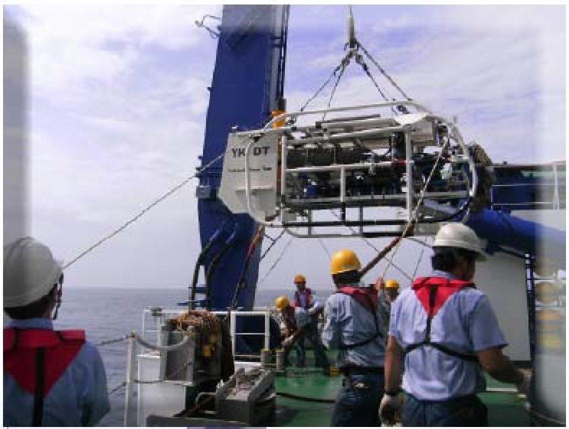
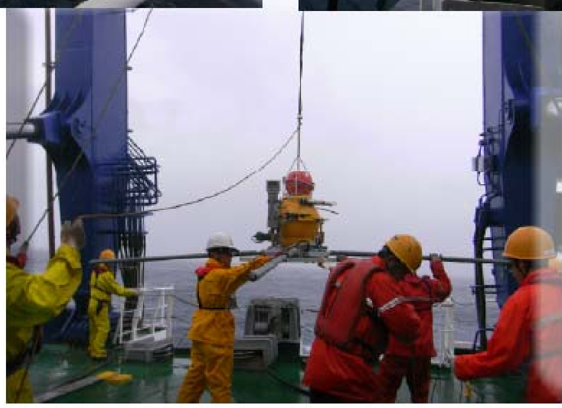
doi : 10.17596/0003223

YOKOSUKA Cruise Report

YK09-09





Kumano, off Kii peninsula

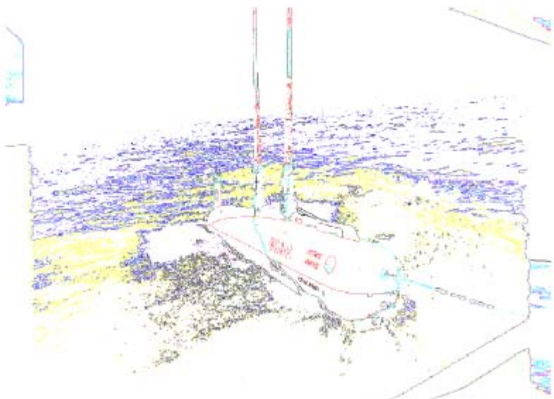
July 19 2009 – July 29 2009

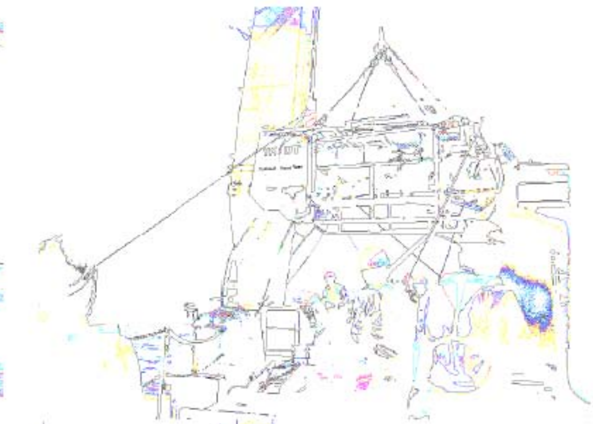
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Acknowledgements

We would like to thank all ship officers and crew of R/V YOKOSUKA, the operation team of AUV URASHIMA and YKDT (Yokosuka Deep-Tow) and a marine technician of NME for their supports during our cruise.

This cruise was partly supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Grant-in-Aid for Scientific Research, 2074263, 2007 and a development program of fundamental tools for exploration of deep seabed resources was started in 2008 with financial support of the MEXT.





YK09-09 Cruise report contents

1. Objectives of YK09-09 cruise

1.1 Electro-magnetic survey around the mega-thrust earthquake zone

The electro-magnetic survey method is an important technology to obtain the subsurface structure using resistivity. We carried out the EM survey around the mega-thrust earthquake zone, and obtained the resistivity image of the crust and upper mantle. Natural magnetic fields are attenuated by electrically conductive water. Therefore, it is difficult for magneto-telluric method to obtain the shallow structure in the deep sea. The control source EM method is very suitable to detect the shallow structure. Kumano area is over a water depth of 2000m, and there is a strong sea current. It is important matter to establish the technique of the towing survey tool.

This study was partially supported by the Ministry of Education, Culture, Sports, Science and Technology Grant-in-Aid for Scientific Research, 2074263, 2007.

1.2 Development of the natural resource survey technique

Recently, sea-floor hydrothermal deposits including valuable metals like copper, lead, zinc, gold, silver, germanium have again become a subject of special interest in the world through intensifying competition of resource development for a stable supply of the resources. It is, however, difficult to develop the sea-floor hydrothermal deposits because there is no established method to estimate accurate abundance of them. Conventional marine (sea surface) geophysical explorations do not have enough resolution, and an exploratory drilling needs much time and money. Thus, new technology of geophysical exploration near the sea floor is required in order to discover and estimate the resources precisely. With these points as a background, a development program of fundamental tools for exploration of deep seabed resources was started in 2008 with financial support of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). As a part of the program, we have developed new measurement systems for electrical and magnetic explorations by Autonomous Underwater Vehicle (AUV), Remotely Operated Vehicle (ROV) and deep-tow system.

1.3 Cruise information

Cruise number	YK09-09
Ship name	R/V YOKOSUKA, Deep-tow and AUV URASHIMA
Chief scientist	Takafumi Kasaya (IFREE, JAMSTEC)
Proposal title 1	Research for the fluid distribution around the spray fault using the control source EM method (T. Kasaya)
Proposal title 2	Test of high precision magnetometer by deep-tow system and Autonomous Underwater Vehicle Urashima (K. Sayanagi)
Date	19 July 2009 – 29 July 2009
Ports of call	Wakayama port – Yokosuka(JAMSTEC)
Research Area	Kumano trough, off Kii peninsula (Fig.1-1)

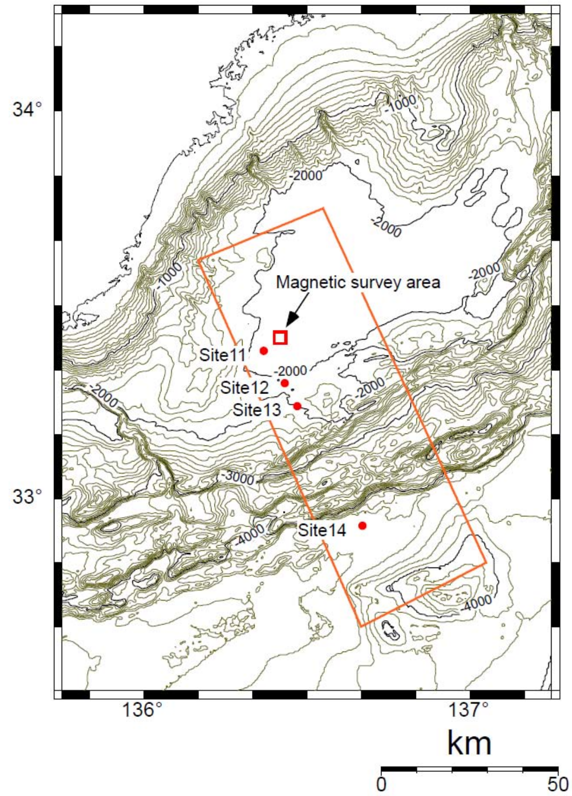


Fig.1-1 Research area of YK09-09 cruise. Red circles show OBEM positions. The towed electro-magnetic survey was conducted around Site11. A red square shows the magnetic survey area used by an AUV URASHIMA and Deep-tow.

