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S/V Yokosuka Cruise Report
YK11-10

Nov. 15, 2011 - Dec. 6, 2011

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1. Cruise Information

● Cruise ID YK11-10

● Name of vessel S/V Yokosuka

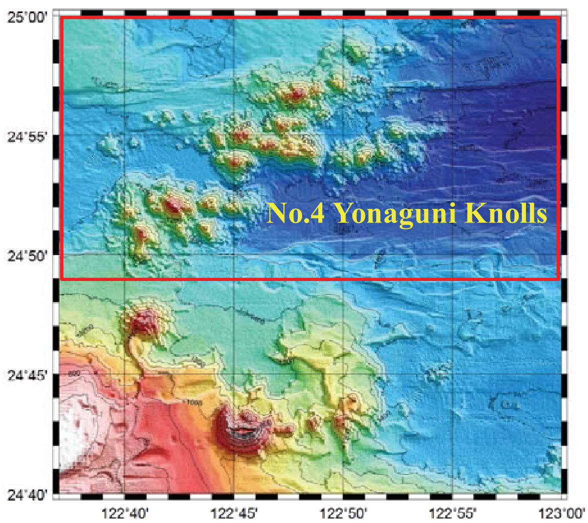
● Title of the cruise Development of Strategy for Finding and Observing Hydro-Thermal Vent Fields in West Part of Okinawa Trough such as No. 4 Yonaguni Knolls by using Two Autonomous Underwater Vehicles

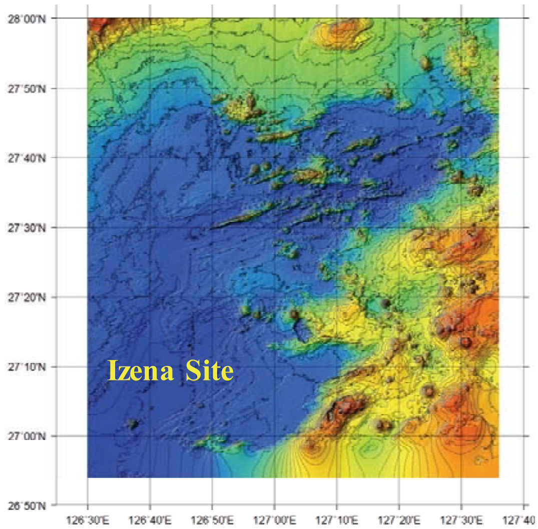
● Cruise period 15th Nov. 2011 ~ 5th Dec. 2011

● Ports of call JAMSTEC, Yokohama ~ Naha, Okinawa

● Research area No.4 Yonaguni Knolls and Izena Site in Okinawa Trough

● Survey areas (Maps)





2. Researchers

● Chief scientist

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● Representative of the science party

Tamaki Ura, Professor of IIS, The University of Tokyo

● Scientist party (List)

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Takashi Sakamaki, IIS, The University of Tokyo

Takeshi Nakatani, The University of Tokyo

Kangsoo Kim, IIS, The University of Tokyo

Kenji Nakane, Mitsui Engineering & Shipbuilding

Tadamasa Obata, MES Tokki Co., Ltd.

Hisashi Koyama, Mitsui Engineering & Shipbuilding

Yuuji Ooyabu, Dominant plus One

Michinari Sunamura, Graduate School of Science, The University of Tokyo

Kei Okamura, Kochi University
Takafumi Kasaya, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Takuro Noguchi, Kochi University
Masakazu Fujii, Atmosphere and Ocean Research Institute, The University of Tokyo

● S/V YOKOSUKA Crews

Shinya Ryono, Captain
Tatsuo Adachi, Chief Officer
Shozo Fujii, 2nd Officer
Tsubasa Shojima, 3rd Officer
Kazuhiko Kaneda, Chief Engineer
Kimio Matsukawa, 1st Engineer
Takahiro Mori, 2nd Engineer
Katsuo Yamaguchi, 3rd Engineer
Hiroyasu Saitake, Chief Radio Officer
Yohei Yamamoto, 2nd Elect. Officer
Mai Minamoto, 3rd Elect. Officer
Yoshikane Oda, Boat Swain
Katsumi Shimizu, Able Seaman
Nobuyuki Ichikawa, Able Seaman
Masanori Ohata, Able Seaman
Saikan Hirai, Able Seaman
Jiro Hanazawa, Sailor
Yoshihiro Ogawa, Sailor
Seiichi Matsuda, No.1 Oiler
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Eiji Aratake, Assistant Oiler
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Tomihisa Morita, Chief Steward
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Masanao Kunita, Steward
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● AUV Urashima Operation Team

