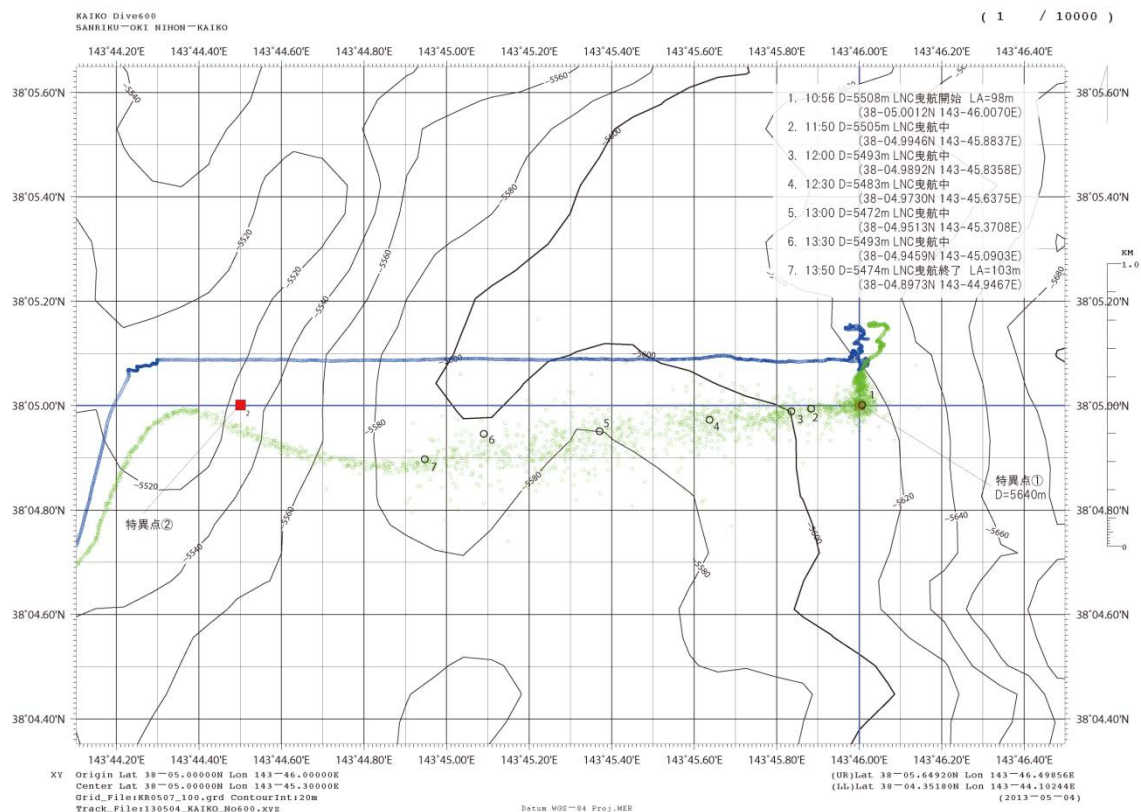


Figure 5.7.1 Track lines of R/V KAIREI (blue), and launcher and vehicle of ROV KAICO (green).

5. 8 Dive 601

During dive 601, bathymetry and subsurface structure were investigated by the SSS and the SBP. The tracks of the R/V KAIREI and ROV KAICO 7000II are shown in Figure 5.8.1. The position of the KAICO was determined by SSBL acoustic navigation system. Altitude of the launcher was 93–108 m above the seafloor during this survey.

