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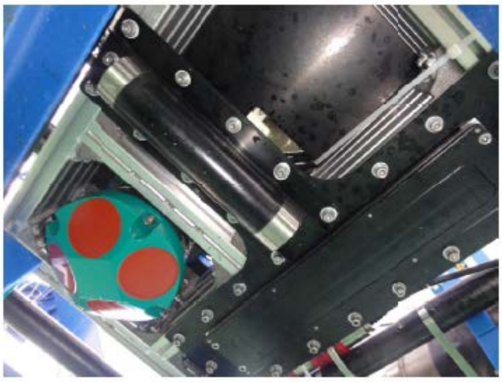
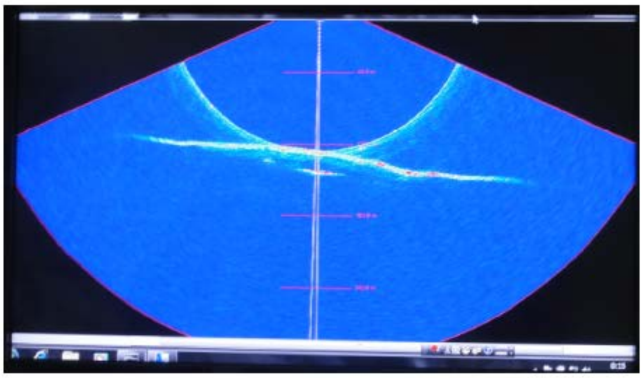
YOKOSUKA Cruise Report
YK11-E06 Leg 1





July 11 2011 – July 28 2011

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

Acknowledgements

We would like to thank Captain Mr. Samejima and all ship crew of R/V YOKOSUKA for their safe cruise. We are grateful to Commander Mr. Ogura and the operation team of a Yokosuka Deep-Tow (YKDT) for their operations in serious condition. We are pleased to MARITEC staff for their supports during our cruise. We also thank Dr. Kodaira, Dr. Kinoshita, Dr Kitazato Dr Takai and Dr Fujikura for their advices of cruise planning.

YK11-E06 Leg 1 Cruise report contents

1. Objectives and Cruise information of YK11-E06 Leg 1 cruise

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 (Maeda et al., 2011) and bathymetric surveys (Fujiwara et al., submitted) indicate that the toe region slipped about 50 m along the thrust. If the thrust fault rapidly deformed the seafloor, as suggested by Ide et al. (2011), the basic theory of tsunamigenesis would predict the generation of tsunamis all along the axis of the Japan Trench.

We plan various observations to make clear many phenomena related with the earthquake. The main task of this cruise is to collect the detailed bathymetric data in the toe region of the Japan Trench slope. Therefore, we prepare to use a high accuracy multi-beam echo sounder "Seabat 7125 system" on a Yokosuka deep-tow (YKDT). A deep sea camera system operation is planed to collect the images and samples in the depth of over 7000 meters. Bathymetric, back scatter image, sub-bottom profiler data, gravity and three-component geomagnetic data were also observed. Other observations based on the observation proposal related with this earthquake are also planed.

Cruise information

Cruise number	YK11-E06 Leg 1
Ship name	R/V YOKOSUKA
Chief scientist	Takafumi Kasaya (IFREE, JAMSTEC)
Date	11 July 2011 – 28 July 2011
Ports of call	Yokosuka – Yokosuka (JAMSTEC)
Research Area	Off Sanriku, Off Boso(Fig.1)

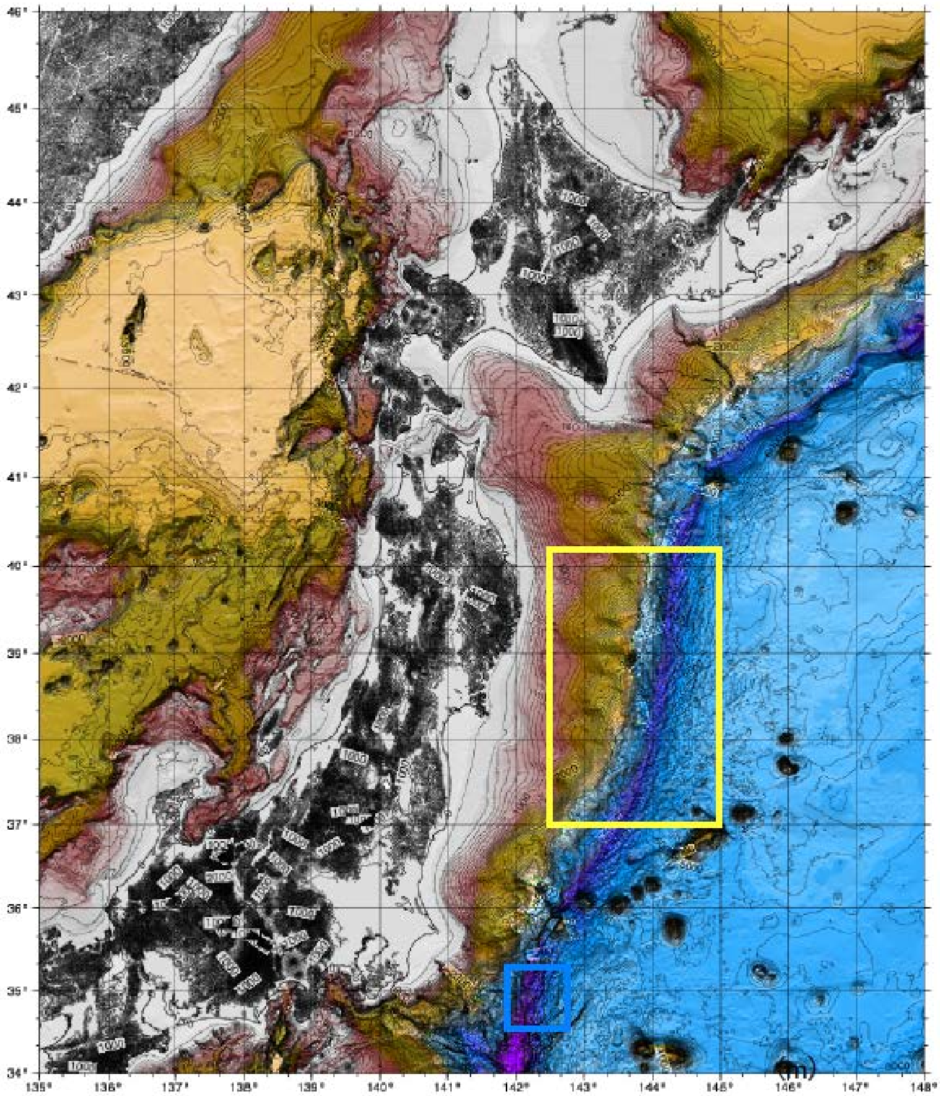


Fig.1 Research area map of this cruise.

2. Participants List

Onboard Scientists

Chief Scientist (IFREE/JAMSTEC)	Takafumi KASAYA
Scientist (IFREE/JAMSTEC)	Miho ASADA
Scientist (IFREE/JAMSTEC)	Arito SAKAGUCHI
Scientist (BioGeos/JAMSTEC)	Kazumasa OGURI
Scientist (BioGeos/JAMSTEC)	Takashi TOYOFUKU
Scientist (Fukada Geological Institute)	Kiichiro KAWAMURA
Scientist (Tohoku University)	Motoyuki KIDO
Scientist (Tohoku University)	Yukihito OSADA
Scientist (Tohoku University)	Yoshihiro ITO
Scientist (JMA)	Kenji HIRATA

Technical Advisor

Technical Staff (Maritec/JAMSTEC)	Junya NIIKURA

Deep Tow Operation Team

Chief Submersible Staff	Satoshi Ogura
2nd Submersible Staff	Akihisa ISHIKAWA
2nd Submersible Staff	Fumitaka SAITO
2nd Submersible Staff	Takuma OONISHI
3rd Submersible Staff	Yudai TAYAMA

R/V YOKOSUKA Crews

Captain	Koji SAMESHIMA
Chief Officer	Takafumi AOKI
2nd Officer	Shozo FUJII
3rd Officer	Yumihiko KOBAYASHI
Chief Engineer	Hiromi YOSHIKAWA
1st Engineer	Takashi OTA
2nd Engineer	Takahiro MORI
3rd Engineer	Kenta IKEGUCHI
Chief Radio Operator	Tokinori NASU
2nd Radio Operator	Yoshikazu KURAMOTO
Crew Trainee	Ryosuke KOMATSU
Crew Trainee	Sho SUZUKI
Crew Trainee	Syogo YOSHIMURA
Crew Trainee	Ippo MURASE

Crew Trainee	Katsuhiro KAWASE
Boat Swain	Shoichi ABE
Able Seamen	Nobuyuki. ICHIKAWA
Able Seamen	Masanori OHATA
Able Seamen	Nozuyuki ISHIZUKA
Able Seamen	Shoji TAKUNO
Sailer	Shinsuke UZUKI
Sailer	Hiroki Shigeta
No.1 Oiler	Kazuaki NAKAI
Oiler	Ryo SATO
Oiler	Souta MISAGA
Oiler	Takeshi WATANABE
Oiler	Masayuki FUJIWARA
Chief Steward	Teruyuki YOSHIKAWA
Steward	Takahiro ABE
Steward	Shinsuke TANAKA
Steward	Mizuki NAKANO
Steward	Toru WADA

3. Ship logs

Logbook YK11-E06Leg1 11/July/11 - 28/July/11, for 18 days				
Date	Time	Description	Remark	Position/Weather/WindDirection/WindVelocity/WaveHeight/Visiblity/Swell
11,Jul,11	9:00	Embark on Yokosuka		Weather: bc = fine but cloudy
	10:00	Depart from the YOKOSUKA JAMSTEC port		o = overcast, f = fog
	12:00	Cruise to the Boso OBS site	Head 190, 15 knots	34-59.2,139-41.8/bc/S/4/2/1/10
	16:00	Arrive at the Boso OBS site		
	16:10	Deploy a transducer		
	17:51	Recover OBS Y2		
	20:43	Recover OBS W2		
	23:15	Recover OBS W3		
12-Jul-11	1:29	Recover OBS V3		
	4:14	Recover OBS V4		
	4:15	Cruise to the DC-1 Site, off Sanriku		
	12:00			37-04.0,143-11.5/bc/SW/4/2/1/1/2
	16:10	Arrive at the DC-1 site		
	16:17	XBT		
	17:02	Deploy the deep-sea camera system (lander) at DC-1 site		
	19:23	Start calibration		

	20:10	Finish calibration
13,Jul,11	8:18	Recover the lander
	8:20	Cruise to the GJT3 site for GPS measurement
	10:20	Arrive at the GJT3 site
	10:50	Tow the GPS system
	11:50	XBT
	12:00	38-16.3,143-28.9/bc/SW/5/4/2/1/0
	14:35	XCTD
	15:07	Finish the GPS system
	15:10	Cruise the DC-2 site for the lander
	17:10	Arrive the site
	17:32	Deploy the lander at DC-2
	19:45	Start calibration
	20:33	Finish calibration
	21:08	Start MBES pre-site-survey
14,Jul,11	1:00	Finish MBES pre-site-survey
	7:17	Recover the lander
	7:20	Cruise to the YKDT#102 site
	8:30	Arrive the site
		But we found troubles in the SeaBat system, so that we cancelled the towing.

	10：45	Cruise to S35 site for OBS deployment	
	12：00		38-16.3,143-31.5/bc/SW/5/4/2/1/0
	12：10	Arrive at S35 site	
	12：16	Deploy OBS S35	
	13：11	Deploy OBS S37	
	14：01	Deploy OBS S36	
	14：52	Start MEBS pre-site-survey	
	15：09	Finish MBES pre-site-survey	
	15：33	Deploy OBEM	
	16：43	Start calibration	
	17：42	Finish calibration	
	19：11	Start MBES pre-site-survey	
	19：57	Finish MBES pre-site-survey	
	22：26	Start MBES survey	
15-Jul-11	4:00	Finish MBES survey	
	6:50	YKDT#102 on the sea surface	
	11：22	Finish the survey because of cable trouble	
	12：00		38-10.9,143-47.0/bc/W/4/3/1/8
	13：57	YKDT on deck	
	16：46	Deploy OBS S3B	
	17：	Deploy OBS S3C	

	38	
	18:19	Start MBES survey
16-Jul-11	2:20	Finish MBES survey
	6:51	YKDT #103 on the sea surface
	12:00	38-10.5,143-46.5/o/SW/3/2/3/6
	16:00	Recover YKDT#103
	18:49	Start MBES survey
17-Jul-11	3:11	Finish MBES survey
	4:39	Start MBES pre-site-survey
	5:25	Finish MBES pre-site-survey
	6:46	YKDT#104 on the sea surface But we found troubles in the camera system, so that we cancelled the towing.
	12:00	39-06.5,143-53.1/f/SW/3/3/3/0.1
	16:06	Recover YKDT#103
	18:49	Start MBES survey
18-Jul-11	3:11	Finish MBES survey
	4:39	Start MBES pre-site-survey
	5:25	Finish MBES pre-site-survey
	6:46	YKDT#104 on the sea surface But we found troubles in the camera system, so that we cancelled the towing.