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Hirofumi Ueki, 2nd Submersible Staff

Keigo Suzuki, 2nd Submersible Staff

Akihisa Ishikawa, 2ndSubmersible Staff

Fumitaka Saito, 2nd Submersible Staff

● NME Marine Technician

Masashi Ito, Marine Technician

3. Observation

3.1 Background

3.1.1 **Underwater Robotics**

As the resource nationalism increases and spreads worldwide, hydrothermal vents which are to be served as a potential benthic deposit start to attract much attention in Japan. Recently, it has become apparent that there are a few potential and active undersea hydrothermal vents within and near Japanese waters. However, only a few hydrothermal vents have been found in Japanese waters yet. In the traditional approaches for discovering unknown hydrothermal vents, acoustic investigation using the multi-narrow beam sonar device installed on a surface vessel is carried out first. On the basis of the results from this shipborne survey which offers the spots of probable hydrothermal activities, ROVs or manned submersibles are deployed to conduct the refined survey over the spots. As is well known, however, resolution of a bathymetric map generated by the shipborne acoustic investigation is restricted by the water depth resulting in the map of insufficient resolution to be used as a guidance for the deployment of ROVs or manned submersibles. As a result, the attempt for finding an unknown hydrothermal vent based on the shipborne acoustic surveys followed by the surveys using ROVs or manned submersibles seems to be neither efficient nor useful. Motivated by the problems in current approaches for finding unknown undersea hydrothermal vents, we have proposed a new undersea survey strategy based on the cooperative deployment of two heterogeneous AUVs; the cruising AUVs and the hovering AUVs.

3.1.2 **Hydrothermal mapping with AUV "Urashima"**

Distribution of hydrothermal plumes, topography of seafloor, and sub-seafloor has been investigated by surface ship or submersibles. These investigation covers wide area, e.g. whole of one hydrothermal area, or detailed investigation but a small area, e.g. just beside hydrothermal vents, respectively. To understand hydrology, distribution of ore deposits, and ecology of hydrothermal systems, the intermediate scale surveys are needed. The AUV offers us to investigate the deep sea hydrothermal systems with much higher accuracy because she can navigate underwater more quickly and closer to the seafloor than surface ship investigation. In addition, water column anomalies have been detected and imaged at methane hydrate area (Aoyama et al. 2009) and hydrothermal area using acoustic profiler. The origin of imaged anomalies in the acoustic investigation has not been confirmed but the acoustic imaging combined with AUV survey must be a great tool for various area of deep sea researches. No.4 Yonaguni knoll is known as the hydrothermal area of the western end of the Okinawa trough. The hydrothermal fluid is rich in not only sulfide and methane but hydrogen (Konno et al. 2006). No.4 Yonaguni knoll is characterized as the sediment hosted liquid CO_2 (Inagaki et al. 2004). However, the spatial distribution of hydrothermal and CO_2 efficient in the plume in deep sea and subseafloor has not been understand. In this cruise, we aim to

- clarify the correlation between acoustic imaging of hydrothermal plume and water physiology and chemistry, using ADCP, Seabat, side scan sonar, water sampling techniques with AUV, and chemical and microbiological analysis.
- estimate the chemical and microbiological flux by combination with high accuracy acoustic hydrothermal imaging and chemical and microbial analysis.
- image high resolution seafloor and subseafloor structures using Seabat, side scan sonar, sub bottom profiler, and magnetometer.