2. Participants List

Onboard Scientists

JAMSTEC	Takahumi KASAYA(Cruise Chair)
Tokai University	Keizo SAYANAGI
Tokai University	Makoto HARADA
JAMSTEC	Takao SAWA
JAMSTEC	Miho ASADA
JAMSTEC	Noriko TADA
JAMSTEC	Hiroshi ICHIHARA
JAMSTEC	Hiroshi OCHI
Tokyo Institute of Technology	Bulent, S., Tank
National Central University	Chin-wen Chiang
NME	Satoshi OKADA

AUV URASHIMA & Deep Tow Operation Team

Chief Submersible Staff	Toshiaki SAKURAI
1^{st} Submersible Staff	Keita MATSUMOTO
2^{nd}Submersible Staff	Keigo SUZUKI
2^{nd}Submersible Staff	Akihisa ISHIKAWA
2^{nd} Submersible Staff	Yosuke CHIDA
2^{nd} Submersible Staff	Humitaka SAITOH
2^{nd} Submersible Staff	Seiji SHIGETAKE
3^{rd} Submersible Staff	Yudai TAYAMA
3^{rd} Submersible Staff	Yudai Sakakibara
3^{rd} Submersible Staff	Masaya KATAGIRI

R/V YOKOSUKA Crews

Captain	Eiko UKEKURA
Chief Officer	Shinichi KUSAKA
2nd Officer	Shintaro HASHIMOTO
3rd Officer	Shunsuke HUJII
Chief Engineer	Toshihiro KIMURA
1st Engineer	Takashi OTA
2nd Engineer	Saburo SAKAEMURA
3rd Engineer	Kenichi SHIRAGATA
Chief Radio Operator	Satoshi WATASE
2nd Radio Operator	Yoichi Inoue
Junior 2nd Radio Operator	Yohei YAMAMOTO
Boat Swain	Yasuyoshi KYUKI
Able Seamen	Shuji TAKUNO
Able Seamen	Osamu TOKUNAGA
Able Seamen	Nobuyuki ICHIKAWA
Able Seamen	Kaito MURATA
Sailer	Shinya ISHIZUKA
Sailer	Daisuke YANAGITANI
Sailer	Hirotaka SHIGETA
No.1 Oiler	Kiyoshi YAHATA
Oiler	Hiroyuki OHISHI
Oiler	Tomoyuki HASHIMOTO
Oiler	Chihaya SANO
Oiler	Takeshi WATANABE
Chief Steward	Tomihisa MORITA
Steward	Yoshinobu HASATANI
Steward	Kiyotaka KOSUJI
Steward	Hiroyuki OHBA
Steward	Hidetoshi KAMATA

3. Ship logs

Actual schedule (YK09-09 09/7/19 - 09/7/29)				Position/Weather/Wind/Sea condition (Noon)
Date	Time	Description	Remark	
19,Jul,09	8:40	departure from WAKAYAMA port		7/19 12:00(JST)
	9:30	on board education	for safety YOKOSUKA life	33-35.4N,135-15.2E
	10:00	on board meeting	for research schedule	fine but cloudy
	15:10	arrived at research area		SSW-2(Light breeze)
	15:17	released XBT		
	15:53～16:31	carried out MBES survey		
	16:56	deployed mooring system		
	17:33	arrived at bottom		
	18:16	deployed OBEM(site11)		
	19:05～19:45	carried out calibration for OBEM	site11	
	20:17～21:20	carried out calibration for mooring system		
20,Jul,09	5:31	released mooring system		7/20 12:00(JST)
	6:03	recovered mooring system		33-25.0N, 136-25.0E
	8:36～17:20	URASHIMA dive#95		cloudy
	18:29	deployed OBEM(site12)		WSW-4(Moderate breeze)
	19:15～20:00	carried out calibration for OBEM	site12	
21,Jul,09	8:34～15:01	URASHIMA dive#96		7/21 12:00(JST)
	16:43	deployed OBEM(site13)		33-25.0N, 136-25.0E
	17:30～18:10	carried out calibration for OBEM	site13	over cast
22,Jul,09	7:22	arrived at SHINGU port		7/22 12:00(JST)
	7:30	disembarked 3 persons		33-34.6N, 136-06.2E

	11:00	commenced proceeding to site14		rain
	15:15	deployed OBEM(site14)		E-1(Light air)
	17:14～ 18:35	carried out calibration for OBEM	site14	
23,Jul,09	9:50～ 15:33	YKDT dive#65		7/23 12:00(JST)
	16:23～ 16:46	carried out calibration for OBEM	site13	33-20.0N, 136-27.9E
				over cast
				N-3(Gentle breeze)
24,Jul,09	9:39～ 14:35	YKDT dive#66		7/24 12:00(JST)
	15:57～ 16:29	carried out test for MANTA cable		33-22.9N, 136-26.0E
				over cast
				NE-3(Gentle breeze)
25,Jul,09	8:37～ 17:18	YKDT dive#67		7/25 12:00(JST)
				33-22.9N, 136-23.6E
				fine but cloudy
				SSW-6(Strong breeze)
26,Jul,09	8:17～ 16:54	YKDT dive#68		7/26 12:00(JST)
				33-21.5N, 136-22.0E
				fine but cloudy
				SW-4(Moderate breeze)
27,Jul,09	5:30	released OBEM(site11)		7/27 12:00(JST)
	6:30	surfaced OBEM		33-25.0N, 136-25.0E
	6:50	recovered OBEM		rain
	8:40～ 17:35	YKDT dive#69		NE-4(Moderate breeze)
28,Jul,09	5:30	released OBEM(site12)		7/28 12:00(JST)
	6:29	surfaced OBEM		33-25.0N, 136-25.0E
	6:38	recovered OBEM		rain

	8:16～ 16:55	YKDT dive#70		SSE-4(Moderate breeze)
	17:15	left the reseach area for JAMSTEC		
29,Jul,09	8:30	arrived at JAMSTEC		7/29 12:00(JST)
	12:00	concluded YK09-09		JAMSTEC

4. OBEM and Deep-towed DC Resistivity Survey System (MANTA) operation

We use the towed DC resistivity survey system (Kasaya et al., 2006; Goto et al., 2008), called MANTA for the control source EM survey. Figure 4-1 shows the image of the control source EM survey. Two transponders were set up at the deep-tow system and the tail of a towed electrode cable to detect the position of them. The length of electrode cable is about 170 m. Four OBEMs were deployed for the receiver of the control source EM survey and the MT survey in Kumano area (see Fig.1-1). Field test of the control source EM survey was carried out around the Site 11. Two OBEMs at Site11 and 12 were recovered on this cruise.

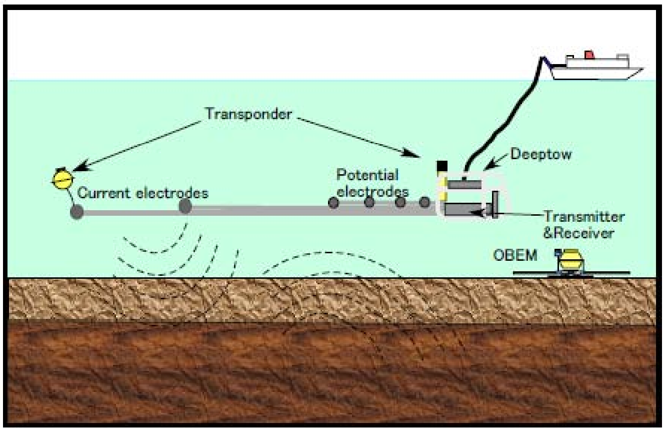


Fig.4-1 Survey image of the electro-magnetic survey.