	12:00		41-04.2,142-02.4/bc/N/2/1/4/10
	12:27	Recover YKDT#104	
	17:19	Deploy OBS S39	
	18:11	Deploy OBS S3A	
	19:05	Deploy OBS S38	
	20:01	Start MBES survey	
	0:00	Finish MBES survey	Cruise to Aomori port
19-Jul-11	8:05	Anchor at No.3 district in Aomori port	Harborage for typhoon No.6 (Margon)
	12:00		40-51.3,140-45.3/bc/NE/4/3/1/10
20-Jul-11	12:00	Aomori port	40-51.3,140-45.7/bc/E/5/4/1/10
21-Jul-11	12:00	Aomori port	40-51.3,140-45.7/bc/E/6/4/1/10
22-Jul-11	12:00	Aomori port	40-51.3,140-45.7/bc/E/5/3/10
	13:15	Disembarkment: Sakaguchi, Kido, Ito, Hirata	
23-Jul-11	12:00	Aomori port	40-51.3,140-45.7/bc/NE/4/2/0/10
	14:25	Weigh the anchor	
24-Jul-11	12:00	Cruise to survey area	Head 142, 9 knots o/NNE/3/4/4/1
25-Jul-11	2:30	Arrive at survey area	
	4:40	Start MBES pre-site-survey	
	5:33	Finish MBES pre-site-survey	

		But we cancelled YKDT operation, because of large swells from typhoon.	
	9:17	Start MBES survey	
	12:00		39-00.5,144-04.5/o/S/5/4/4/7
26-Jul-11	2:30	Finish MBES survey	
	5:56	YKDT#105 on the sea surface, Bathymetric survey using SeaBat7125	
	12:00		39-08.4,143-53.5/o/S/4/2/1/4
	17:35	Recover YKDT#105	
	18:19	Start calibration for ship magnetometer (hachinoji)	
	18:38	Finish the calibration	
	18:42	Start MBES survey	
	23:30	Finish MBES survey	
27-Jul-11	6:03	Tow the GPS system (GFK)	
	7:00	XBT	
	11:20	XCTD	
	11:49	Finish the GPS system	
	11:50	Cruise to JAMSTEC Yokosuka port	
	12:00		37-34.8,142-45.9/bc/NW/2/2/1/4
28-Jul-11	9:00	Arrive at the JAMSTEC port	

4. Deep-Tow dives

4.1 Yokosuka Deep-Tow (YKDT) system

Yokosuka Deep-tow is attached by armored cable between the mother vessel. There are color TV camera, black-white TV camera, digital still camera and CTD sensors.

color TV camera	SONY DXC-990, NTSC luminous intensity ：1 lux
black-white TV camera	SONY XC-ST50, NTSC luminous intensity ：0.3 lux
digital steel camera	AquaPix SeaSnap (3.34Mpixel)
flood lamp	500W×2 250W×2
CTD	Seabird SBE49
alt meter	MESOTECH 1007
trans ponder	Oki SB-1023 (7kHz)
releaser	Inter Ocean MR5000

Table 4.1.1 The specifications of Yokosuka Deep-tow

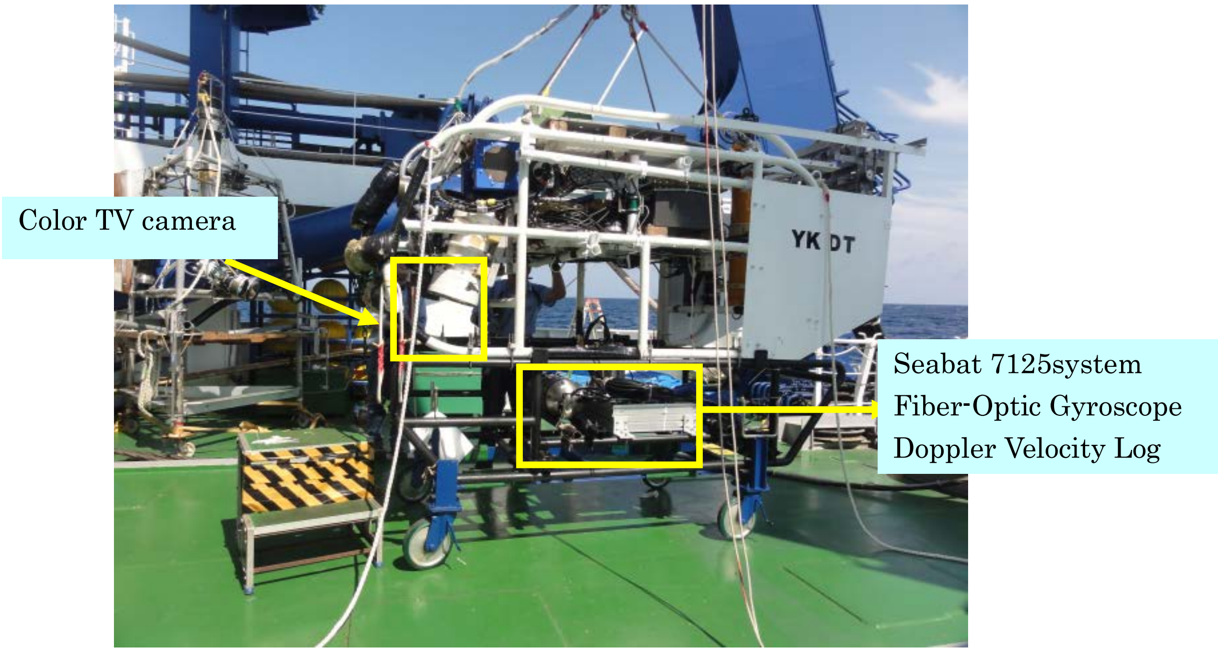


Fig.4.1.1 Yokosuka Deep-tow with a “SEABAT 7125” system.

4.2 SEABAT 7125 system

Junya Niikura

SeaBat7125 mounted on YK-DT during YK11-E06 cruise is a 400 kHz high resolution bathymetric system that collects high resolution bathymetric data and backscattering intensity data simultaneously. 512 beams and equi-distant footprints provide us extremely high density and maximizing swath width. All measurements are corrected for actual YK-DT attitude by using PhinsDVL motion sensing unit. With No.3 fiber optic cable, SeaBat7125 and PhinsDVL mounted on YK-DT can map water as deep as 6,000 meters. The specification of the system is shown in Table 4.2.1.

Table 4.2.1

SeaBat7125

Frequency : 400kHz

Max Slant Range : 200m

Swath Coverage : 128°

Beam Width : 0.5× 1 ° (Along-track ×Across-track)

Number of Beams : 256 / 512 Equi-angle or 512 Equi-distant

Depth Resolution : 6 mm

Operating Depth : 6000m

PhinsDVL

Heading Accuracy : 0.01°(working with GPS)

Roll / Pitch Accuracy : 0.01°rms

DVL Frequency : 600kHz

Operating Depth : 6000m

SeaBat7125 system is composed of the receiver array, projector array, and SeaBat7125 Control PC (see, Fig.4.2.1). PhinsDVL is a subsea inertial navigation system providing position, true heading (Fiber Optic Gyroscope), attitude, speed and heave. To increase position accuracy, Doppler Velocity Log (DVL) and depth sensor are connected to PhinsDVL.

Optical transmit device has two tasks. One is supplying electric power to Seabat7125 and PhinsDVL. The other is transmitting PhinsDVL data to Seabat7125 control PC, and transmitting Seabat7125 and Phins DVL data to surface.All bathymetric data including backscattering data and PhinsDVL data are stored on a hard disk drive in SeaBat7125 Control PC pressure case.

Block diagram of the system used during YK11-E06 cruise Seabat 7125 is shown in Fig.4.2.2. Through the No.3 fiber optic cable, SeaBat7125 and PhinsDVL can be controlled and monitored at ship's operation room. For optical communication being not available, real time monitoring of the SeaBat7125 and PhinsDVL data is not available. However, all data is stored in the Seabat7125 control PC of wet part.

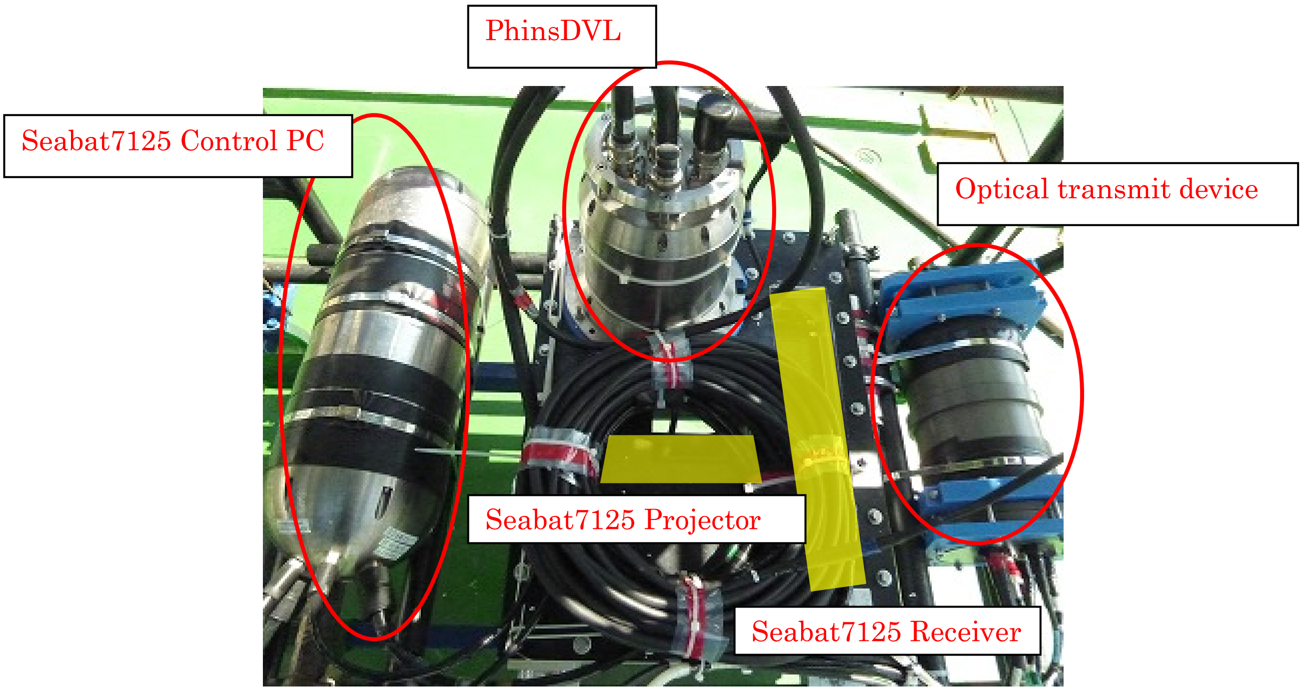


Fig.4.2.1 SeaBat 7125 and PhinsDVL

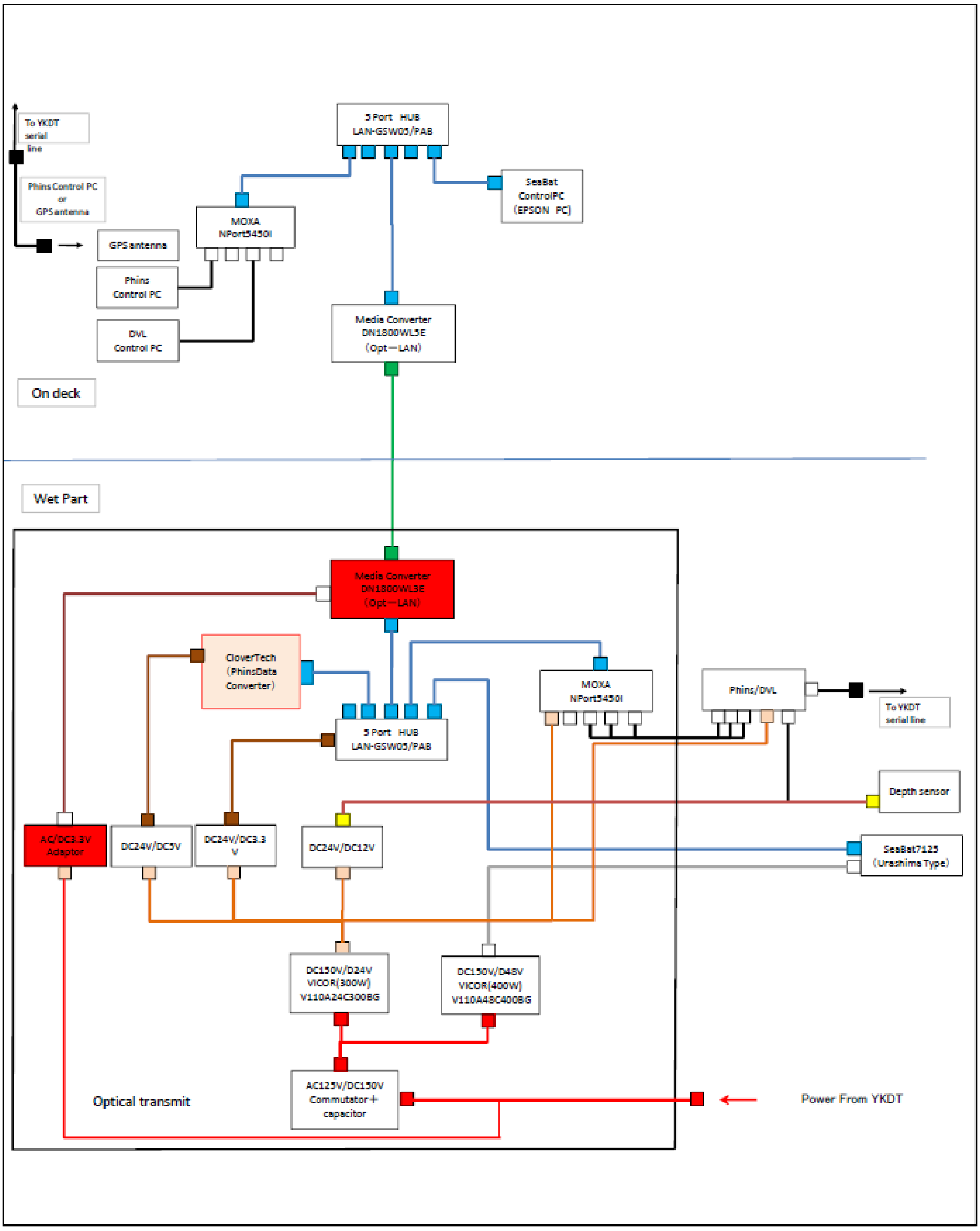


Fig.4.2.2 Block diagram of the SeaBat7125

4.3 Dive summary

Takafumi Kasaya, Miho Asada, Kiichiro Kawamura, Arito Sakaguchi

We carried out the camera observation for the safety check of a "Shinkai 6500" dive and high accuracy acoustic measurement using the "seabat 7125 system". However many trouble of the optical cable communication were occurred. Therefore, we could not enough to obtain the data through this cruise.