4. Facilities

4.1 Cruising AUV "Aqua-Explorer 2000a"

Aqua-Explorer 2000a (AE2000a) is an evolved version of the Aqua-Explorer 2000 originally designed and constructed for the undersea cable inspection. By means of the full remodeling and redesign in both hardware and software architectures, AE2000a has been completed on November 2011. Owned and operated by Institute of Industrial Science (IIS), The University of Tokyo, AE2000a is a small cruising AUV capable of working at the maximum depth of 2000 m. Overall feature of AE 2000a is shown in Fig. 4.1.1. Length, breadth, and height of AE 2000 are 3.0 m, 0.7 m, and 0.7 m, respectively. Total mass of it in air is 300 kg. Nominal and maximum cruising speeds of AE 2000a are 2.0 and 2.8 kts, respectively. Principal dimensions, specifications, and main equipments of AE 2000a are listed in Table 4.1.1.

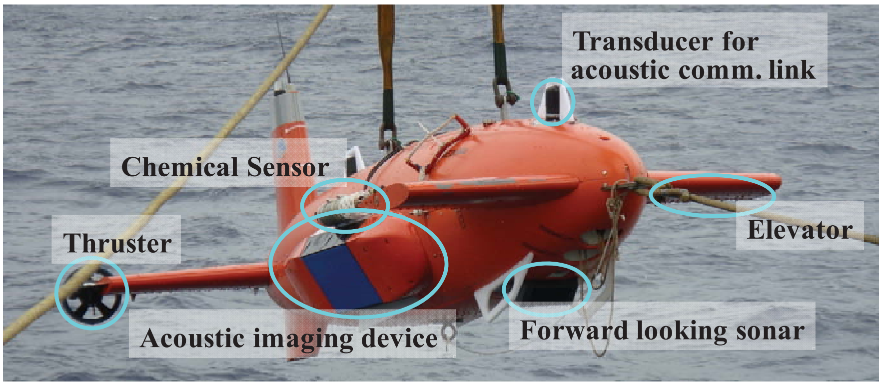


Fig. 4.1.1 Overall feature of Aqua-Explorer 2000a

Table 4.1.1 Principal dimensions and specifications of AE 2000a

Dimensions	L 3.0 × B 0.7 × B 0.7 m
Mass	300 kg
Max. oper. Depth	2000 m
Speed (Max. / Cruising)	2.8 / 2.0 kts
Energy source	Li-ion battery
Duration @ cruis. spd.	16 hr
Observation sensors	Outfitted : GeoSwath, CTD, ph-meter

4.1.1 Acoustic Imaging Device

For the visual observation of the seafloor, an acoustic imaging device called "GeoSwath" was installed on AE 2000a. GeoSwath is a phase measuring bathymetric sonar system which simultaneously acquires swath bathymetry and side scan image. Having dual configuration, the transducer array of GeoSwath is composed of five ceramic staves, one of which for transmission and four of which for reception. After transmission, one of the receive stave registers the amplitude of the signal scattered from the seafloor and uses this to produce the side scan images. The phase of the sonar signal on the four receive stave is used to determine the angle of arrival of the sonar data. And the phase measuring algorithm determines the direction of the returning sound, which results in the seafloor bathymetry. Figure 4.1.2 shows configuration of the GeoSwath. Table 4.1.2 and 4.1.3 present technical specification of GeoSwath system installed on AE 2000a.

Fig. 4.1.2 GeoSwath system: stand alone (left) and installed on AE 2000a (right)

Table 4.1.2 Technical specifications of GeoSwath

Frequency	125 kHz
Max. water depth below transducers	200 m
Max. swath width	780 m
Depth resolution	6 mm
Two way beam width (horizontal)	0.85°
Transmit pulse length	128 μs to 896 μs
Max. swath update rate	30 per second
Transducer dimensions	540 × 260 × 80 mm
Transducer weight	11.6 (in air) / 3.3 (in water) kg
Deck unit dimensions	490 × 430 × 280 mm

Table 4.1.3 Acquisition parameter of GeoSwath

Side Scan Gain	2
Pulse Length	3
Power	7
Ping Length (Range)	390 m

4.1.2 Geochemical Sensor

In preparation for the survey dives by AE2000a during YK11-10 cruise, compact geochemical sensors for measuring conductivity, temperature, depth (CTD), and pH of the seawater have been developed. Figure 4.1.3 shows the chemical sensor unit installed on AE2000a. Contained in the four compact cylindrical bodies, the geochemical sensors continuously measures CTD and pH of the seawater, operating independent of the vehicle control unit.