4.1 OBEM
4.1.1 Outline of the OBEM system

The OBEM system with a high sampling rate was designed to investigate the crustal and mantle structure (Fig. 4-2). 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 4-3 shows the schematic diagram of the arm-folding system. For measuring the electric field, we used Ag-AgCl electrode 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. 4-2). 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).

Clock synchronization before deployment and calibration after recovery are important. This OBEM system can synchronize to the laptop PC using USB communication. To synchronize the laptop PC to GPS clock, we developed the NTP server unit (Fig. 4-4).

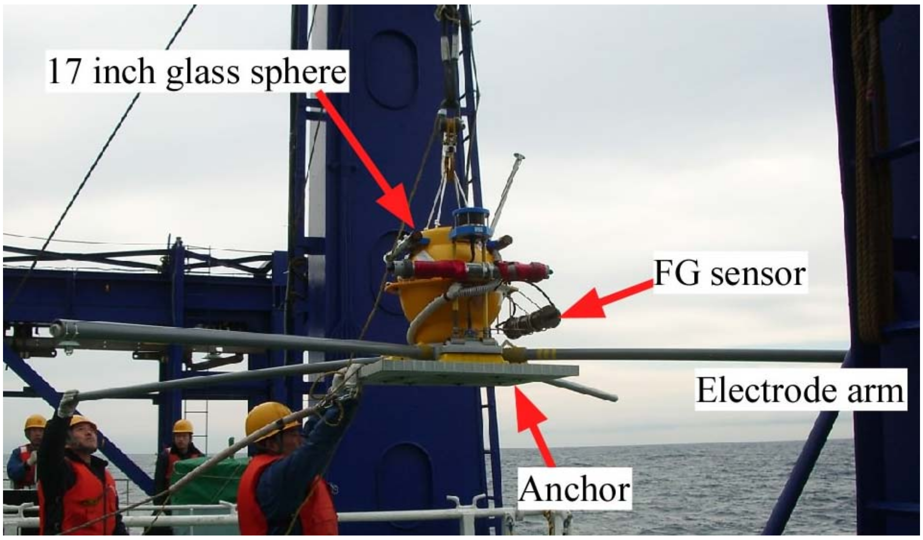


Fig. 4-2 Photo of a small OBEM system.

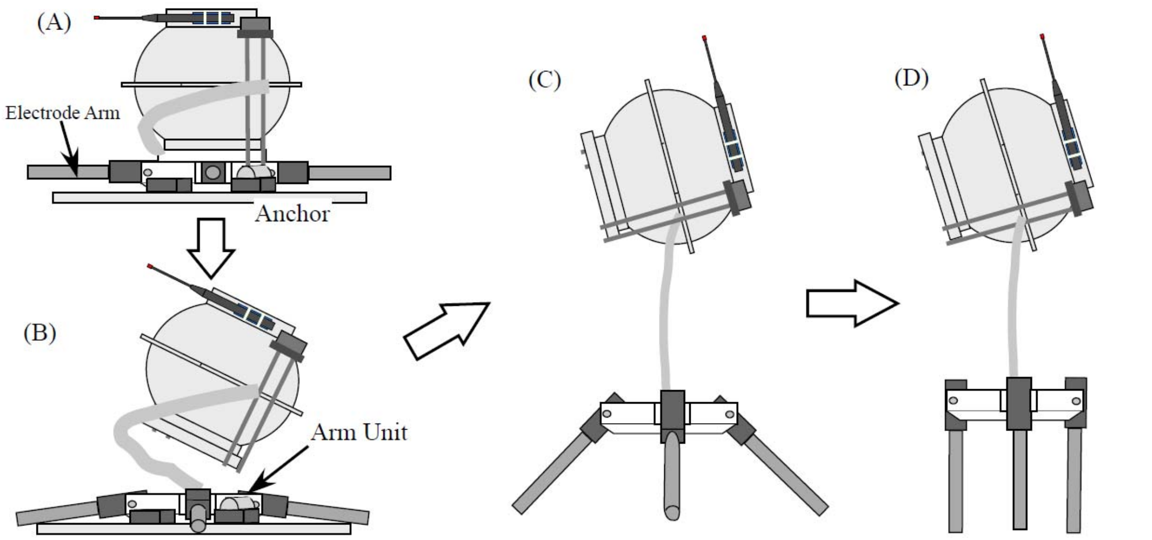


Fig. 4-3 Schematic diagram of the arm-folding system. After starting to pop up, the arm unit is picked up as the sphere ascends (Patent number of Japan: 4346605).

Fig. 4-4 Photo of the developed NTP server unit.

4.1.2 OBEM operation

The OBEMs were launched from deck using A-frame for all stations (Site11, Site12, Site13 and Site14), and sunk by their own weights. The operations were quick and smooth. We tracked the OBEMs by acoustic signals and confirmed that the OBEMs were successfully settled on the seafloor. Then, the settled positions were determined by measurements of the slant ranges at least three positions surrounding the launched point for each OBEM (Table 4-1-1, Figs 4-3 to 4-6). Two OBEMs at Site11 and 12 were recovered in this cruise. Other OBEMs at Site 13 and 14 will be recovered in the KR09-12 cruise

After finishing recovery operation, the time difference between the OBEM's clock and the laptop pc synchronized by NTP server unit was measured. Their results and other clock information were shown in Table 4-1-2. Obtained EM data were very clean. Figure 4-7 and 4-8 presents the raw time series obtained by OBEMs at C2 and C3. Total magnetic variation in each figure was calculated by the three components fluxgate magnetometer.

Site	Site 11	Site 12	Site 13	Site 14
Launched position	33°22.9730′N 136°22.0140′E	33°17.9860′N 136°25.9060′E	33°14.2100′N 136°27.9400′E	32°55.8240′N 136°39.7080′E
Settled position	33°22.9299′N 136°22.0563′E	33°17.9473′N 136°25.9839′E	33°14.1084′N 136°28.1972′E	32°55.7473′N 136°40.4069′E
Depth	2063.4m	2001.8m	2044.2m	4446.0m

Table 4-1-1 Information of the OBEMs deployed during this cruise.

SiteID	Clock set time (JST)	Recovery data(JST)	Clock compare time (JST)	Time difference (sec)
11	2009/7/19 17:36:42	2009/11/9	2009/7/27 7:30:30	+0.2185 sec
12	2009/7/20 18:06:42	2009/11/8	2009/7/28 7:16:47	+0.2719 sec
13	2009/7/21 16:02:37	KR09-12		
14	2009/7/22 10:47:56	KR09-12		

Table 4-1-2 Clock information of each OBEM.