4.3.1 Dive #102

The purpose of this dive is to confirm the safety for the "Shinkai 6500" dive around this "Fissure site". We could see the sea bottom covered with the sediment. However, visibility was poor due to muddy water. All communication using the optical cable was not available on the way. YKDT crews tried to recover the optical communication, but we gave up this dive at 11:20.

2011.7/15. Yokosuka@Japan Trench

Time	Cable Length	Altitude	X	Y	Remarks
651	0				Sea surface
900	5333				Information cutt off (Alt, Conduct, Azimuth)
911	5510				Transponder error. Stop roll down.
947	5982		-3680	760	Landing. Clasts scattering with thin cover sediment.
951	5968				Layered strata with thin cover sediment.
952	5968				During moving, camera view is whiteout due to muddy water.
954	5968				Calsts with thin cover sediment
1004	5965				During moving, camera view is whiteout due to muddy water.
1012	5970		-3570	780	During moving, camera view is whiteout due to muddy water.
1020	5976		-3450	750	During moving, camera view is whiteout due to muddy water.
1025	5980		-3390	740	During moving, camera view is whiteout due to muddy water.
1030	5986		-3350	780	During moving, camera view is whiteout due to muddy water.
1040	5993		-3200	770	During moving, camera view is whiteout due to muddy water.

1050	6011	-3080	760	During moving, camera view is whiteout due to muddy water.
1100	6018	-2950	780	During moving, camera view is whiteout due to muddy water.
1110	6017	-2810	790	During moving, camera view is whiteout due to muddy water.
1117	6003			blackout due to cable maintanance
1120	6003	-2660	760	Give up survey
1126				Wire in

Table 4.3.1 Dive log (event log) of YKDT dive #102.

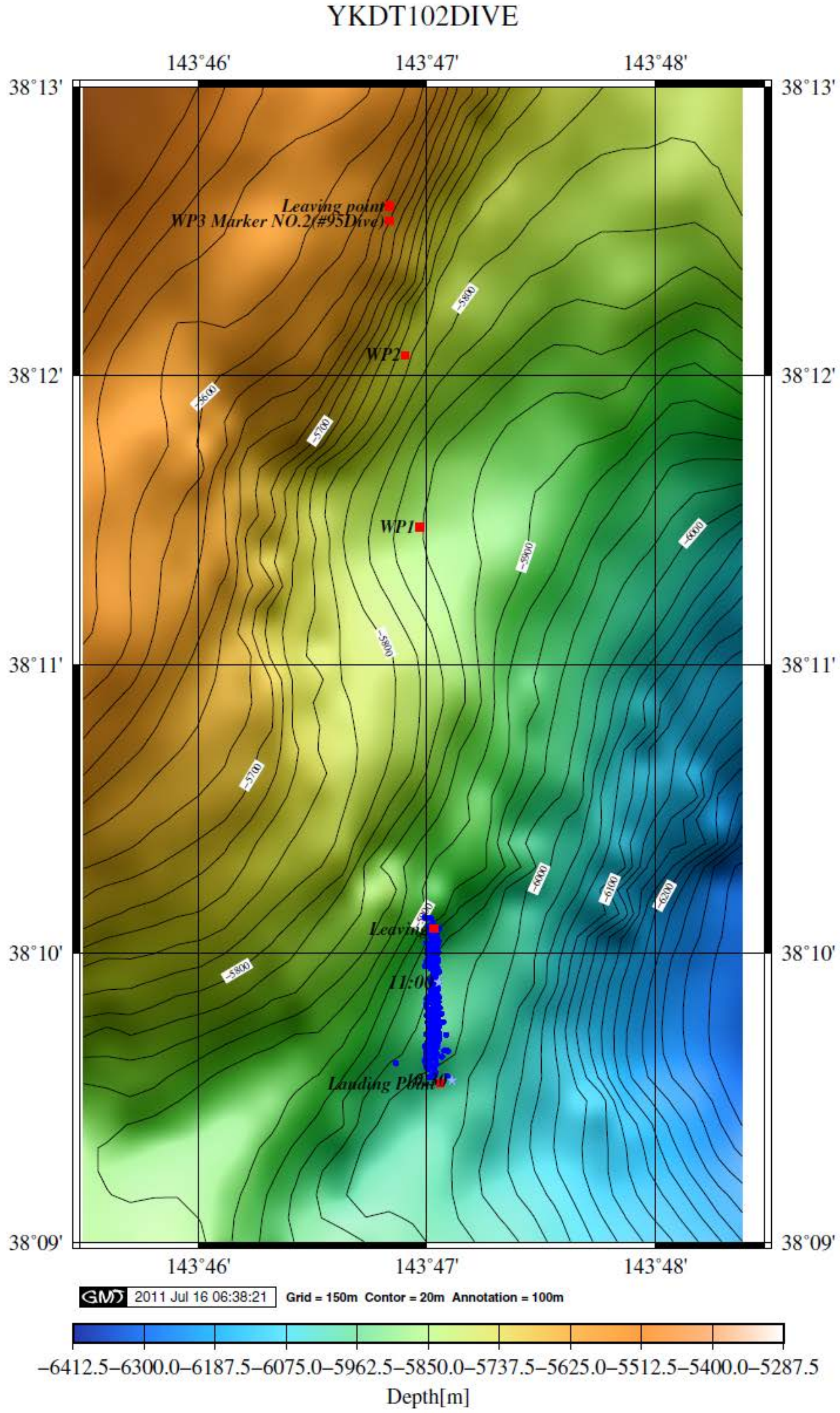


Figure 4.3.1 Dive track of the YKDT dive #102.

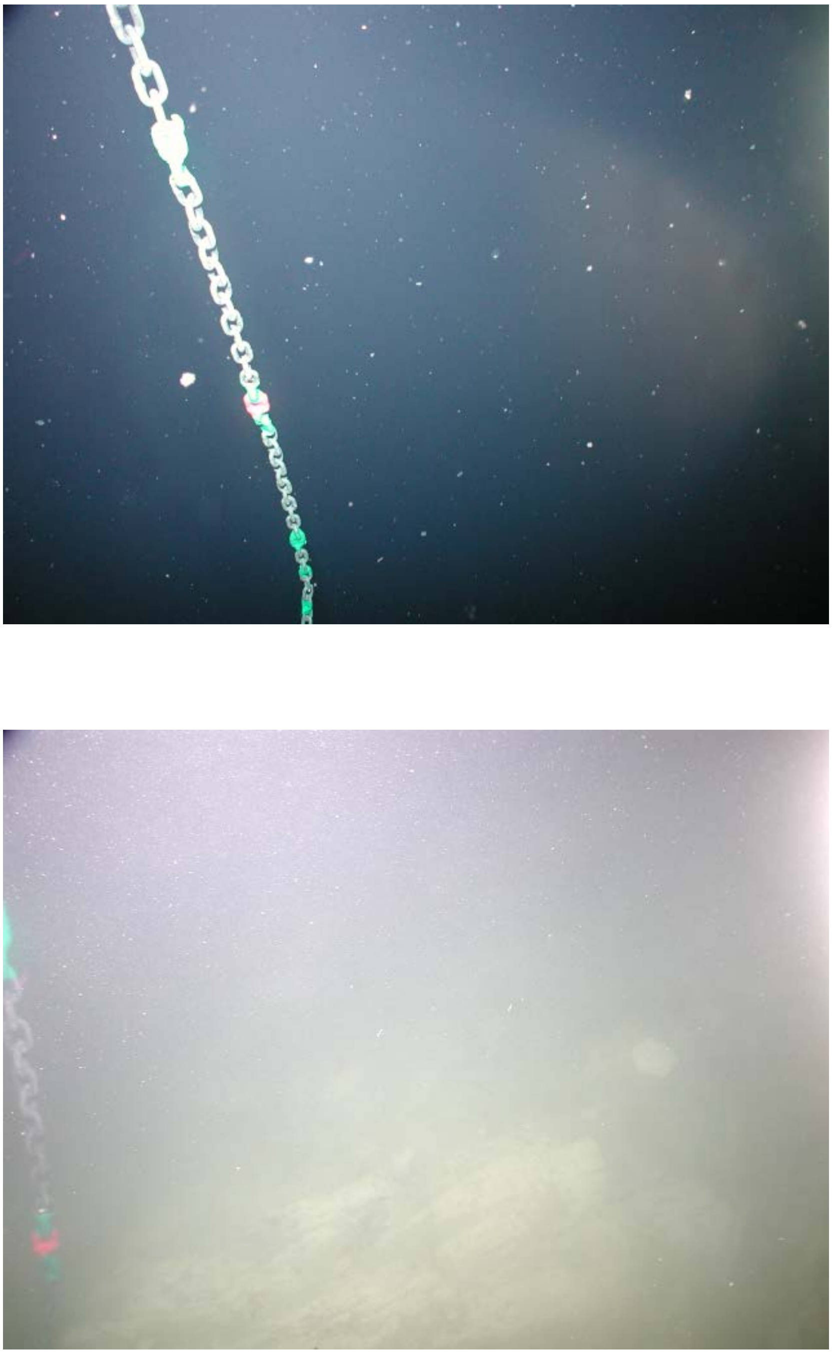


Fig. 4.3.2 Photos taken in the YKDT dive #102. Visibility was poor due to muddy water.

4.3.2 Dive # 103

In this dive, a multi beam echo sounder system (Seabat 7125) was loaded on the YKDT to obtain the detailed image around a "Fissure site". Before arriving at the planed observation depth, all optical communications were not available. However, we continued to survey without navigation data because the Seabat 7125 data was only stored in the internal memory device. Ship crews controlled the YKDT using the position and depth data of a SSBL system. Figure 4.3.4 shows the time series of YKDT depth data by a SSBL system.

2011.7/16. Yokosuka@Japan Trench point#95 and 96

Time	Cable Length	Altitude	X	Y	Remarks
934	5500				Sonner image available
955	5603				Survey start. Camera and onboard sonner image is not available.
1000	5600		2230	950	
1010	5580		2210	690	
1020	5580		2270	680	
1030	5586		2080	880	
1040	5704		1990	810	
1050	5590		1880	850	
1100	5830		1730	760	
1110	5640		1540	710	
1120	5610		1360	640	
1130	5580		1200	600	
1140	5590		1010	500	
1150	5560		770	450	
1200	5570		550	420	
1210	5570		380	370	
1220	5610		140	350	
1230	5610		-90	350	
1240	5610		-380	250	
1250	5620		-630	170	
1300	5640		-890	150	
1310	5690		-1100	70	
1320	5760		-1350	30	
1330	5760		-1640	-30	Finish survey

Table 4.3.2 Dive log (event log) of YKDT dive #103.

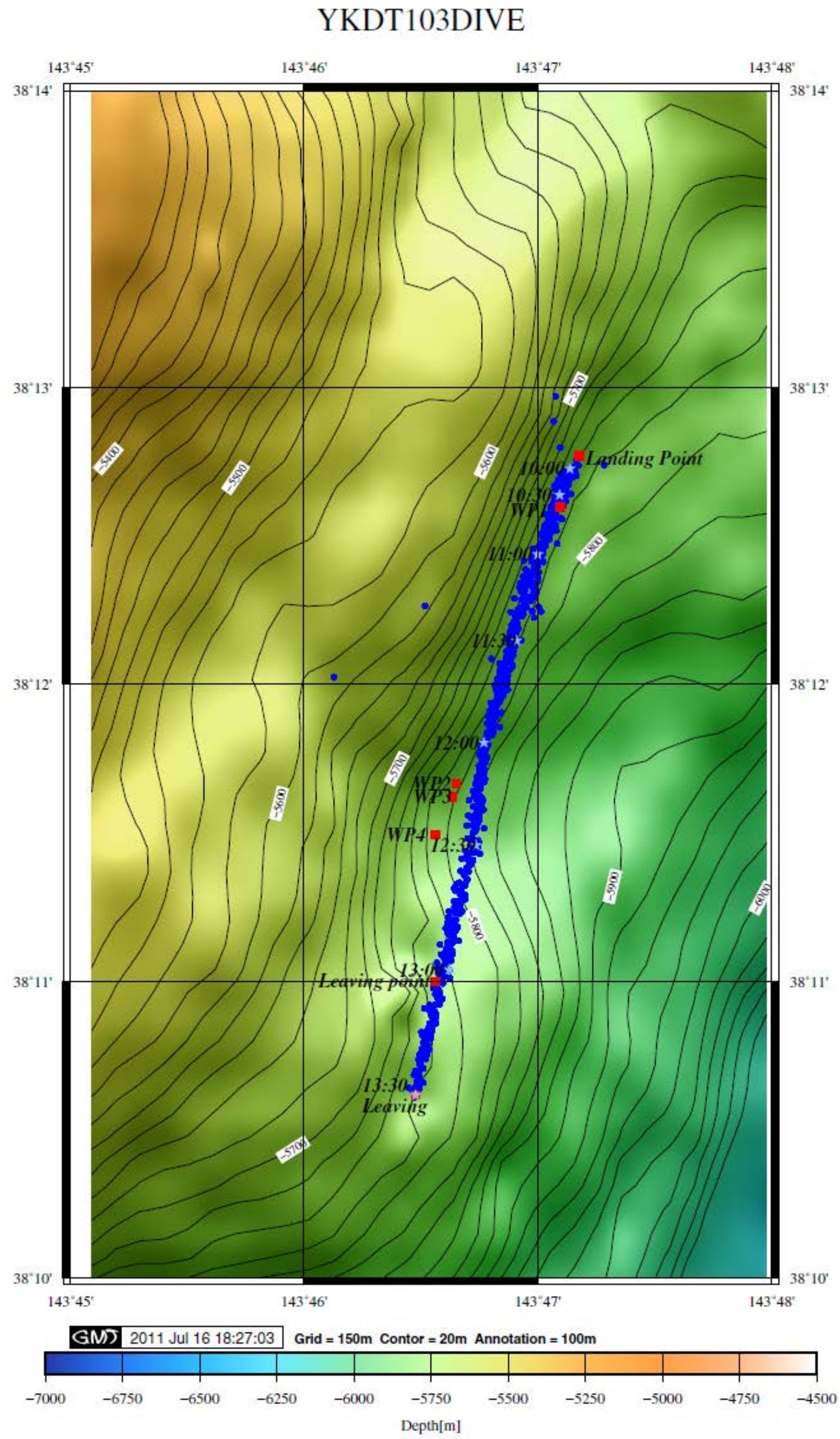


Figure 4.3.3 Dive track of the YKDT dive #103.