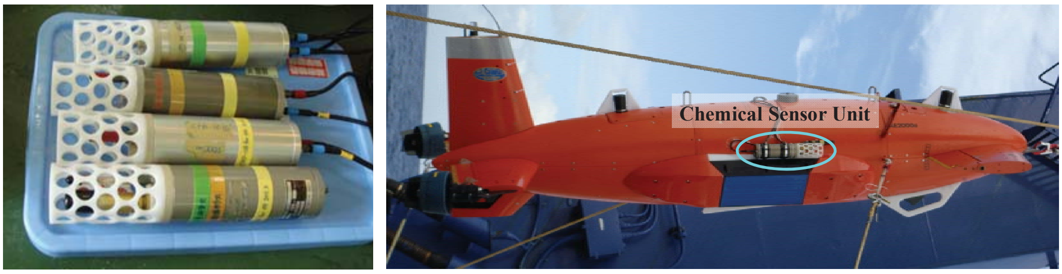


Fig. 4.1.3 Chemical sensor units: stand alone (left) and installed on AE2000a (right)

4.1.3 Actuators

By the actions of twin main thrusters installed on the outer edges of the horizontal tail fin (Fig. 4.1.4), AE2000a can proceed with the maximum speed of 2.8 kts. At the condition of nominal power consumption, AE2000a exhibits the cruising speed of 2.0 kts. In addition to the propulsion, twin main thrusters also work as the yaw control mechanism. By generating the deviation between thrusts exerted by two individual thrusters, AE2000a attains the yaw moment for the turning motion. At the speed of 2.0 kts, minimum turning radius of AE 2000 is 7.0 m.

For the motion control within the vertical plane, AE2000a utilizes two elevators which constitute the trailing edge part of the horizontal head fin (Fig. 4.1.4). By the action of the maximum elevator deflection of ±18°, AE2000a exhibits its ascending and descending motions, taking the largest pitch magnitude of ±35°. As for the sign of the elevator action, upward deflection is defined to be positive which leads to the negative pitch for the descending motion.

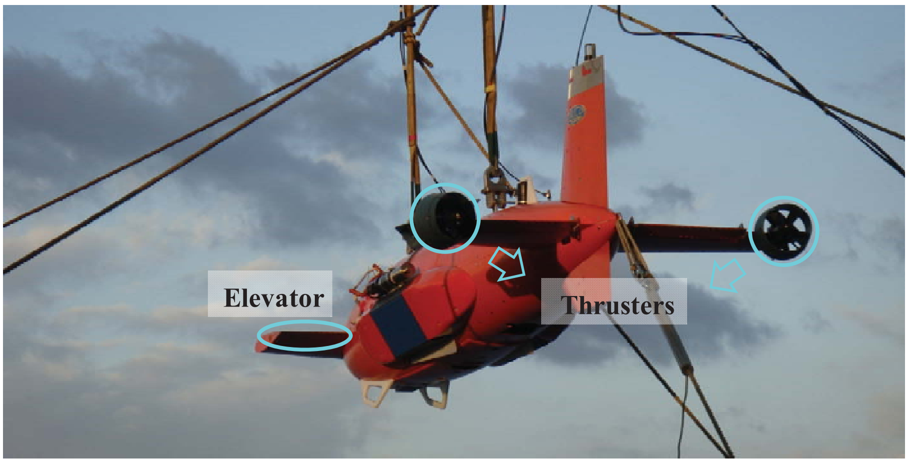


Fig. 4.1.4 Thrusters and elevators of AE2000a

4.1.4 Acoustic Navigation Devices

For the remote monitoring and control of the vehicle states, AE2000a is equipped with a system for acoustic communication link. Two transducers installed on the rear and the fore part of the body take the role of the uplink (to a support vessel) and the downlink (to AE2000a) communications, respectively (Fig. 4.1.5).

For the underwater position fixing by a Super Short Baseline (SSBL) system mounted on a support vessel, AE2000a is designed to carry a transponder (Fig. 4.1.5). By using the SSBL system of Yokosuka, real-time position tracking of AE2000a was successfully achieved during all dives performed.