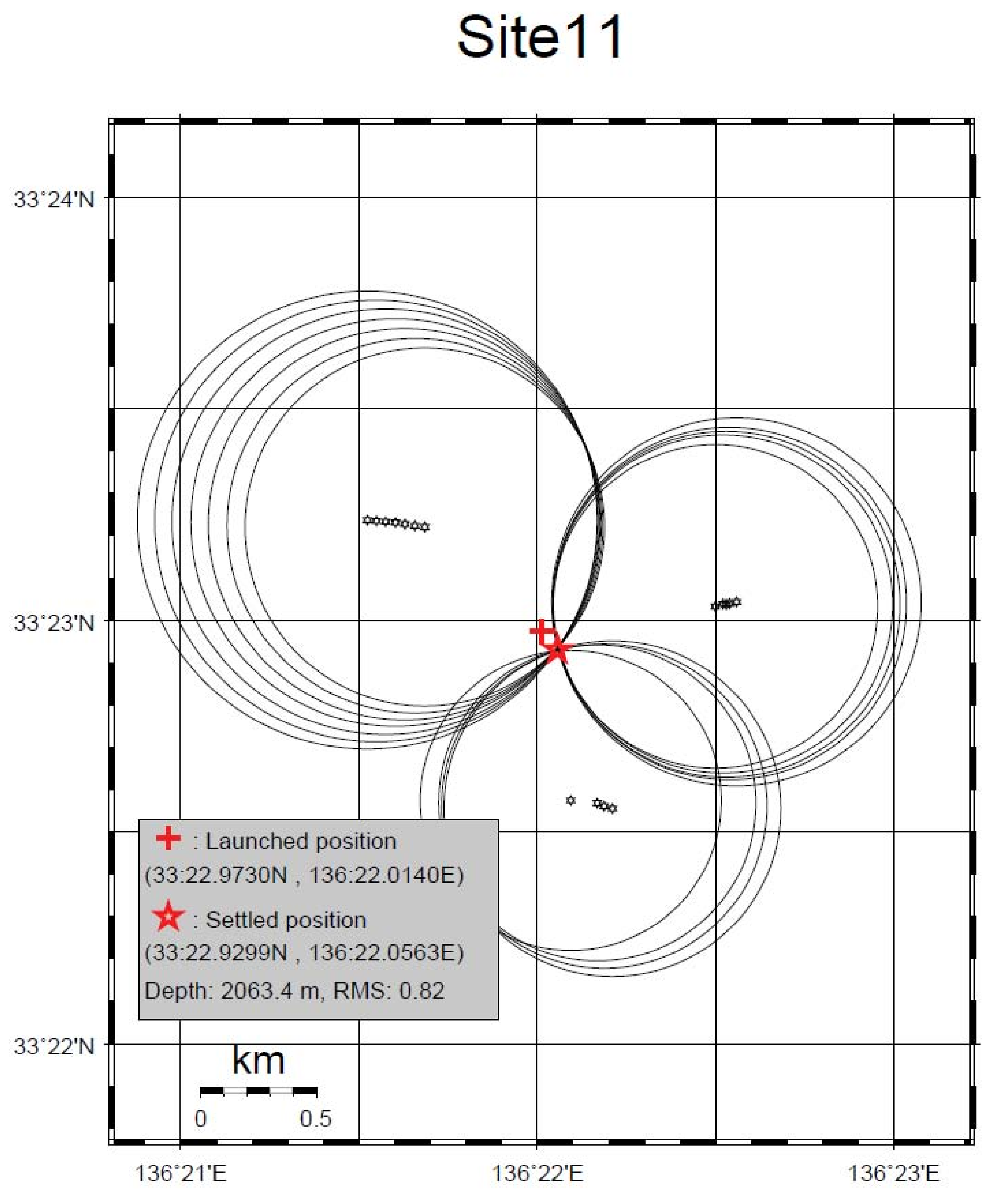


Fig. 4-3 Red cross-shape and star show the launched position and settled position at site 11, respectively. Each black star shows t he acoustic measurement position.

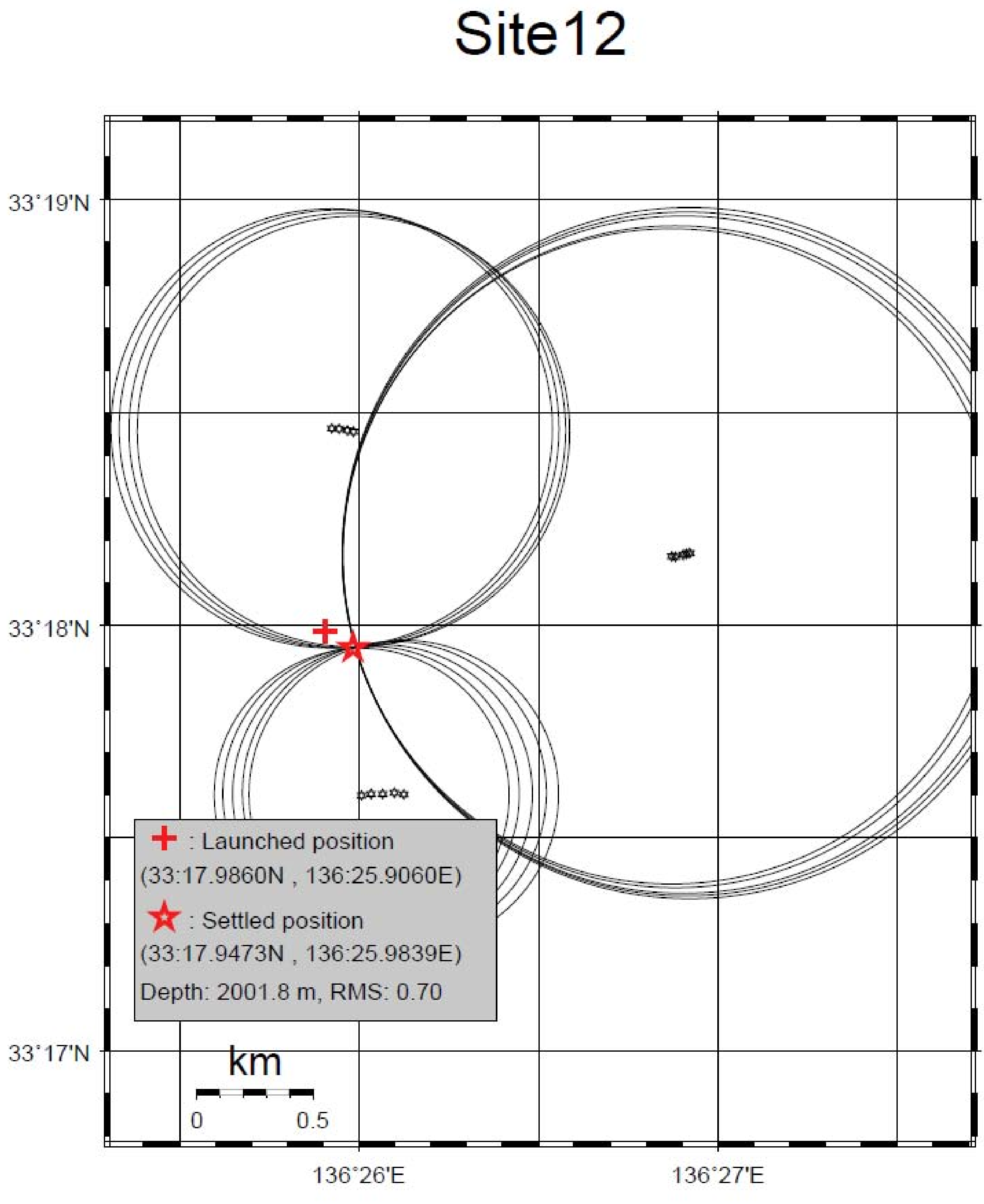


Fig. 4-4 Red cross-shape and star show the launched position and settled position at site 12, respectively. Each black star shows t he acoustic measurement position.