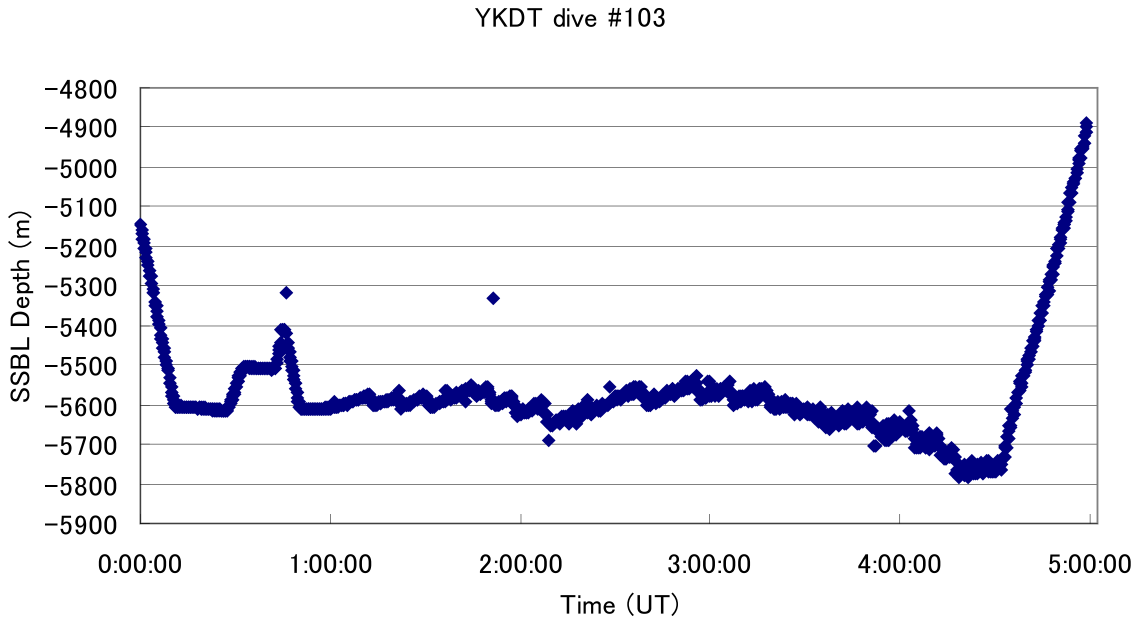


Fig. 4.3.4 Time series of YKDT depth by a SSBL system.

4.3.3 Dive # 104

The purpose of this dive is to confirm the safety for the "Shinkai 6500" dive around this "39° N site". We could see the sea bottom covered with the sediment, and observed some bacrerial mats. All communication using the optical cable was not available on the way. We tried to recover the optical communication, but we gave up this dive at 10:14

2011.7/17. Yokosuka@Japan Trench point SHIROURI

Time	Depth	Altitude	X	Y	Remarks
900	5345		-410	1110	Landing. Muddy sea floor. Clear view without muddy water.
905	5341				Many small shrimp?
908	5341		-300	1110	
910	5340		-270	1070	Many small shrimp? →Sea cucumbers？
916	5338				Decrease of shrimp →Sea cucumbers？
918	5340				Dead shrimps →Sea cucumbers？
920	5340		-170	1010	
925	5335				Muddy floor. Only one rock.
930	5335		-50	870	Muddy floor
932	5336				Living shrimp.
934	5334		-10	850	Bacrerial mat
935					Muddy floor.
940	5332		30	708	Bacrerial mat
944	5332				Some traces
945	5330		60	730	Some bacrerial mats
946	5330				Muddy floor.
950	5328		120	640	Great bacrerial colony
951	5328		140	620	Many small bacterial mats
953	5329				Many small bacterial mats
954	5329		150	600	Many small bacterial mats
955	5330				Scattered small bacterial mats
956	5329				Scattered small bacterial mats
959					Bacrerial mat
1000			190	500	Backout
1005					Blackout
1010			240	380	Blackout
1014			260	300	Giveup. Rollup

Table 4.3.3 Dive log (event log) of YKDT dive #104.

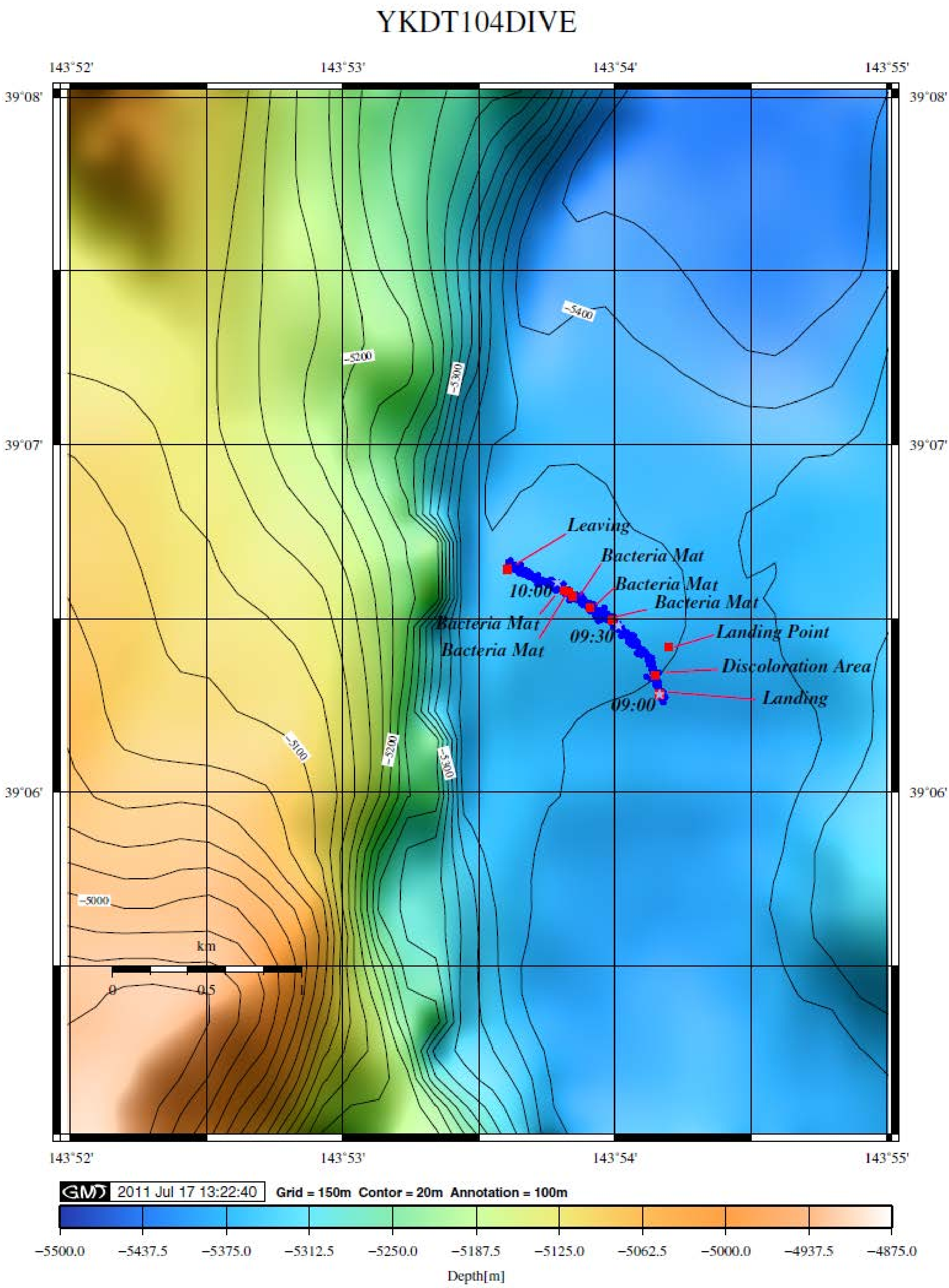


Figure 4.3.5 Dive track of the YKDT dive #104.

Fig. 4.3.6 Photos taken in the YKDT dive #104. Many bacrerial mats were observed through this dive. Small shrimp sometime passed in front of a camera's view.

4.3.4 Dive # 105

This dive is a second dive using a multi beam echo sounder system (Seabat 7125) to obtain the detailed image around a "39°N site". At a depth of 2500 meters, all optical communications were not available. However, we continued to survey without navigation data. In this dive, the internal memory device stores not only the Seabat 7125 data but also navigation data. Ship crews controlled the YKDT using the position and depth data of a SSBL system. Figure 4.3.8 shows the time series of YKDT depth data by a SSBL system.

2011.7/26 Yokosuka@Japan Trench, the site is same as YKDT#98

Time	Cable Length	Depth of Trapon	X	Y	Remarks
7:02	2500				Camera and other data from the deep-tow system were disconnected.
8:11					Cable out 30 m
8:14					Out until 5100 m
8:20	5101		-2650	-440	Stop the winch
8:30	5151		-2460	-440	
8:40	5151		-2250	-410	
8:50	5151		-2010	-390	Cable out 50 m, enter the survey line, Start the survey
8:53	5200				Stop the winch
8:55	5200				Cable out 30 m
8:56	5230				Stop the winch
8:59	5231				Command room said "Present location is 160 m north of #2." Operation room decided the starting time for this survey being 8:50.
9:00	5231		-1790	-370	
9:10	5231		-1570	-360	
9:12	5231				Cable out 50 m
9:14	5283				Stop the winch
9:15	5283				Cable out 50 m
9:17	5333				Stop the winch
9:20	5333		-1380	-370	
9:30	5333		-1120	-340	
9:37	5333				Cable out 50 m
9:39	5384				Stop the winch
9:40	5384	5090	-950	-320	
9:50	5384	5080	-700	-310	

9:59	5384				Cable out 60 m
10:00	5441	5110	-460	-300	Stop the winch
10:10	5441	5100	-160	-310	
10:20	5441	5080	90	-310	
10:30	5441	5080	340	-300	
10:40	5441	5080	650	-310	
10:50	5441	5070	940	-300	
11:00	5441	5080	1210	-300	
11:10	5441	5050	1500	-280	Finish the first survey line, cable in until 5000m. Turn the ship, and cruise to the second survey line #3.
11:20	5046	4680	1810	-310	To the second survey line.
11:22	4998				Stop the winch
11:30	4998	4590	2050	-350	To the second survey line.
11:40	4998	4830	2280	-300	
11:50	4998		2510	-290	
12:00	4998	4919	2710	-270	
12:10	4988	4875	2820	-200	
12:20	4998		2780	-130	
12:30	4998		2690	-90	
12:34	4998				Cable out 200 m
12:39	4998				Out until 5300 m
12:40	5260		2520	-60	
12:41	5302				Stop the winch
12:44	5302				Out until 5400 m
12:47	5400				Stop the winch
12:50	5400	5140	2360	-50	
13:00	5400	5130	2120	-10	
13:01	5400				Cable out 80 m
13:03	5481				Stop the winch
13:10	5481	5164	1900	10	Cable out 70 m
13:12	5551	5190			Stop the winch
13:20	5551	5183	1730	10	
13:27	5551		1490	20	Start the suvey line
13:30	5551		1470	30	
13:36	5551				Cable out 60 m
13:38	5611				Stop the winch
13:40	5611		1220	20	
13:50	5611	5168	960	50	
13:56	5611				Cable out 60 m

13:59	5671				Stop the winch
14:00	5671	5212	750	30	
14:10	5671		410	0	
14:14	5671				Cable out 60 m
14:17	5731	5198			Stop the winch
14:20	5731		190	-20	
14:30	5731	5202	-90	-50	
14:40	5731	5182	-340	-40	
14:50	5731	5187	-620	-60	
15:00	5731	5218	-940	-100	
15:10	5731	5226	-1190	-130	
15:20	5731	5155	-1510	-120	
15:30	5731		-1810	-160	Finish the survey. Recover the deep tow.

Table 4.3.4 Dive log (event log) of YKDT dive #105.