Fig. 4.1.5　Acoustic devices installed in Aqua-Explorer 2000a

4.2 Hovering AUV "Tuna-Sand"

Tuna-Sand (TS) is a hovering AUV developed for the visual investigation of the seafloor features. Figures 4.2.1 and 4.2.2 show the overall feature and general arrangement of TS. Principal dimensions and specifications of the vehicle are listed in Table 4.2.1.

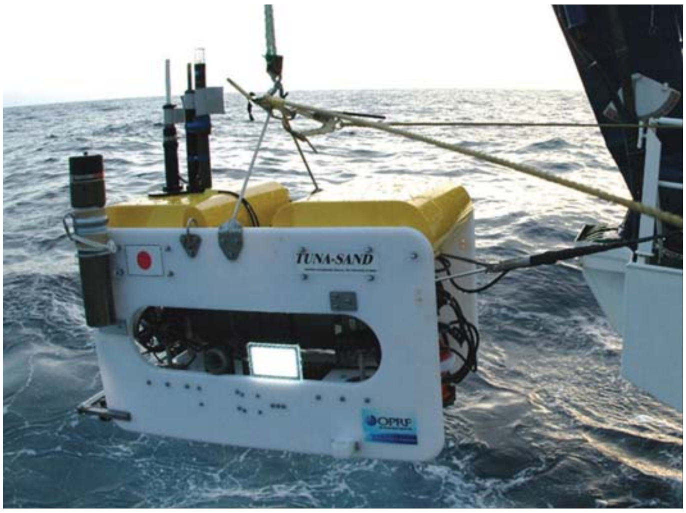


Fig. 4.2.1 Hovering AUV "Tuna-Sand"

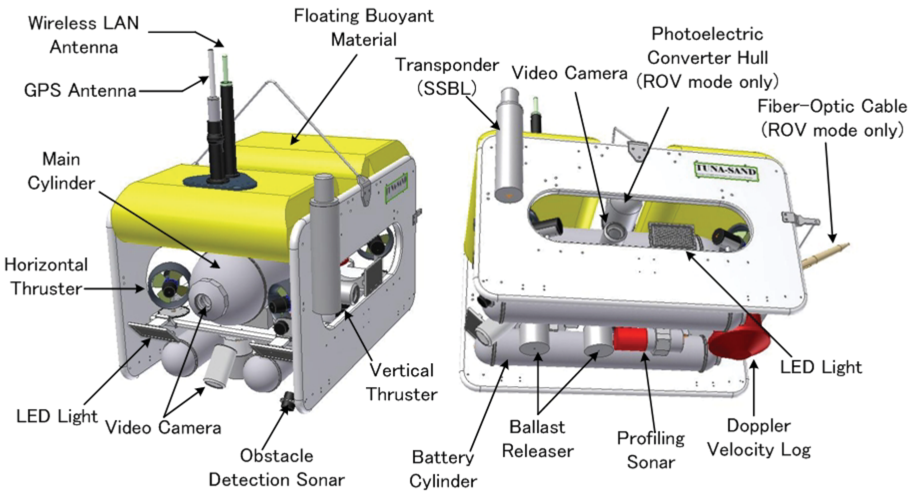


Fig. 4.2.2 General arrangement of Tuna-Sand

Designed as an open-frame structure, TS pursues the on-site robustness and enhanced operability in its mission achievement. An AUV as it is, in response to a mission or on-site requirement, TS is also alternatively operable as a Remotely Operating Vehicle (ROV), tethered by an optical fiber cable. It is noted that equipped with an Inertial Navigation System (INS) of high-accuracy, TS is able to compensate for its drift-induced position error by referring to seabed topography. Based on this position error compensating technology, we can deploy TS in an undersea environment even in which the position reference by GPS is fundamentally unavailable, and achieve a successful automatic navigation by letting the vehicle to track the pre-defined reference waypoints.