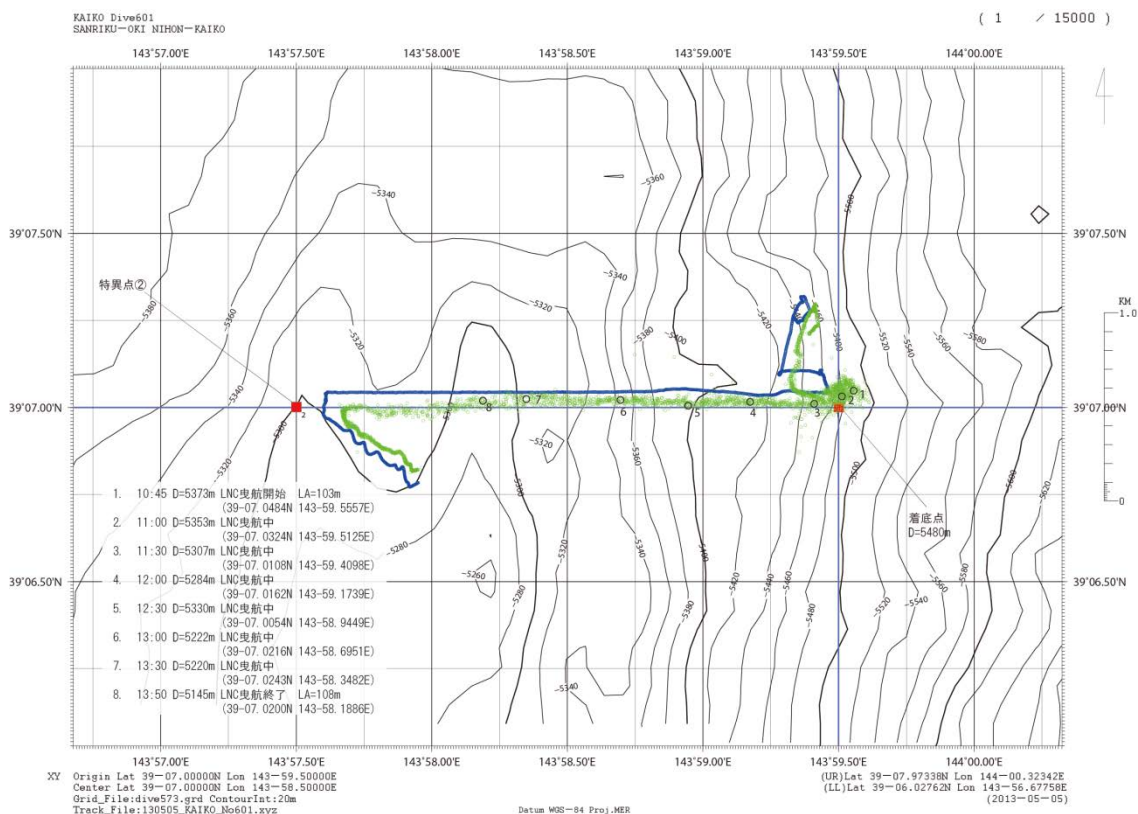


Figure 5.8.1 Track lines of R/V KAIREI (blue), and launcher and vehicle of ROV KAICO (green).

5.9 Dive 602

During dive 602, bathymetry and subsurface structure were investigated by the SSS and the SBP. The tracks of the R/V KAIREI and ROV KAIKO 7000II are shown in Figure 5.9.1. The position of the KAIKO was determined by SSBL acoustic navigation system. Altitude of the launcher was 95–103 m above the seafloor during this survey.