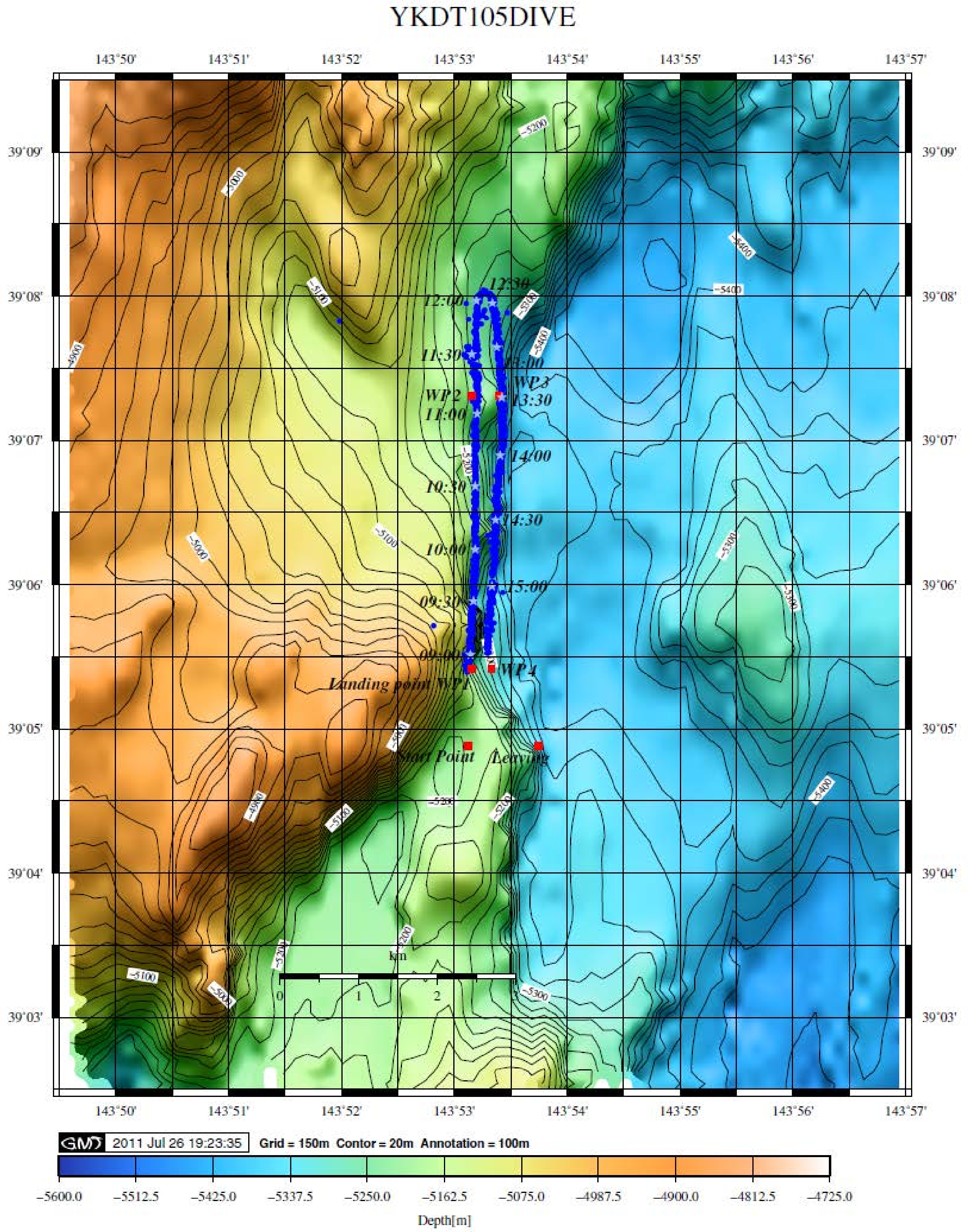


Figure 4.3.7 Dive track of the YKDT dive #105.

5. Other observations

5.1 Deep sea camera system

Kazumasa Oguri, Takashi Toyofuku

5.1.1 Overview

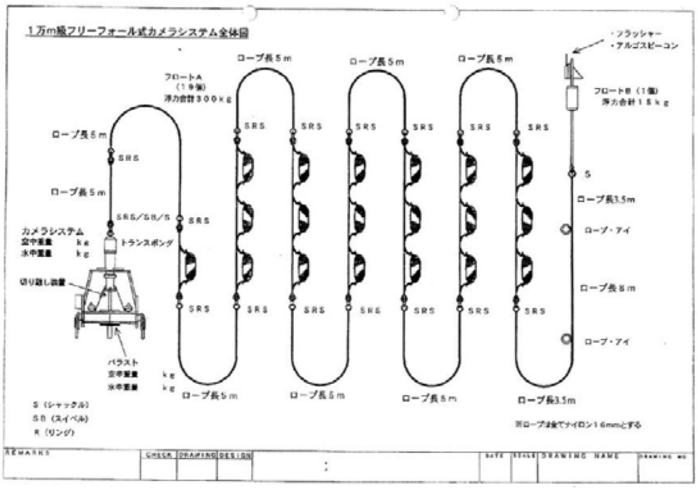
To record sediment surface and organisms and to collect sediments from the axis in the Japan Trench, deep-sea camera system was developed (Figure 5.1.1; Murashima et al., 2009). This instrument consists of nineteen deep-sea floats and main aluminum frame mounted transponder/releaser, HDTV camera, light, battery, CTD, two Niskin bottles with electrolytic fuses, three short core samplers and ballast weight (Figure 5.1.2). In this cruise, the camera system was used to collect sediments, sea floor observations, collection of organisms with baited trap, and depth, temperature and salinity measurements in water column. When the camera system was released from the ship, the CTD was started to record pressure, conductivity and temperature. The camera was started to record by the power supply from internal timer circuit. Sediments were collected in the core tubes mounted on the tripod legs during the landing. The transponder released the ballast weight when receiving the release command from the ship. The position of the camera system was always monitored on board to receiving the acoustic signal from the transponder. Table 5.1.1 shows the setting of the camera system in each deployment. Figure 5.1.3 shows the landing sites, and figures 5.1.4 and 5.1.5 show the image captured from the HDTV movies in the respective sites.

Reference

Murashima, T. Nakajoh, H. Takami, H. Yamauchi, N. Miura, A. Ishizuka, T. (2009) 11,000m class free fall mooring system. Proceedings of OCEANS 2009-EUROPE, 2009. OCEANS '09, p1-5.

	Date deployed	Latitude (N)	Longitude (E)	Max. CTD depth (m)	Sediment sampling	HDTV video recording	CTD
Camera1	2011/7/12	38°05.1595’	143°59.4547’	7553	○	○	○
Camera2	2011/7/13	38°05.1190’	144°02.6174’	7261	○	○	○

Table 5.1.1 Setting of the camera system in each deployment.



※重量

カメラシステム本体	空中 283.7kg	水中 156.7kg（清水）	153.5kg（海水：比重 1.025）
投棄バラスト	空中 214kg	水中 186.5kg（清水）	185.9kg（海水：比重 1.025）
係留系	空中 586.5kg	水中-257.9kg（清水）	-279.0kg（海水：比重 1.025）

Figure 5.1.1 Schematic overview of deep-sea camera system.

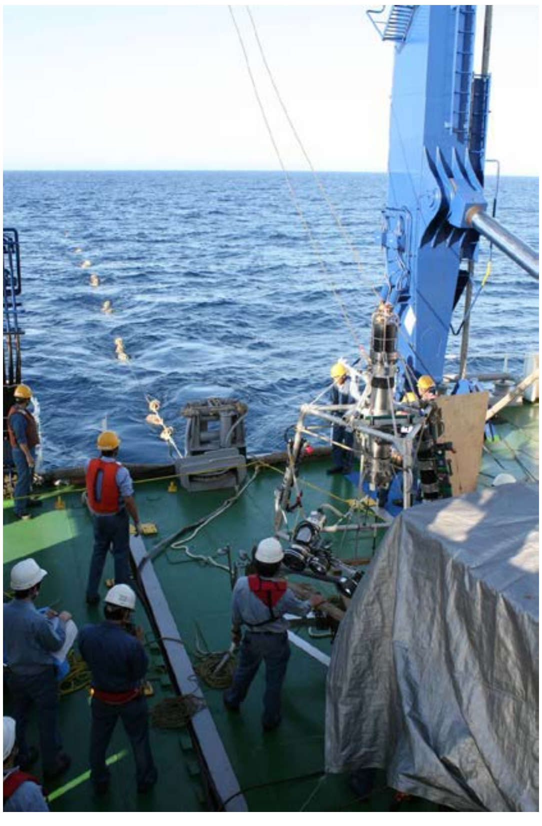


Figure 5.1.2 Deep-sea camera system (Camera 1).

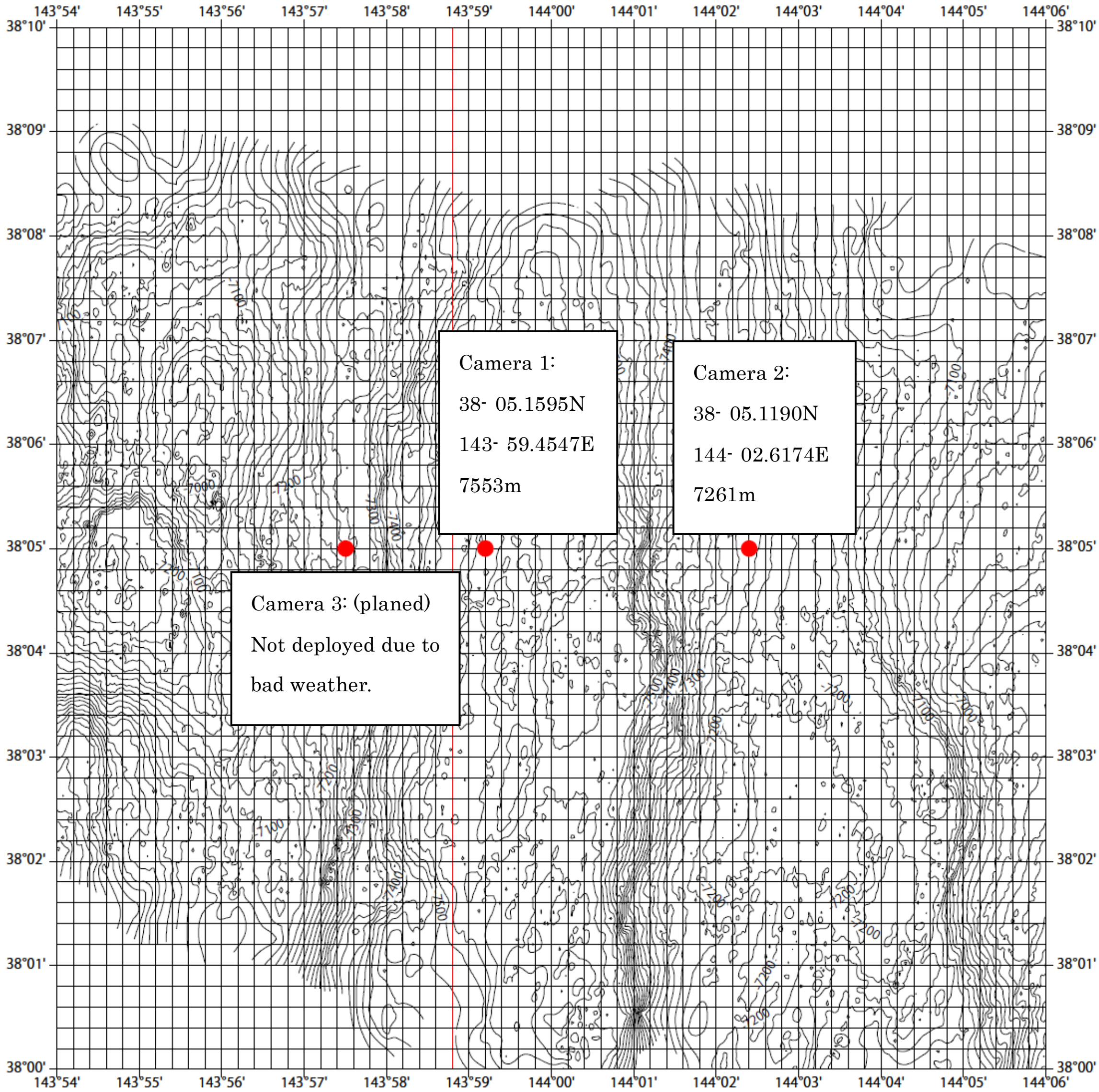


Figure 5.1.3 Landed points of the deep-sea camera system.

Figure 5.1.4 Typical image at bottom of the central axis of the trench (7553m). Highly turbidity was observed.

Figure 5.1.5 Image taken from bottom of the trench (7261m). Amphipods were seen during the recording the movie at the lower left.

5.1.2 Sediment samples

Five sediment cores were obtained during the two deployments of the camera system. The Schematic illustrations of the cores are shown in the Fig.5.1.6. The longest cores collected in each site were stored in the refrigerator to take X-ray CT images after the cruise. Other cores have been sliced every 0.5 cm intervals from core top to 3 cm and every 1 cm intervals for 3 to 15 cm to investigate taxa of benthic foraminifera and abundance of bacteria and virus populations.

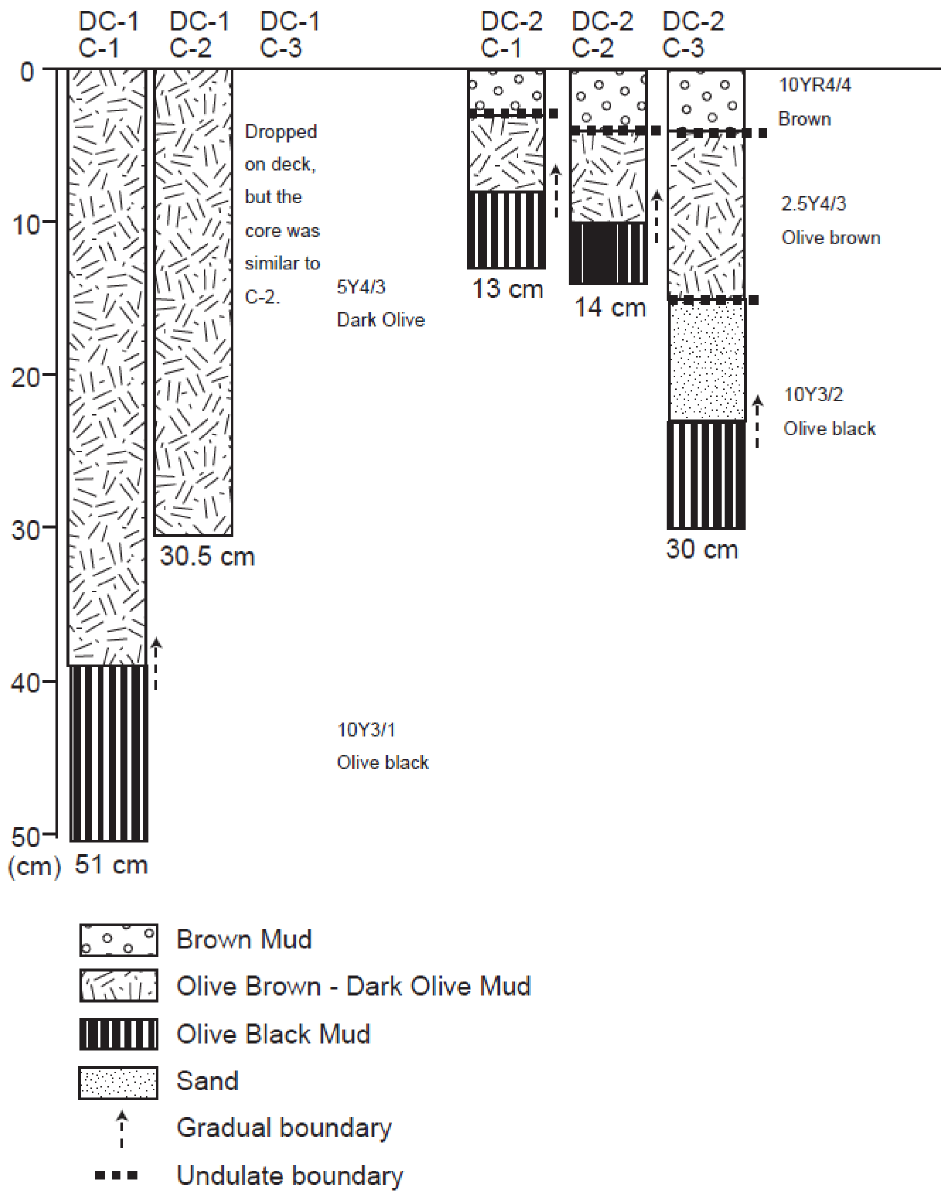


Figure 5.1.6 Schematic illustrations of the sediment cores collected from Japan trench: DC-1 (from 7553m) and DC-2 (from 7261m).