Table 4.2.1 Principal dimensions and specifications of Tuna-Sand

Vehicle	
Size	1.1m(L)×0.7m(H)×0.7m(W)
Mass	240 kg
Max.speed	1.7 knot
Max.depth	1,500 m
Duration	4 hours
Actuators	Thrusters 220W × 4, 100W × 2
Power	Ni-H Battery 50.4V 9Ah × 4
Communication	Wireless LAN, Fiber-Optic Comm.(ROV mode only)
CPU (Main)	NS Geode GX1-300MHz
CPU (Comm. with sensors)	NS Geode GX1-300MHz
OS	VxWorks
Sensors	
Inertial Navigation System	iXSea PHINS (FOG)
GPS	NovAtel OEM4-G2L
Doppler Velocity Log	RDI Navigator 600kHz
Depth	Mensor Series 6000
Obstacle Avoidance	Echo sounder ×3
SSBL	System Giken
Payload	
Camera	Hitachi KP-D20B(CCD) ×3
Lighting	LED light board × 3
Bathymetry	Imagenex 881a Profiler 675 kHz

During an undersea mission, TS manages its dive by switching the predefined navigation modes sequentially. Figure 4.2.3 depicts the navigation modes defined in the vehicle navigation software of TS.

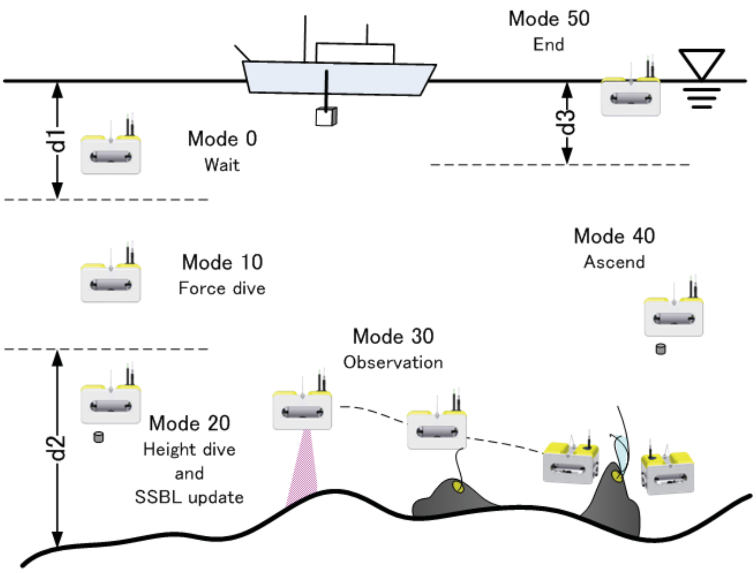


Fig. 4.2.3 Navigation modes defined in the dive managing software of TS.

4.3 Large Cruising AUV "Urashima"

Developed by Japan Agency for Marine-Earth Science and Technology (JAMSTEC) since 1998, "Urashima" is one of the largest AUVs currently working in the world. Its large size enables the Urashima to realize the long duration, leading to the long cruise range of 100 km (with Li-ion battery), or 300 km (with fuel cell). As an underwater navigation device, Urashima employs high-precision inertial navigation system (INS) composed of ring-laser gyro and Doppler velocity log (DVL). During the dive, Urashima collects oceanographic data such as salinity, water temperature, pH, conductivity, and dissolved oxygen. At the same time, Urashima is able to investigate the sea bottom and sub-bottom structure by using acoustic imaging devices such as side scan sonar (SSS) or sub-bottom profiler. Fig. 4.3.1 shows the overall feature of Urashima. Table 4.3.1 shows the specifications and principal dimensions of Urashima.

Fig. 4.3.1　Sea cruising AUV Urashima

Table 4.3.1　Principal dimensions and specifications of Urashima

Maximum depth capability	3,500 m
Cruising distance	More than 100 km (using a lithium-ion battery)
	More than 300 km (using a fuel cell)
Dimensions	10 m (L) × 1.3 m (W) × 1.5 m (H)
Weight	Approx. 8 tons (with a lithium-ion battery)
	Approx. 10 tons (with a fuel cell)
Speed	3 knots (4 knots maximum)
Power source	Lithium-ion battery or fuel cell
Operation	Autonomous or acoustic remote control (wireless, operated from the support ship)
Survey instruments	Physical measurement devices • Automatic water sampler (for measuring CO_2) • CTDO (salinity, water temperature, dissolved oxygen)
	Deep seafloor research (earthquake research, etc.) • High-sensitivity digital camera • Side scan sonar • Sub-bottom profiler • Multibeam echo sounder