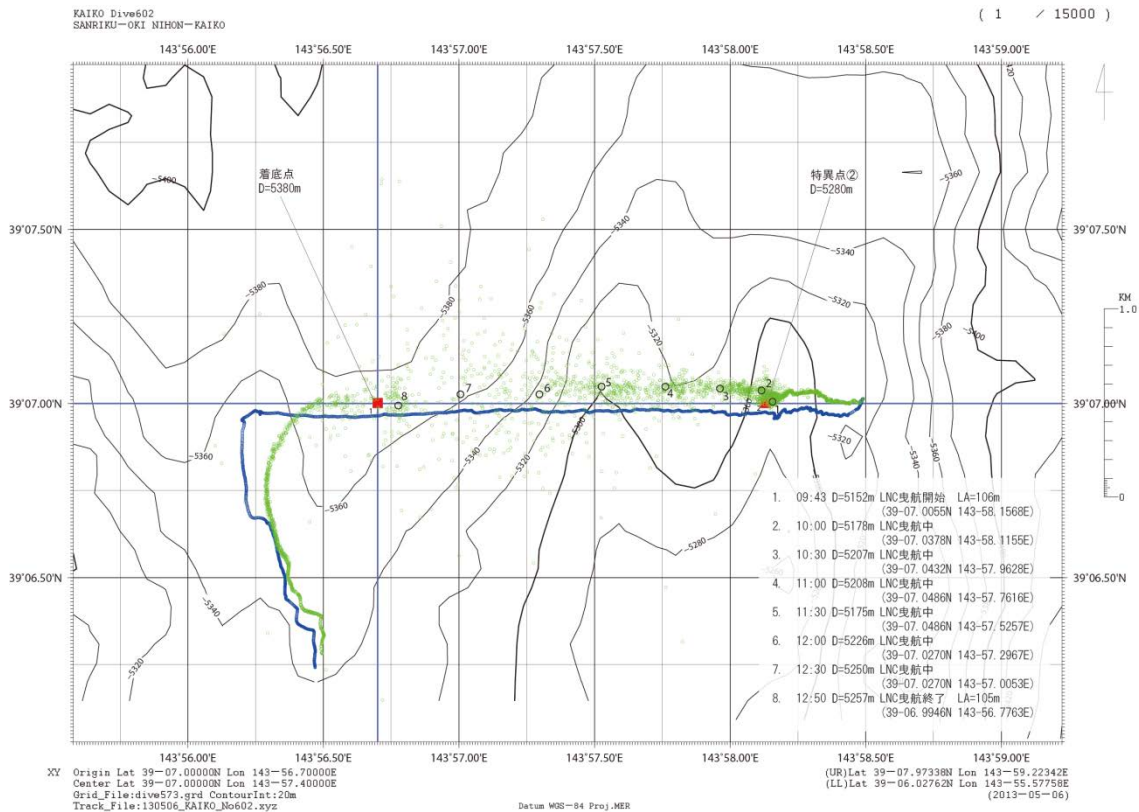


Figure 5.9.1 Track lines of R/V KAIREI (blue), and launcher and vehicle of ROV KAIKO (green).

6. Shipboard data

Bathymetric data are obtained by the SEABEAM2112 system with an array of transducers and hydrophones installed along and across keel of the R/V Kairei. The system transmits a 12 kHz sonar pulse at $2^\circ \times 2^\circ$ resolution for fore/aft direction, and records the travel time and amplitude of the returning echoes. The number of beams for this cruise is fixed in 121, thus there are overlap of beams in 1° . The swath range is changeable between $90 - 150^\circ$, and we fixed the range 120° during this cruise. Sound velocity profiles were obtained from ship-launched XBT measurements at five sites (see Fig. 6.1), and were updated in the SEABEAM system. This MBES system has a sub-bottom profiler with 4 kHz frequency and we could also obtain the SBP data. Ship speed is 6 and 10 knots in SBP survey and MBES survey only, respectively. Table 6.1 shows the survey line list of this cruise. Figure 6.1 shows the survey line map in this cruise.

Specification of SEABEAM2112.004 on R/V Kairei

Depth range; 50-11000 m

Frequency; 12 kHz

Number of beams; 151 max

Beam resolution; $2^\circ \times 2^\circ$

Beam spacing; 1°

Maximum speed; 12 knot (8 knot fix during this cruise)

Accuracy of measurement; 0.5% of depth

Swath range; $90-150$ (150° for $\sim 300\text{m}$, 140° for $\sim 1500\text{m}$, 120° for $\sim 4500\text{m}$, 100° for 8000m , and 90° for 11000m in depth. 120° fix in this cruise)