5.1.3 CTD data

Depth, temperature and salinity of water column were measured by SBE 49 CTD system mounted on the camera system. The CTD recorded pressure, conductivity and temperature from release to the recovery of the camera system. The depth was obtained to convert the pressure. Deployment date and the depth are shown in table #-1. Profiles of temperature and salinity are shown in figures #-1 and #-2, respectively.

	Date	Maximum CTD depth (m)
Camera 1	2011/7/12	7553
Camera 2	2011/7/13	7261

Table 5.1.2 Deployment date and the depth obtained by the CTD.

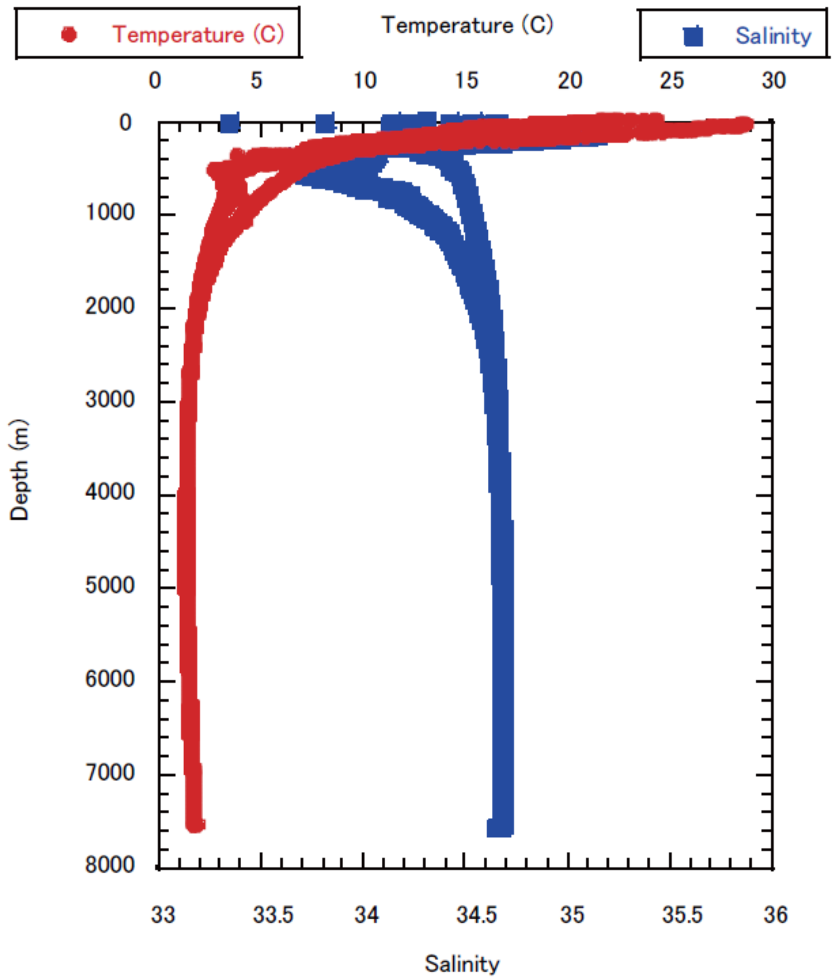


Figure 5.1.7 Profiles of temperature and salinity at Camera 1 deployment.

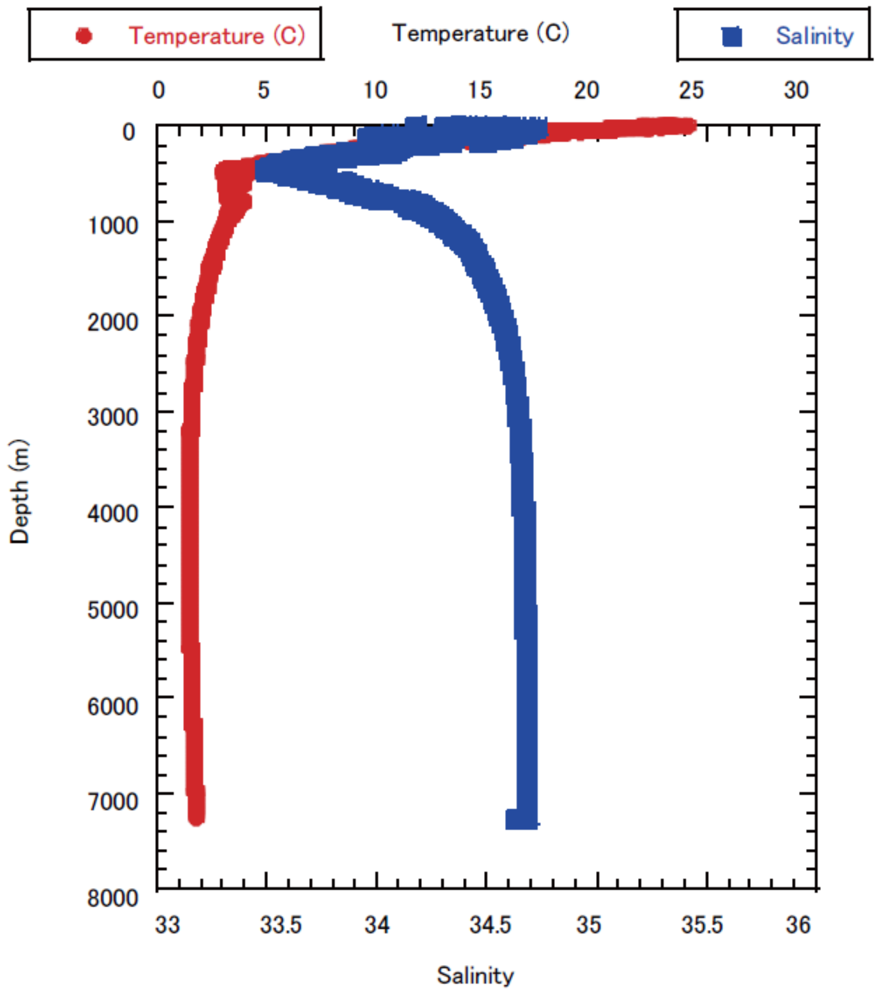


Figure 5.1.8 Profiles of temperature and salinity at Camera 2 deployment.

5.2. OBEM operation

5.2.1 Outline of an OBEM system

The OBEM system with a high sampling rate was designed to investigate the crustal and mantle structure (Fig. 5.2.1). It has a folding-arm system to facilitate assembly and recovery operations (Kasaya et al., 2006; Kasaya and Goto, 2009). Concepts of our developed OBEM and OBE system are miniaturization, a high sampling rate, easy assembly and recovery operations, and low costs of construction and operation. Figure 5-2 shows the schematic diagram of the arm-folding system. For measuring the electric field, we used Ag-AgCl electrodes mounted at the toe of each electrode arm.

Electric circuit used for each system is contained in the pressure glass spheres. The fluxgate magnetometer of the OBEM system is mounted outside the glass sphere (Fig. 5-1). The salient characteristic of our system is its arm-folding mechanism, which facilitates and simplifies our onboard operations. We used an acoustic release system that had been already used by JAMSTEC for Ocean Bottom Seismography (OBS).

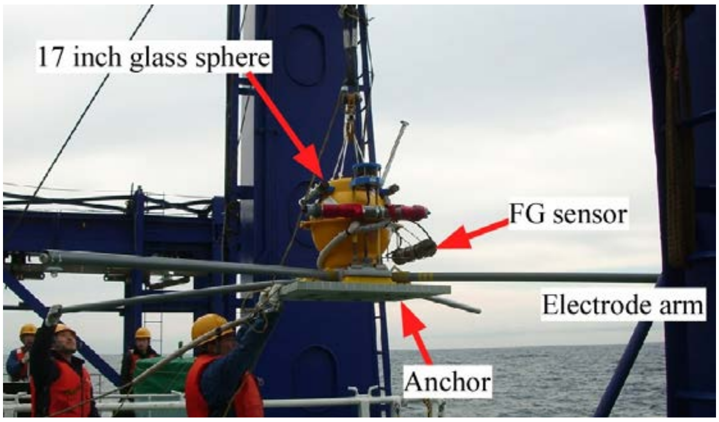


Fig. 5.2.1 Photo of a small OBEM system.

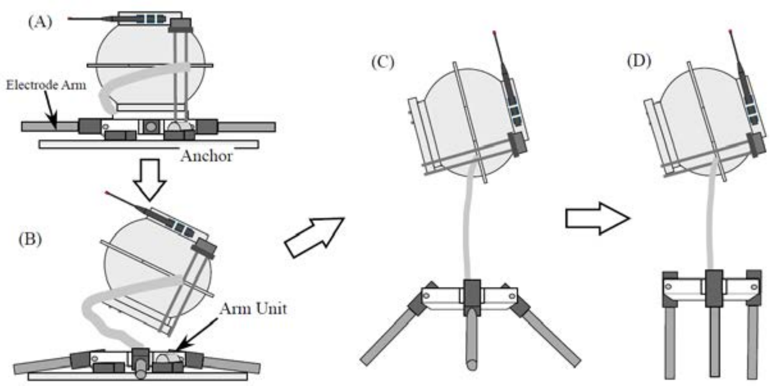


Fig. 5.2.2 Schematic diagram of the arm-folding system. After starting to pop up, the arm unit is picked up as the sphere ascends (Patent number of Japan: 4346605).

5.2.2 OBEM operation

OBEM was launched from deck using A-frame, and sunk by own weights. The operation was quick and smooth. We confirmed that the OBEM was successfully settled on the seafloor. Then, the settled positions were determined by measurements of the slant ranges at three positions surrounding the launched point for each OBEM (Fig.5.2.3). It will be recovered in a next leg of this cruise. A calculated OEBM position is 38.2422218˚ N, and 143.355881˚ E.

This OBEM system can synchronize to the laptop PC using USB communication. Clock synchronization before deployment was carried out using the NTP server unit.

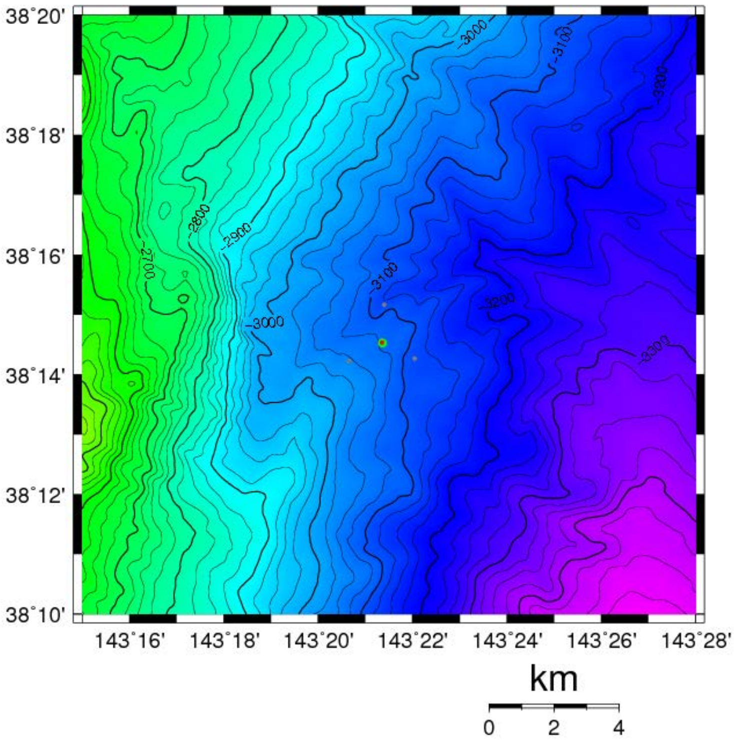


Fig. 5.2.3. Red and green circle shows settled and launched position, respectively. Three gray circles show the slant range measurement positions.

References

Kasaya, T., T. Goto, and R. Takagi (2006), Marine electromagnetic observation technique and its development –For crustal structure survey-, *BUTSURI-TANSA, 59*, 585-594 (in Japanese with English abstract).

Kasaya, T. and T. Goto (2009), A small OBEM and OBE system with an arm folding mechanism , *Exploration Geophysics*, *40*, 41-48.

5.3 OBS deployment (Tohoku University)

Yoshihiro Ito

In order to investigate the aftershock seismicity of the 2011 Tohoku-Oki earthquake near the epicenter, we deployed eight ocean-bottom seismometers (OBS) off Miyagi, northeastern Japan. A short-period seismometer with an eigenfrequency of 1 or 4.5 Hz is used. The sensor, data logger, and batteries are packed into a glass sphere (Fig. 5.3.1). It is possible to record continuous data related to the vertical and two horizontal components for three months with a sampling rate of 200 Hz.