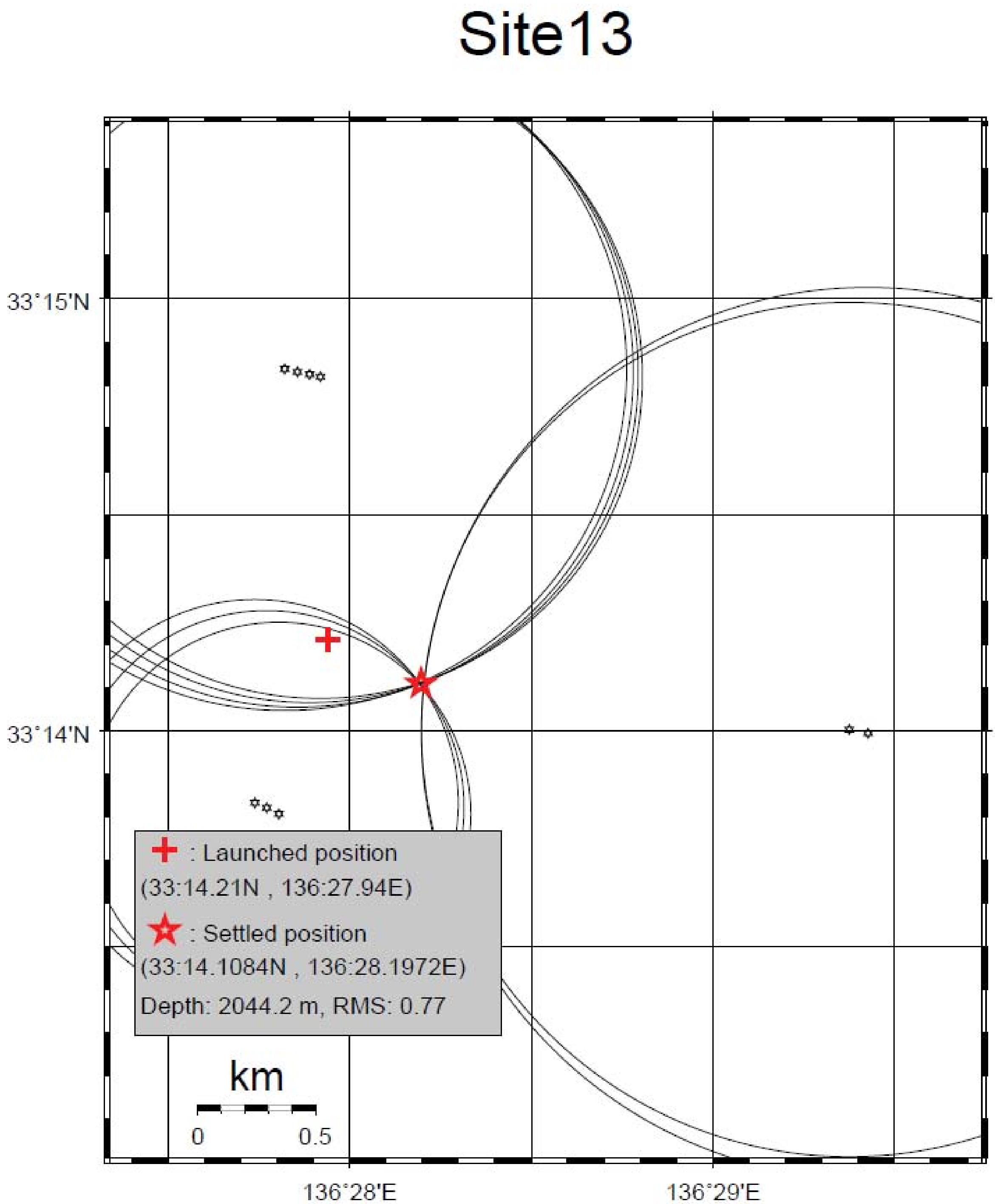


Fig. 4-5 Red cross-shape and star show the launched position and settled position at site 13, respectively. Each black star shows t he acoustic measurement position.

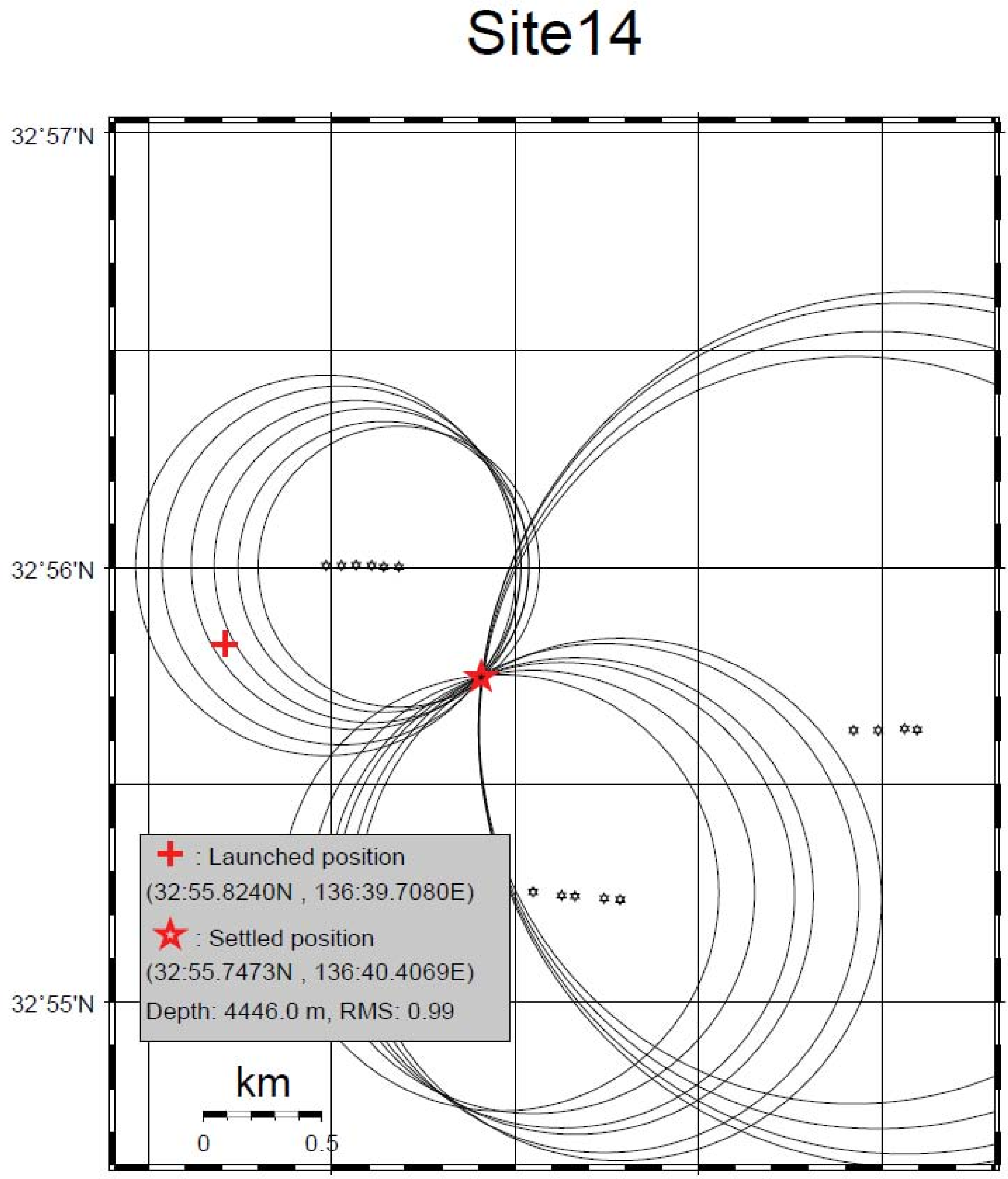


Fig. 4-6 Red cross-shape and star show the launched position and settled position at site 14, respectively. Each black star shows t he acoustic measurement position.