Specification of sub-bottom profiler system

Frequency; 4 kHz

Beam width; $45^\circ \times 5^\circ$

Profiling limit; 75mbsf

Number of pixels; 1000 pix. each for port and starboard

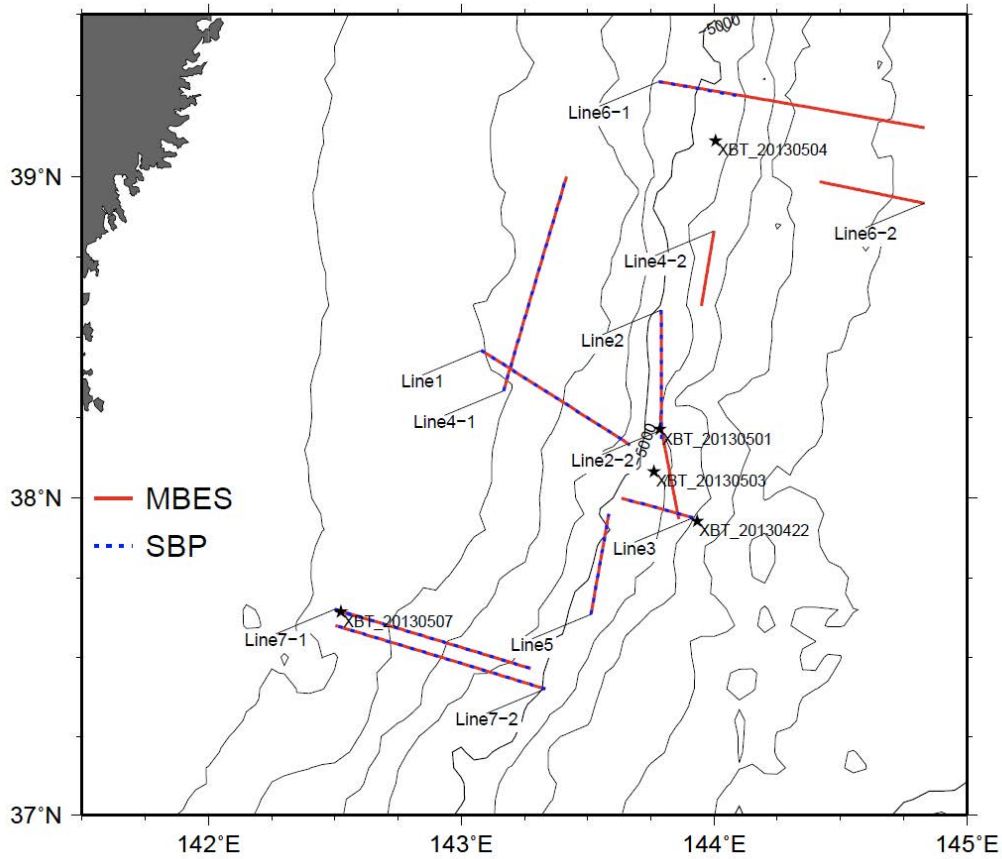


Figure 6.1 Survey lines on this cruise. Red and blue dashed line show the MBES and SBP survey, respectively.

Table 6.1 List of MBES survey lines.

Line Name	source	Start				End			
		Date	time(JST)	Latitude	Longitude	Date	time(JST)	Latitude	Longitude
Line1	MBES	4/29	09:17	38:27.6228N	143:04.7672E	4/29	15:09	38:09.9895N	143:40.0323E
	SBP	4/29	09:17	38:27.6229N	143:04.7673E	4/29	15:09	38:09.9896N	143:40.0324E
Line2	MBES	5/1	20:24	38:35.1693N	143:47.4472E	5/2	00:03	38:12.7680N	143:47.5000E
	SBP	5/1	20:24	38:35.1693N	143:47.4472E	5/2	00:03	38:12.7680N	143:47.5000E
Line2-2	MBES	5/2	00:03	38:12.7680N	143:47.5000E	5/2	03:00	37:56.0914N	143:51.6083E
	SBP	5/2	00:03	38:12.7680N	143:47.5000E	5/2	00:30	38:09.9776N	143:47.4983E
Line3	MBES	5/2	20:54	37:56.2690N	143:55.0452E	5/3	00:31	37:59.9947N	143:37.9962E
	SBP	5/2	20:54	37:56.2690N	143:55.0452E	5/3	00:31	37:59.9947N	143:37.9962E
Line4-1	MBES	5/3	15:18	38:20.0782N	143:10.0241E	5/3	21:58	38:59.9492N	143:24.9545E
	SBP	5/3	15:18	38:20.0782N	143:10.0241E	5/3	21:58	38:59.9492N	143:24.9545E
Line4-2	MBES	5/4	00:11	38:49.8944N	143:59.9826E	5/4	02:18	38:35.9182N	143:56.9778E
Line5	MBES	5/4	19:02	37:38.0944N	143:30.7819E	5/4	21:56	37:57.0108N	143:35.0107E
	SBP	5/4	19:02	37:38.0944N	143:30.7819E	5/4	21:56	37:57.0108N	143:35.0107E
Line6-1	MBES	5/5	17:52	39:17.5337N	143:46.7725E	5/5	23:27	39:09.0010N	144:49.8880E
	SBP	5/5	17:52	39:17.5081N	143:46.9482E	5/5	20:05	39:14.9105N	144:05.3467E
Line6-2	MBES	5/6	00:33	38:55.0092N	144:49.9173E	5/6	02:25	38:58.9948N	144:25.0571E
Line7-1	MBES	5/8	08:06	37:39.0200N	142:29.9945E	5/8	14:56	37:27.8485E	143:16.5143N
	SBP	5/8	08:06	37:39.0200N	142:29.9945E	5/8	14:56	37:27.8485E	143:16.5143N
Line7-2	MBES	5/8	15:24	37:23.9925N	143:19.9695E	5/8	21:46	37:35.9667N	142:30.1373E
	SBP	5/8	15:24	37:23.9925N	143:19.9695E	5/8	21:46	37:35.9667N	142:30.1373E
Line7-1_cont	MBES	5/8	22:47	37:38.7852N	142:30.1364E	5/8	23:34	37:37.5561N	142:35.9738E
	SBP	5/8	22:47	37:38.7852N	142:30.1364E	5/8	23:34	37:37.5561N	142:35.9738E

Appendix

A.1 R/V KAIREI

The deep sea research vessel "KAIREI" is designed to survey deep sea floor and sub-seafloor structures of arc-trench-backarc systems, ridge systems and basic oceanic crustal structure. R/V KAIREI is the exclusive mother vessel for "KAIKO 7000 II".