We deployed three, two and three OBSs on July 14, 15, and 17, respectively. All of the OBSs were dropped from the deck to the seafloor. The OBSs were sunk with a speed of 50–60 m/min, which were measured by an acoustic ranging. The locations of the OBSs are listed in Table 5.3.1 and are shown in Fig. 5.3.2. They will be recovered by a pop-up system after three months.

Station	Latitude	Longitude	Depth (m)
S35	38° 00.8965'N	143°28.8822'E	4261
S36	38° 03.8550'N	143°17.8723'E	2995
S37	38° 54.8814'N	143°21.8369'E	3576
S38	38°04.9844'N	143°07.0055'E	2114
S39	37°50.9643'N	143°13.9796'E	2858
S3A	37°56.9946'N	143°05.9989'E	2075
S3B	38°10.0012'N	142°56.9866'E	1616
S3C	38°00.9740'N	142°55.9971'E	1736

Table 5.3.1. Location of ocean-bottom seismometers

Fig. 5.3.1. Ocean-bottom seismometers on the deck.

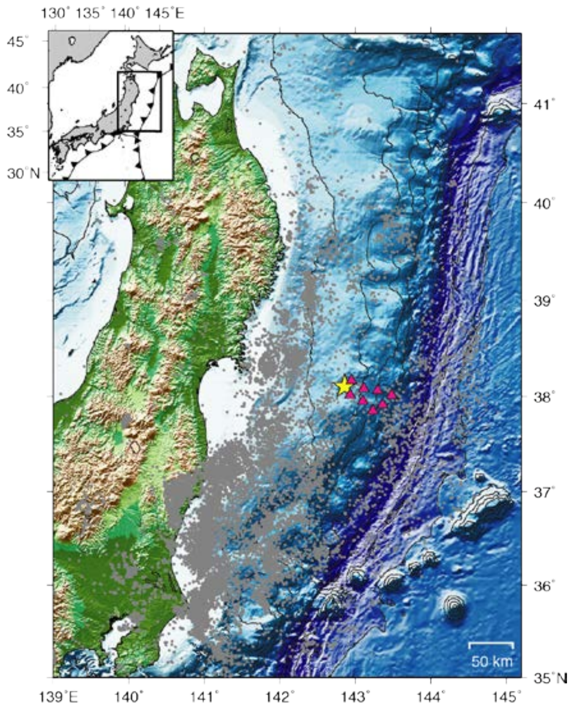


Fig. 5.3.2. Location of OBSs. Red triangles indicate the locations of the installed OBSs. Yellow star indicates the epicenter of the 2011 Tohoku-Oki earthquake. Gray dots indicate the epicenters of the aftershocks reported by Japan Meteorological Agency. Contour

5.4 GPS/acoustic seafloor geodetic observation (Tohoku University)

Motoyuki Kido, Yukihitoto Osada

GPS/acoustic observation can measure position of seafloor transponders, hence seafloor displacement, with an accuracy of few centimeters. The technique is the combination of kinematic GPS tracking of a surface buoy or a transducer and acoustic ranging to transponders installed on the seafloor. Figure of our buoy and its deck operation are shown in Photo 5.4.1.

After the 2011 Tohoku-oki earthquake, we have detected as large as 31 m of displacement at one of our survey site GJT3. Furthermore we have constructed new survey site GFK after the earthquake. In this cruise, we carried out surveys at GJT3 for 4 hours and GFK for 6 hours as the following time table (Table 5.4.1). XBT or XCTD measurements were concurrently done to calibrate sound speed in ocean.

Table 5.4.1 Time table on GPSA observation

Site	Day(JST)	Time	
GJT3	2011/07/13	11:00	deployed the buoy
		11:50	XBT
		14:35	XCTD
		15:00	retrieved the buoy
GFK	2011/07/27	06:00	deployed the buoy
		06:41	XBT
		11:25	XCTD
		11:50	retrieved the buoy

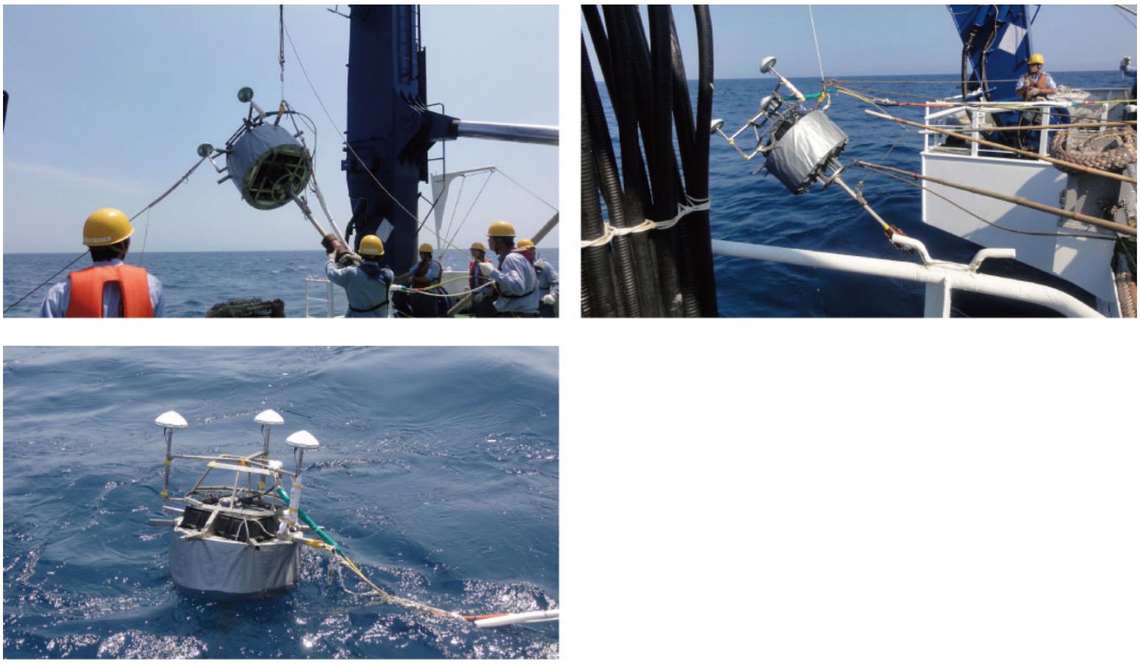


Figure 5.4.1 photograph of our buoy and the deck operation.

5.5 OBS recovery (Meteorological Research Institute / JMA)

Kenji Hirata

On July 11 to July 12, we recovered 5 ocean-bottom seismometers (OBSs) off Boso Peninsula (Fig.5.5.1). The OBSs are the last 5 seismometers that Meteorological Research Institute (MRI) should recover; from late April to early May 2011, MRI had deployed total of 39 OBSs in the southern continental slope of the Japan Trench by using the Japan Meteorological Agency (JMA)'s R/V Ryofu-Maru. 31 of those were already recovered by JMA's R/V Keifu-Maru in June 2011 and by JAMSTEC R/V Yokosuka (YK11-E05) in June to July 2011. Three of those were failed to recover because of troubles in OBS transponder and/or OBS releaser.
Specification of the OBSs that were recovered during the YK11-E06 cruise are shown in Table 5.5.1.

Weather and sea conditions were good and calm so that the OBSs could be recovered efficiently. We communicated with the OBS transponders by using a portable acoustic transducer that was sunk from the port side on the upper deck floor of R/V Yokosuka. For al of 5 OBSs, we confirmed takeoff of the OBSs from the ocean floor averagely 16 minutes after transmitted corresponding release commands to the OBS transponders with the portable transducer (Table 5.5.2). During floating-up of the OBS in water, we intermittently measured slant-ranges between the transducer and OBS transponder. Then the measured slant ranges allowed for R/V Yokosuka's radio officers to estimate location of floating-up OBS in water on the basis of a geographical method. At the same time, we also monitored location of the floating-up OBS by using a portable SSBL system. The locations of the floating-up OBS measured with the portable SSBL system roughly coincided those estimated based on the geographical method by R/V Yokosuka'S radio officers. The floating-up speed of the OBSs was approximately 58 m/min on average.

Surfaced OBSs could be identifed by R/V Yokosuka crews immediately after OBS radio beacon were received. An electric direction finder, installed within the submersible control room behind the navigation bridge room, perhaps helps them to identify surfaced OBSs as quickly as possible.

Every OBS was recovered on starboard side on the upper deck floor of R/V Yokosuka approximately 10 minutes after OBS was surfaced (Table 5.5.2). We confirmed that file size of WIN-formatted, seismic waveform records on the recovered OBSs' internal hard-disk drive reached from 850 MB to 1150 MB (Table 5.5.2). The observed seismic waveform records will be merged with other records that were already recovered by R/Vs Keifu-Maru and Yokosuka (TK11-E05) and then will be processed for seismic phase picking.

This study is partly supported by the Special Coordination Funds for the Promotion of

Science and Technology (MEXT, Japan) titled as the integrated research for the 2011 off the Pacific coast of Tohoku Earthquake.

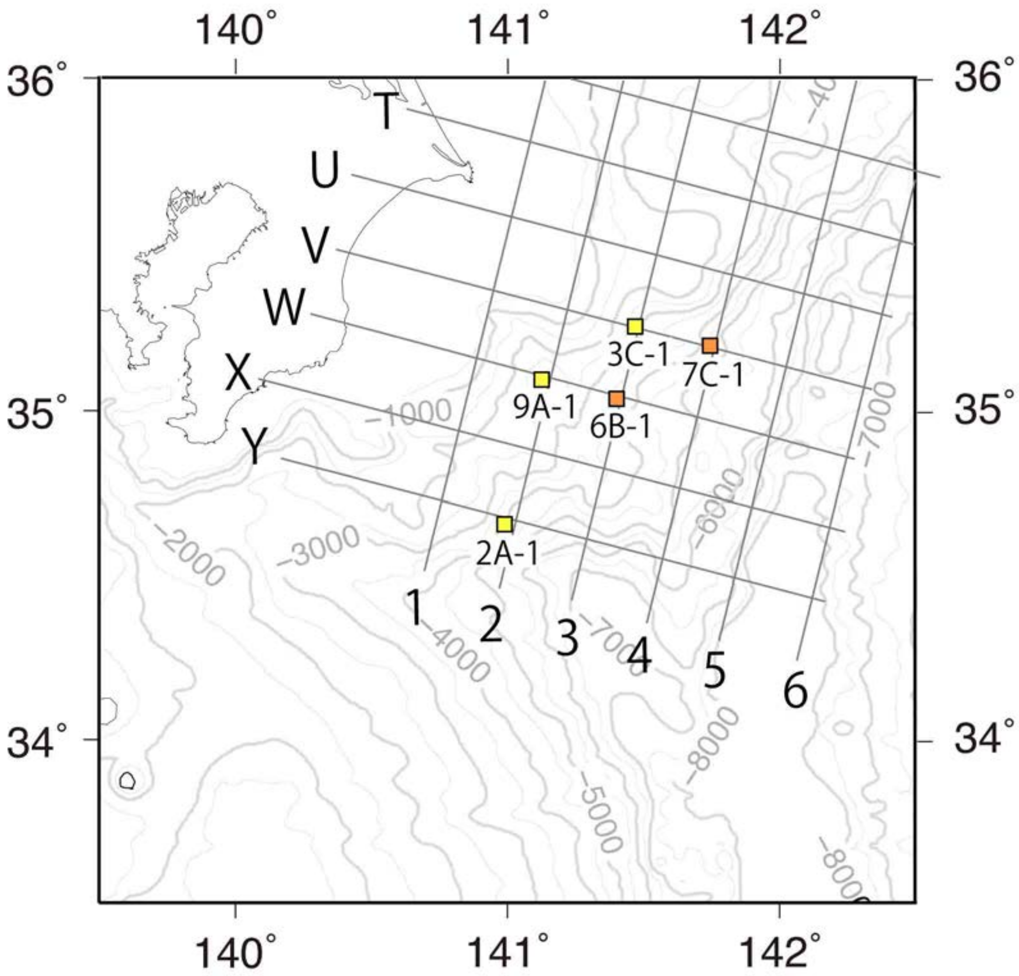


Fig 5.5.1 Location of the OBSs that were recovered by MRI during the YK11-E06 cruise. Each symbol is filled by the same color as those that OBS hardhat has. Alphanumeric code below the symbol indicates release command of each OBS transponder.

Seismometer	・three-component velocity sensors (1 x vertical, 2 x horizontal) on a gimbal unit ・natural period of pendulum 1/4.5 Hz ・pre-amp gain x 100 ・ low-passed filter at 200 Hz ・ 16 bit A/D sampling at 100 Hz
Hydrophone	・pre-amp gain x 10000 ・ low-passed filter at 200 Hz ・16 bit A/D sampling at 100 Hz
Raido Beacon	・PSI inc., radio wave frequency 43.528 MHz
Flasher	・PSI inc., optical sensor
Recorder	・Clovertech DAT-4 (Ver.C_1.2)
Battery	・Lithium-ion rechargeable

Table 5.5.1 Specification of MRI's OBS

OBS	Lat (N)*1		Long(E)*1		water depth	release comm-and	Take off	radio beacon	reco-very	takeoff time	float-ing-up time	wind		current		file size	remarks
												direc tion	spee -d	direc tion	spee -d		
	deg	min	deg	min	m	hour:min*2				min	min	deg	m/s	deg	m/s	MB	
V3	35	15.2	141	28.0	2879	24:07	24:31	25:21	25:30	24	50	190	4.6	38	2.5	1,086	flasher was broken
V4	35	12.0	141	44.5	4632	26:32	26:47	28:06	28:15	15	80	203	4.5	36	2.2	1,141	
W2	35	5.5	141	7.4	2495	19:34	19:48	20:32	20:43	14	43	184	3.0	36	2.3	873	
W3	35	2.2	141	24.0	3630	21:51	22:07	23:03	23:13	16	63	197	5.2	30	2.1	866	
Y2	34	39.4	140	59.2	3984	16:15	16:31	17:40	17:50	16	69	192	5.1	21	1.2	1,006	

*1 Lat (N) and Long(E) were determined by using triangle acoustic loacation.