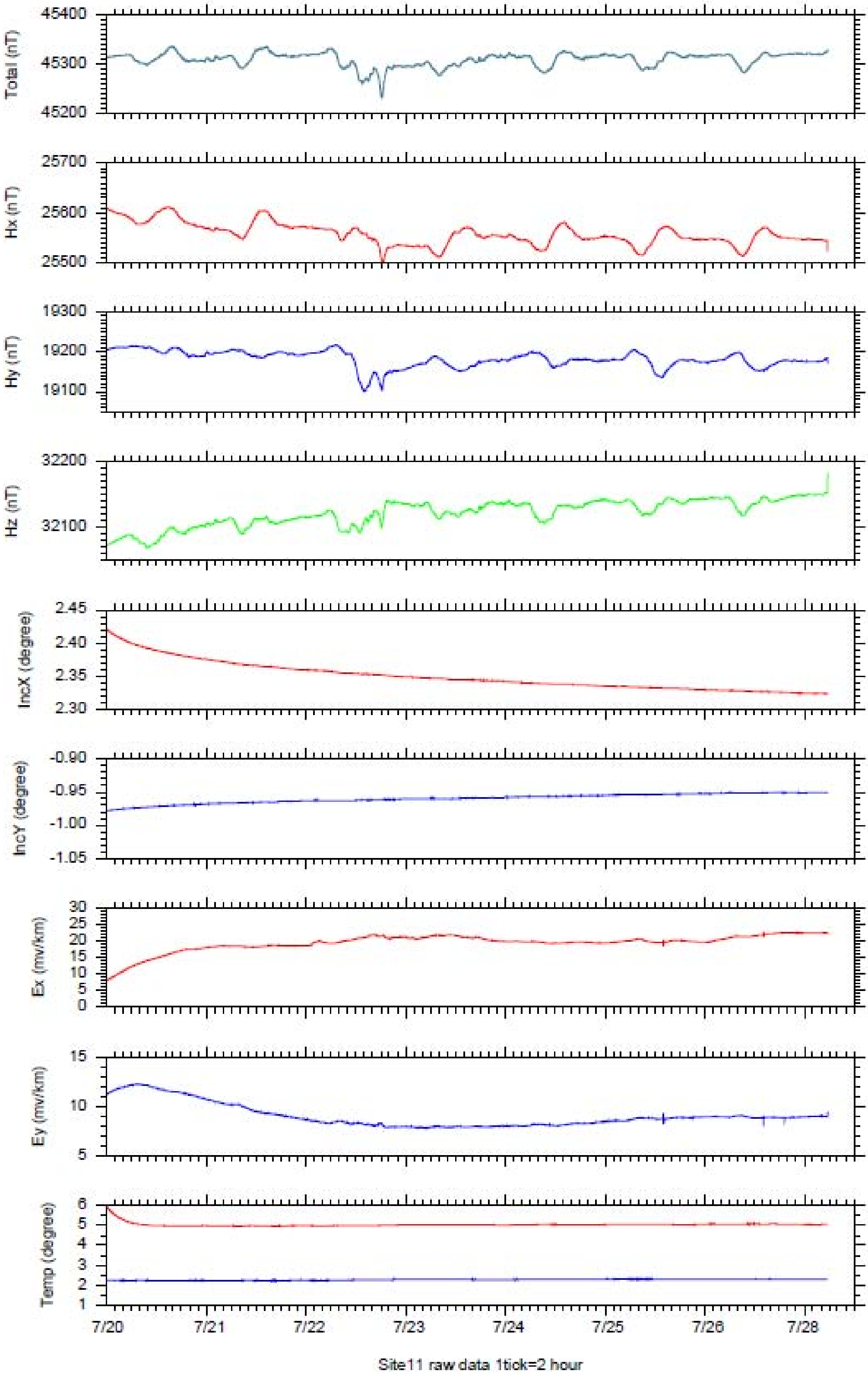


Fig. 4-7 Raw time series re-sampled with 1 minute at site 11. The total magnetic intensity time series at the top graph was calculated from the three components fluxgate magnetometer.

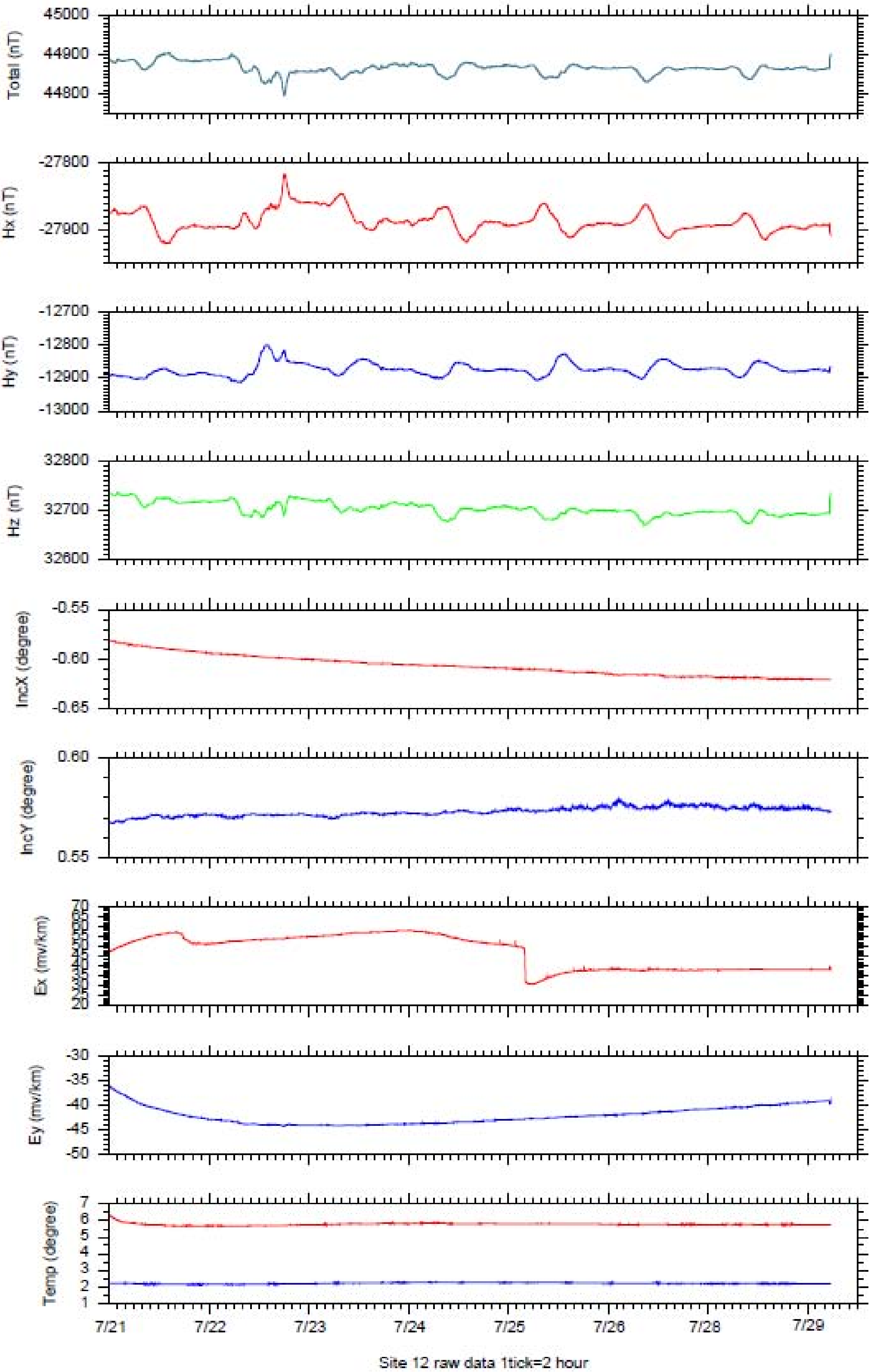


Fig. 4-8 Raw time series re-sampled with 1 minute at site 12. The total magnetic intensity time series at the top graph was calculated from the three components fluxgate magnetometer.

4.2 Deep-towed DC Resistivity Survey System (MANTA)

4.2.1 Outline of MANTA

It is difficult for natural source MT method to sense the structure shallower than a hundred meters in the deep sea. Therefore, we must use other survey methods used with the control source. The deep-towed marine DC resistivity survey system (MANTA) was developed to detect details of the shallow structures with depth of a hundred meters. Our system, with a transmitter and a 160-m-long tail with eight source electrodes and a receiver dipole, is towed from a research vessel near the seafloor (Fig. 4-1). This transmitter is added on the frame of the 4000m class deep-towed system of R/V Yokosuka in this cruise (Fig. 4-7). The maximum output power of the transmitter is 0.8kW with maximum voltage of 72 V p-p and current of 44 A p-p.