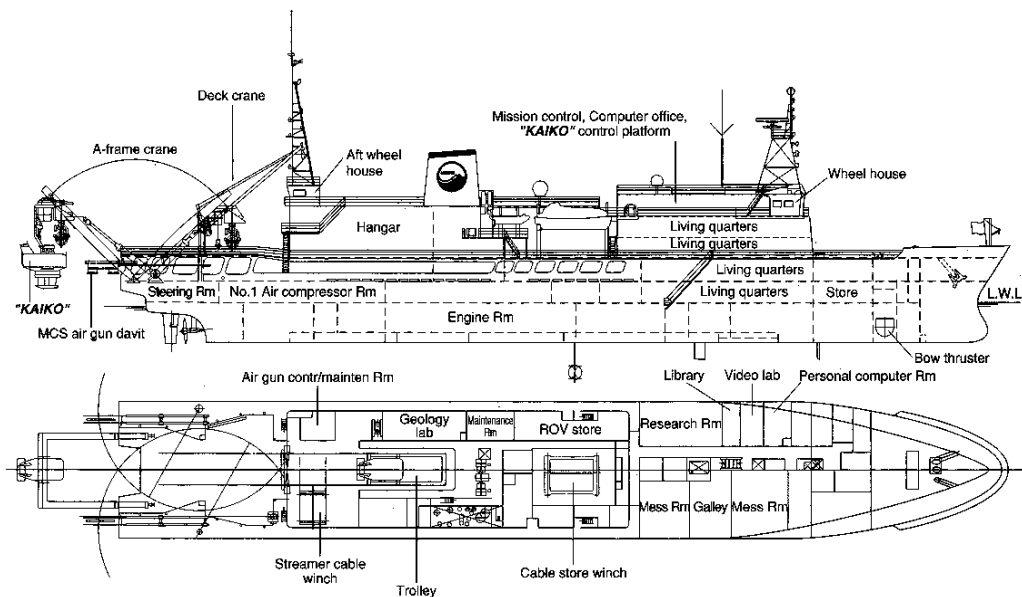
In addition, R/V KAIREI is equipped with various kinds of geophysical equipment; a multi narrow beam echo sounder and a sub bottom profiler (Sea Beam 2112.004, Sea Beam Instruments, Inc.), a gravity meter (Marine Gravity meter System type KSS 31, BODENSEEWERK PERKIN-ELMER), a three axis magnetometer (Type SFG-1212, Tera Technica Inc.), and a proton magnetometer (Type PM-217, Kawasaki Geological Engineering Co., Ltd.). The specifications of R/V KAIREI are listed below.

The general specifications of R/V KAIREI

Nationality	JAPAN
Owner	JAMSTEC
Operator	Nippon Marine Enterprises, Ltd
Length overall	106.0 m
Beam overall	16.0 m
Draft	4.5 m
Gross tonnage	4,517 tons
Maximum speed	16.7 knots
Main propulsion system	Diesel engines
Main propulsion method	2,206kW x 2 Controllable pitch propeller x 2

Complement

Crew / Submersible operation staff	38 persons
Researchers	22 persons
	Total 60 persons



A.2 KAIKO 7000 II System

The 7,000m-class ROV “*KAIKO 7000 II*” system has been developed for use in deep-sea research that has not been possible by existing manned submersible for reason of ocean depths or sea floor topographies.

The specifications of Launcher

Dimensions	5.2m (Length) x 2.6m (Wide) x 3.2m (Hight with fin)	
Weight	5.8 tons in air / 3.5 tons in water	
Tow speed	MAX 1.5 knots	
Operating depth	MAX 11000m	
Equipment		
Side Scan Sonar (SSS)	Frequency : 42kHz, 38kHz	
	Range : 1000m in each side	
Sub Bottom Profiler (SBP)	Parametric method	
	Frequency : 60kHz (Primary wave)	
	2.5, 3.5, 5.0kHz (Secondary)	
	Pulse level : 235dB	
CTD, Gyro compass, Obstacle avoidance sonar, Acoustic positioning system, Monitoring camera, Pitch / roll sensor,		

The specifications of Vehicle

Dimensions	3.0m (Length) x 2.0m (Wide) x 2.1m (Hight)
Weight	4.0 tons in air / 0.0 tons in water
Speed	0 – 0.5 knots
Propulsion	4 horizontal thrusters / 6 vertical thrusters
Operating depth	MAX 7000m
Equipment	
CTD, Gyro compass, Obstacle avoidance sonar, HDTV camera x2, Color TV camera x2 (with Pan &Tilt), Digital still camera, manipulators x2, Sample basket (Payload:100kg in air, 50kg in water)	