*2 Time of release command transmission, takeoff, identifying of radio beacon, and recovery (on deck) is measured from 00:00 (JST) of July 11, 2011

Table 5.5.2 List of recovered OBSs

6. Shipboard data (Bathymetry and Geophysical data)

Takafumi Kasaya, Miho Asada

6.1 Shipboard bathymetric survey in YK11-E06 leg1

Miho Asada

Bathymetric data are obtained by SEABEAM2112 system with an array of transducers and hydrophones installed along and across keel of the R/V Yokosuka. The system transmits a 12 kHz sonar pulse at 2° x2° 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° , and we fixed the range 120° during this cruise. Sound velocity profiles were obtained from ship-launched XBT measurements, and were updated into the SEABEAM system. Ship speed is 8 knots for all survey lines. The system has sub-bottom profiler with 4 kHz frequency, but we obtain the SBP data during on only on track in this cruise because of night-time survey.

Specification of SEABEAM2112.004 on R/V Yokosuka

Depth range; 50-11000 m
Frequency; 12 kHz
Number of beams; 151 max
Beam resolution; 2° ×2°
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 ~300m, 140° for ~1500m, 120° for ~4500m, 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° ×5°
Profiling limit; 75mbsf
Number of pixels; 1000 pix. each for port and stbd

Survey lines

13 July Night – 14 Morning
144:07.0 38:08.0
143:29.0 38:13.5

14 July Night – 15 Morning
144:20 37:50
143:25 37:58.5

15 July Night – 16 Morning
143:00.0 37:55.6
144:20.0 37:42.1

16 July Night – 17 Morning
143:55.0 38:00.0
143:57.2 38:10.0
144:09.5 39:00.0

17 July Night – 18 Morning
143:56.0 40:00.0
143:43.0 38:40.0
143:25.0 38:00.0
143:25.0 37:50.0

25day-26morning July
144:30.0 38:56.25
143:03.5 39:10.0
143:10.0 39:27.5
144:25.0 39:15.0

26night July
143:55.0 39:02.5
143:51.8 38:38.8
143:41.0 38:15.0
end

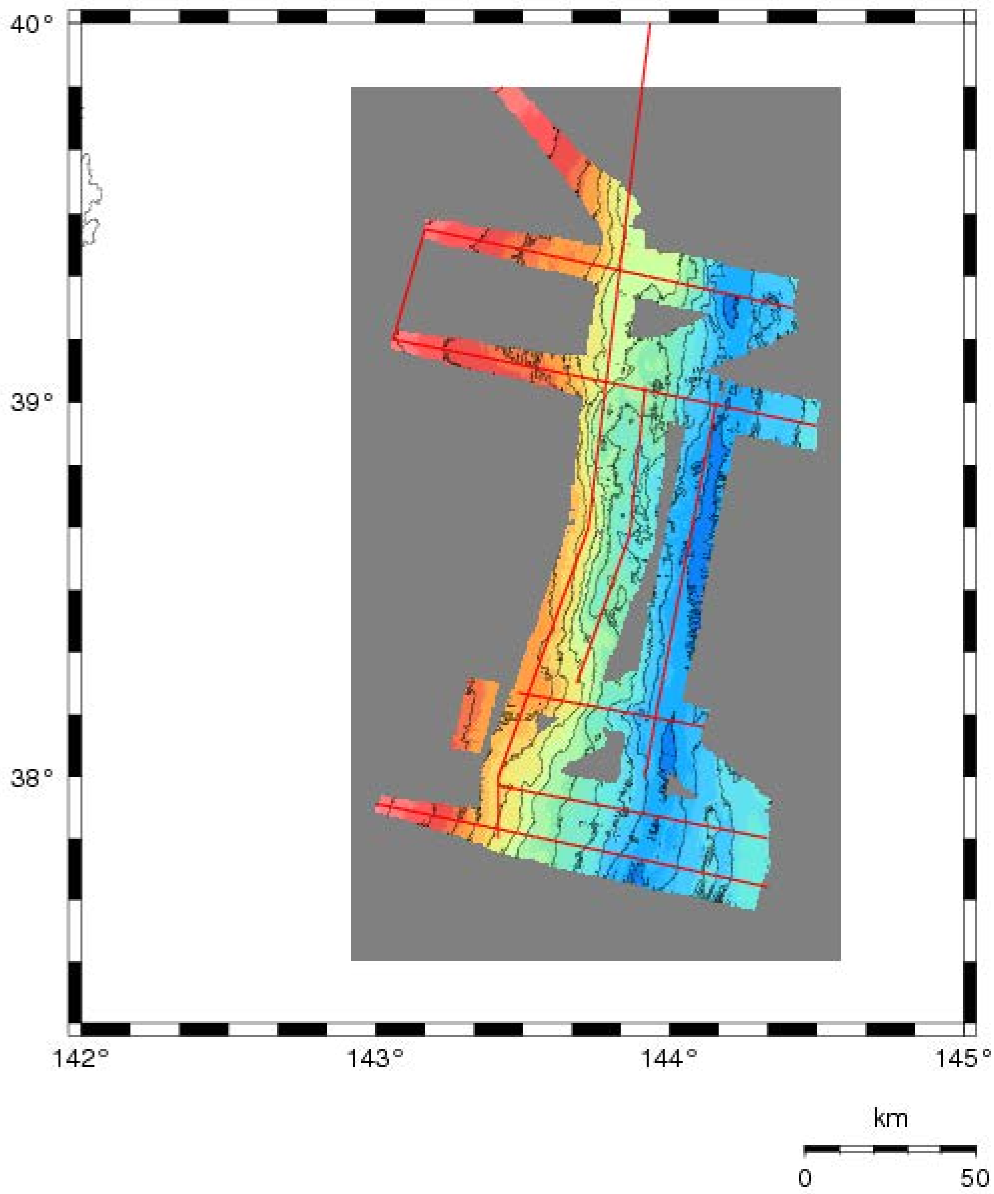


Fig. 6.1.1 Index map of the seabeam and gravity survey in this cruise.

6.2 Gravity data

Takafumi Kasaya

Gravity was measured continuously through the entire length of the cruise. The gravity meter on board R/V Yokosuka is the Air-Sea Gravity System Ⅱ (Fig. 6.2.2) made by LaCoste & Romberg Corporation, USA. The control system basically consists of remote and host computers. The former performs all real-time activity associated with controlling the platform and gravity meter as well as maintaining the system clock. The latter receives the data, computes the cross-coupling correction, and performs the final filtering before archiving the data. Time is kept very accurately by a temperature-compensated crystal oscillator. During this cruise, the gravity meter produced filtered data at 10-second intervals. These data were reduced to 1-minute-interval by the host computer. The detailed information are shown in Table 6.2.1.

The Specifications of Gravity Meter	
Measurement Range (mGal)	12,000
Drift	3 mGal Per month or less
Stabilized Platform	
Platform Pitch (dig.)	±22
Platform Roll (deg.)	±25
Platform Period (min.)	4 ～ 4.5
Beam Interval (deg.)	1
Control system	
Recording Rate (Hz)	1
Serial Output	RS-232
System Performance	
Resolution (mGal)	0.01
Static Repeatability (mGal)	0.05
50,000 mGal Horizontal Acceleration (mGal)	0.25
100,000mGal Horizontal Acceleration (mGal)	0.50
100,000mGal Vertical Acceleration (mGal)	0.25
Dimension (cm)	71×56×84
Weight (kg)	Meter:86, UPS:30

Table 6.2.1 Information of the Air-Sea Gravity System

Fig. 6.2.1 Photo of the Air-Sea Gravity System

6.3 Geomagnetic field vector on the sea

Takafumi Kasaya

A shipboard three-component magnetometer (STCM: Isezaki, 1986) were used for the measurements of the geomagnetic field during the cruise. The STCM (SFG-1212, TIERRA TECNICA) is a 3-axis flux-gate magnetometer installed on the Nav. deck above the bridge (Fig. 6.3.1). The specifications of the STCM are shown in Table 6.3.1.

The logging PC is connected to the vessel's GPS. The clock was manually synchronized to GPS time (ship- time), at the start of the survey. To obtain information of ship's attitude and direction (roll, pitch and heading), a gyro system was installed on board. These data were collected with a sampling rate of 8Hz during the cruise.

The STCM data contains the effects of the ship's magnetic field, which must be corrected in order to derive the geomagnetic field. In general, "8-shaped navigation" was made for calibration of the ship's magnetic effect, related to magnetic susceptibility of the ship, and a permanent magnetic moment of the ship's body (Isezaki, 1986). The "8-shaped navigation" was made by steering ship in a tight circle, both clockwise and counter clockwise. The "8-shaped navigation" was conducted from 18:19 to 18:38 at 26th, July as shown in Table 6.3.1.

The Specifications of 3 axes Fluxgate Magnetometer	
System	Ring core Fluxgate
Number of Component	Directly 3 axes
Cable Length (m)	50
Sensor Dimension (mm)	ϕ280×130H
Measurement Range (nT)	±100,000
Resolution (nT)	1

Table 6.3.1 Information of the three-component magnetometer.

Information of "8-shape navigation"			
MM/DD	TIME (JST)	Locations	
7/26	18:19～18:38	39° 2.9562′	143° 54.1189′

Table 6.3.2 Information of "8-shape navigation", calibration of the STCM.

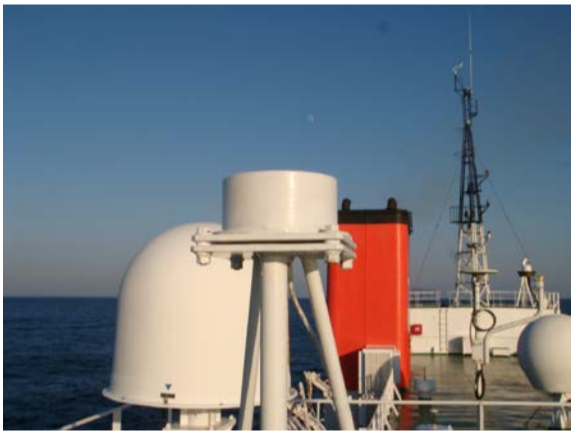


Fig. 6.3.1 The fluxgate magnetometer sensor is mounted on the Nav. Deck (Upper panel). The SFG-1212 system is installed in No.1 study room (Lower panel).

7. Summary

Main purposes of this cruise are high accuracy topographic survey and the safety check for the "Shinkai 6500" dive using a 6000m class deep-tow called "YKDT".

We carried out the high accuracy acoustic measurement using the "seabat 7125 system" and the camera observation for the safety check of a "Shinkai 6500" dive. However many trouble of the optical cable communication were occurred. Moreover, a powerful and slow-moving typhoon has formed passed close by our research area. Therefore, we could not enough to obtain the data through this cruise.

To obtain the detailed images of the sea bottom, YKDT dives with multi beam echo sounder system (Seabat 7125) also were carried out at same sites. YKDT dive #103 was carried out around "Fissure site" at 14^{th} July. Before arriving at the observation depth, all optical communications were not available. However, we continued to survey without navigation data because the Seabat data was only stored in the internal memory device. Finally, we could obtain the bathymetric and back scatter data.

Two safety check dives were carried out at "Fissure site" and "39° N site". Both dives gave up on the way because of the problem of optical cable communication. At "Fissure site", we could see the sea bottom covered with the sediment. However, camera view is not clear due to muddy water. All communication using the optical cable was not available on the way. We tried to recover the optical communication, but we gave up this dive at 11:20. Then, YKDT dive #104 conducted at "39° N site". We could see the sea bottom covered with the sediment, and sometimes detected some bacrerial mats. All communication using the optical cable was not available on the way. We tried to recover the optical communication, but we gave up this dive at 10:14

A deep sea camera system is very powerful tool to take images and samples in the depth of over 7000 meters. In this cruise, the camera system was used to collect sediments, sea floor observations, collection of organisms with baited trap, and depth, temperature and salinity measurements in water column at two sites. When the camera system was released from the ship, the CTD was started to record pressure, conductivity and temperature. The camera was started to record by the power supply from internal timer circuit. Sediments were collected in the core tubes mounted on the tripod legs during the landing.

In this cruise, bathymetry, back scatter image, subbttom profiler data, gravity and three-component geomagnetic data were also observed. These geophysical data acquisition were carried out at rates of 8-10 knots.

Other observations based on the observation proposal related with this earthquake were also carried out. At first of this cruise, five OBSs of MRI were recovered off Boso peninsula area. We deployed three, two and three OBSs on July 14, 15, and 17, respectively. All of the OBSs were dropped from the deck to the seafloor. Moreover, GPS/acoustic seafloor geodetic observations succeed at two sites.

Appendices

Explanatory notes

Research Vessel Yokosuka

R/V Yokosuka is designed serve as the mother vessel for Shinkai 6500 and Autonomous Underwater Vehicle Urashima. It has silent engine an advanced acoustic navigation systems and an underwater telephone for its state of the art operations.

There are 4 laboratories on Yokosuka, No.1～No.3 laboratories and No.1 Study room. No.1 Lab. has dry space. Permanent installations are video editing system, PC and printer. No.2 Lab. has semi - dry and wet space. There are two freezers (-40 & -80 deg.C), incubator, Milli-Q, fumigation chamber at dry one, and wet one has rock saw. No.3 Lab. has dry space with storage.No.1 Study room has dry space, there are gravity meter, data acquisition system of gravity meter, 3 axis fluxgate magnet meter and also proton magnet meter, work station for data processing, and A0 size plotter.

Length overall	105.2 m
Beam overall	16.0 m
Depth	7.3 m
Draft	4.5 m
Gross tonnage	4,439 tons
Service speed	16knot
Complement	
Crew	27 persons
Submersible operation staff	18 persons
Researchers	15 persons
Total	60persons
Main propulsion system	Diesel engines: 2,206kW x 2
Main propulsion method	Controllable pitch propeller x 2

Table A-1 Principal specifications of R/V Yokosuka