Fig. 4-7 Photo of the MANTA system on the YKDT(Yokosuka Deep-Tow)

4.2.2 MANTA operation

Field test of MANTA was carried out from 23th July to 26th July. As the result of the first dive, the wave form of the receiver was disturbed by high frequency noise. It is estimated that this noise is caused by the failure of receiver electric circuit. Therefore, we decided to conduct this field test around site 11. This circuit failure was already fixed after this cruise. Figure 3 shows the position of the deep-tow and the tail of towed electrode cable detected by SSBL (see Fig.4-7). Blue and red symbol shows the position of a deep-tow and a towed electrode cable, respectively. This figure presents that towing posture is very stable, even if the black current (Kuroshio) is over 3 knot. EM signal recorded by OBEM (Site11) was very clear. Analyzing these EM data, we will update the resistivity image around the Kumano area. The towing operation is generally of no matter. Because of the strong sea current, breaking of electrical cable occurred at the recovery operation of the electrode cable. We need to improve a towing electrode cable.

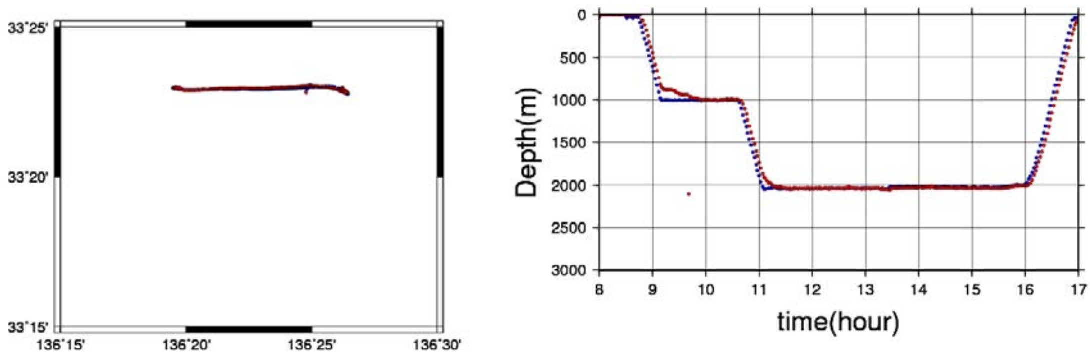


Fig.4-8 A deep-tow and a towed electrode cable position data deduced by SSBL system. Left panel is the horizontal projection, and right panel is the vertical one. Blue and red symbol shows the position of a deep-tow and a towed electrode cable, respectively.

References

Goto, T., T. Kasaya, H. Machiyama, R. Takagi, R. Matsumoto, Y. Okuda, M. Satoh, T. Watanabe, N. Seama, H. Mikada, Y. Sanada, and M. Kinoshita (2008), A marine deep-towed DC resistivity surevey in a methane hydrate area, Japan sea., *Exploration Geophysics, 39*, 52-59.

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. Magnetometer

5.1 Outline of magnetometer observation

Recently, sea-floor hydrothermal deposits including valuable metals like copper, lead, zinc, gold, silver, germanium have again become a subject of special interest in the world through intensifying competition of resource development for a stable supply of the resources. It is, however, difficult to develop the sea-floor hydrothermal deposits because there is no established method to estimate accurate abundance of them. Conventional marine (sea surface) geophysical explorations do not have enough resolution, and an exploratory drilling needs much time and money. Thus, new technology of geophysical exploration near the sea floor is required in order to discover and estimate the resources precisely. With these points as a background, a development program of fundamental tools for exploration of deep seabed resources was started in 2008 with financial support of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). As a part of the program, we have developed new measurement systems for electrical and magnetic explorations by Autonomous Underwater Vehicle (AUV), Remotely Operated Vehicle (ROV) and deep-tow system.

5.2 System

The magnetic exploration system consists of two flux-gate magnetometers and an overhauser magnetometer. The flux-gate magnetometers were attached to the inside of the frame of the AUV or the deep-tow system. The overhauser magnetometer was mounted on the back of the AUV or suspended from the deep-tow system. Figure 5-1 and 5-2 shows the schematic diagram for AUV and Deep-tow, respectively.

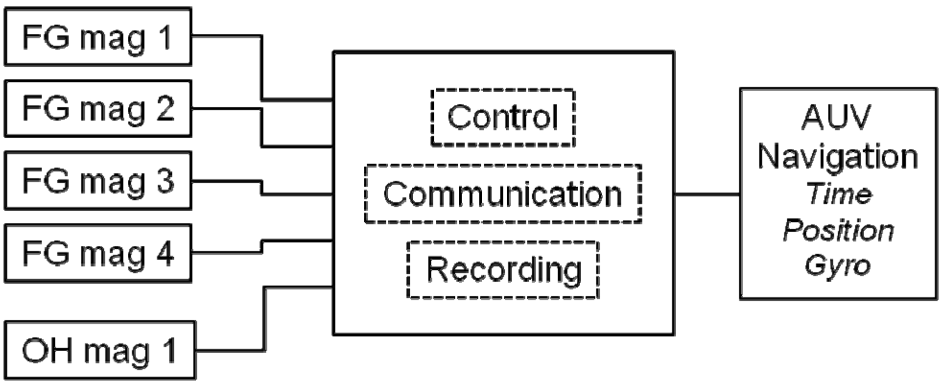


Fig. 5-1 Magnetic measurement system for AUV exploration

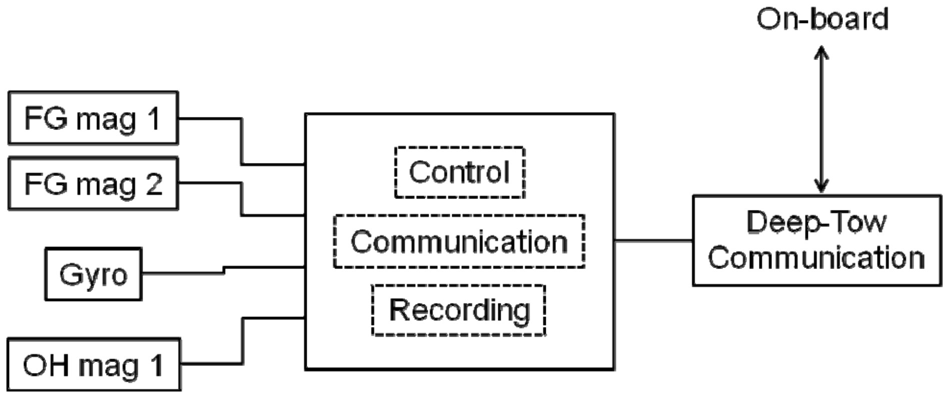


Fig. 5-2 Magnetic measurement system for Deep-Tow exploration

5.3 Preliminary results of magnetic survey deduced by AUV and Deep-tow dives

During this cruise, we carried out performance tests of a magnetic exploration system under development by "Yokosuka Deep-Tow" and AUV "Urashima" in the Kumano Basin area (water depth: 2000m). The tests contained 2 dives by the AUV on July 20 and 21, and 2 dives by the deep-tow system on July 27 and 28. Each dive had 6 to 9 hours. Figure 4 shows the configuration of the tests. The magnetic exploration system consists of two flux-gate magnetometers and an overhauser magnetometer. The flux-gate magnetometers were attached to the inside of the frame of the AUV or the deep-tow system. The overhauser magnetometer was mounted on the back of the AUV or suspended from the deep-tow system. The AUV or the deep-tow system moved 5 to 40 m above an artificial magnetic target while measuring the magnetic field.

In these tests, the flux-gate magnetometer on the AUV and the overhauser magnetometer of the deep-tow system clearly recorded expected magnetic anomalies caused by the magnetic target. The overhauser magnetometer on the AUV could, however, not measure the magnetic field, because the gradient of the ambient field was probably too large due to inappropriate position of the magnetometer. Although the flux-gate magnetometer on the deep-tow system detected the magnetic anomalies, they were not clear and noisy compared with those in the case of the AUV. The noise possibly arose from the following causes: (a) the power supply and (b) the induced magnetic field of the frame made of iron. Since the amplitude of the magnetic anomalies depend on a distance between the magnetometer and the magnetic target, it is necessary to determine positions of the AUV, the deep-tow system and the magnetic target for further discussion. From these tests, we could successfully obtain basic data for the measurement of our magnetic exploration system by the AUV and the deep-tow system. The results indicate that the system can be basically operated by the AUV and the deep-tow system with expected performance and practicality. We will improve the accuracy of measurement by fully analyzing the noise of data in future.

We also corrected the sidescan sonar and multi beam echo sounder data in this operation.

Accordint to quick view on board, sidescan sonar imagery showed some high-backscattering things around the magnetic target. We will try to identify the target position using the acoustic sonar data.

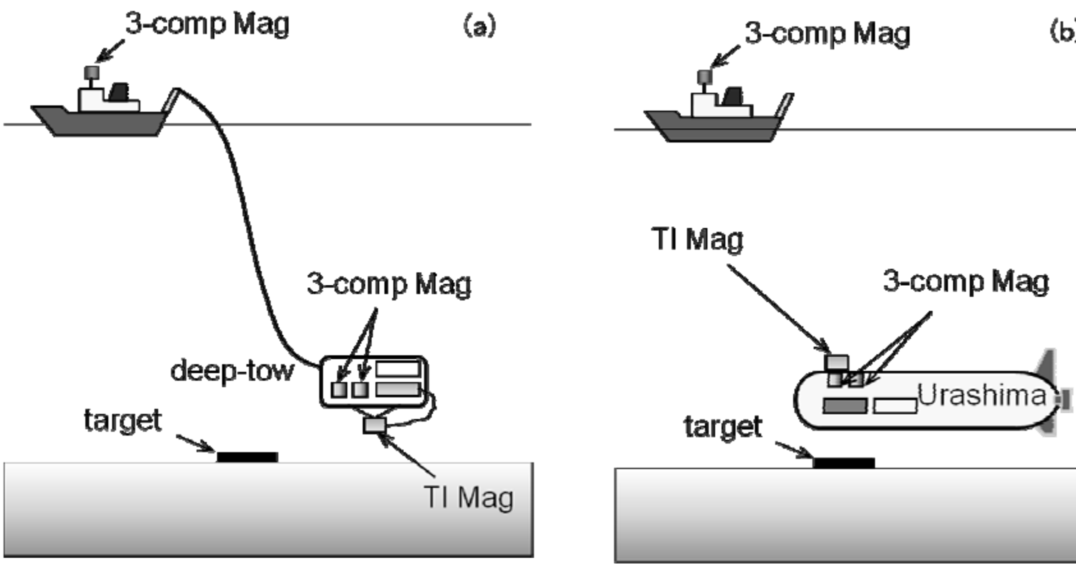


Fig. 5.1 A performance test of a magnetic exploration system using Yokosuka deep-tow (a) AUV Urashima (b) and a during the R/V Yokosuka YK09-09 cruise. 3-comp Mag: 3-component magnetometer, TI Mag: total intensity magnetometer.

6. Summary

We completed the various operations using the deep-tow, AUV and OBEMs. It was the first experimental test to use the YOKOSUKA deep-tow for the DC resistivity survey system, MANTA. The renewed electric circuit had some trouble of high frequency noise. Therefore, we could not correct enough quality DC resistivity data in this cruise. However, we could transmit the electrical signal to an OBEM at the site 11. This OBEM data corrected the transmitted signal, and we are analyzing this data. In addition, this circuit failure was already fixed after this cruise.

Performance tests of a magnetic exploration system under development by "Yokosuka Deep-Tow" and AUV "Urashima" also were carried out in the Kumano Basin area (water depth: 2000m). The tests contained 2 dives by the AUV on July 20 and 21, and 2 dives by the deep-tow system on July 27 and 28. Each dive had 6 to 9 hours. According to the preliminary results of obtained data, very clear anomalous changes were detected around the magnetic target. However, we need to consider the effect of the AUV and deep-tow. We will consider the analyzing method to carry out further detailed data analysis.

Appendix

Explanatory notes

A1. 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 The principal specifications of R/V Yokosuka

A2. AUV URASHIMA

Autonomous Underwater Vehicle (AUV) Urashima is cruised by oneself for built in control system. It is not connected by the cable between the mother vessel, therefore it can survey the sea floor widely and clearly. There are acoustic sonar equipments and sensors, Side Scan Sonar, Sub Bottom Profiler, Multi Narrow Beam Echo Sounder, and CTDO sensor.

Dimensions	Length(m) Width(m) Height(m) Weight(t)	10 1.3 1.5 10
Cruising Range(km)	Li-ion Fuel Cell(km)	100 300
Max Depth	3500m	
Cruising Speed	3kn	
Positioning	Inertial Navigation System Doppler Sonar SSBL Sonar	
Operation Mode	Autonomous Remote(Acoustic, Optical)	
Payload	300kg in air	
Equipments	Side Scan Sonar Multi Narrow Beam Echo Sounder Forward Looking Sonar CTDO	

Table A-2 The specifications of AUV Urashima

A3 Yokosuka Deep-tow

Yokosuka Deep-tow is attached by armored cable between the mother vessel. There are color TV camera, black-white TV camera, digital steel 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 A-3: The specifications of Yokosuka Deep-tow

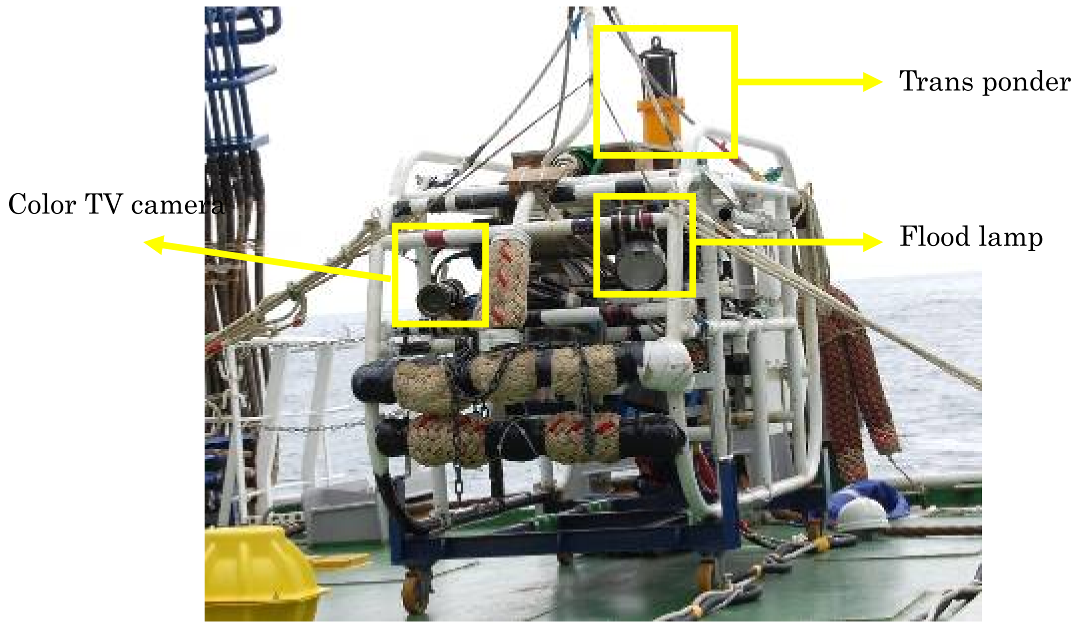


Fig.A-1 Part of equipments of Yokosuka Deep-tow