4.3.1 Multibeam echo sounder

Bathymetric data were collected by Reson SEABAT7125 on AUV Urashima. SEABAT7125 is a multibeam survey system that generates data for wide-swat h bathymetry maps and backscattering images. The system consists of two main subsystems, transmitter and receiver. The 400 kHz projector array is positioned fore and aft along the ship's keel. The along-track transmit beam width is 1°. The receiver array detects and processes the returning echoes through stabilized multiple athwart ship beams in a fan shape. The across-track receive beam width is 0.54°. The equi-distance mode is selected in beam forming. The ping rate is 2 Hz. The system swath angle is 120° and maximum number of beams is 512, but actual swath coverage is less during the survey. The swath width was about 3 times of center depth until 120 m of altitude, and decreased to 250-300 m at 120-160 m of altitude, and then 50% of center depth at 160-180m of altitude. Above 200 m from seafloor no effective data was logged. Data were logged in .s7k format and preliminary onboard processing was done using CARIS ver 6.1.

4.3.2 Side scan sonar

Acoustic wave is the best and often only means to investigate the water column and seafloor efficiently and accurately. Side scan sonar system is one of the acoustic mapping systems. AUV Urashima emits a pulse of sound energy that radiates away from the source transducer and detects backscattering strength. When the sound energy impinges on objects harder than water, the energy is scattered in a new directions. Some of the energy is scattered back toward the source of the sound (= echo). The source transducer detects the returning energy for a fixed period of arrival time. The side scan sonar system assumes that observation of flat floor with constant altitude to a seafloor, and uniform propagation velocity of acoustic wave in seawater. The first returning echo is considered that come from just below the AUV (nadir) and is able to determine the altitude. Once the first echo was detected, they catch the magnitude of the pixels. Detected sounds after the first echo are aligned along arrival time from below the fish to side. Backscattering strength shows information of seafloor materials (sand or rock), seafloor roughness (fine grains or cobbles, for example), and inclination of seafloor (facing or opposite slope to the vehicle), in jumble magnitude. A series of processing, including gain control, slant range collection, altitude correction, noise reduction, bottom tracking, radiometric correction, and positioning correction, is needed for analyzing the side scan sonar data. Specifications of side scan sonar (Edge-Tech 2200C) installed in AUV Urashima are shown below. Urashima enables to use 120 kHz and 410 kHz acoustic wave but only 120 kHz wave was worked during the YK11-10 cruise.

4.3.3 Sub bottom profiler

Sub bottom profiler (Edge-Tech DW106) is installed near the head part of the AUV Urashima. The sub bottom profiler transmits chirp signals of 1-6 kHz, and detects sub- seafloor objects when the seafloor is covered by thick sediments. In case of YK09-08 cruise, we could not obtained sub-seafloor image from the sub bottom profiler, because of thin or almost no sediments.

4.3.4 Magnetometer

Magnetic anomalies observed in the ocean are basically originated from the variation of the magnetization of oceanic crusts mainly formed by basaltic rocks. Hydrothermal vent activities are possible cause of reduction of rock magnetization, namely demagnetization, in the small scale. Anomalous magnetic signals have been observed around past and present hydrothermal vent sites. However, anomalous magnetic signatures of hydrothermal vent sites are usually difficult to elucidate from sea-surface surveys. Near-bottom magnetic survey by using an AUV is an effective method to reveal the detailed magnetic anomaly signatures of ocean floor such as those around hydrothermal vent sites. In order to detect signals of hydrothermally altered rocks in the southern Mariana Trough, the measurements of total intensity and three-components of the geomagnetic field are conducted by using AUV Urashima. Four three-axis fluxgate type magnetometers and an Overhauser type magnetometer are attached on AUV Urashima during the cruise. In addition, four three-axis fluxgate magnetometers were used in this survey in order to figure out the magnetic noises derived from AUV Urashima itself and other equipments on it, and those noise data are used to obtain the real geomagnetic anomaly signals.

4.3.5 CTD-DO-pH-transmit-Colored DOM sensors

To detect the signals of hydrothermal plume anomaly, CTD-DO-pH-transmit-CDOM sensor system is equipped in AUV Urashima. The sensor system is deployed at the front payload space of Urashima just behind the water inlet tube. The sensor systems is constructed from CTD-DO-pH system with rechargeable battery (Ocean Seven 316 plus, IDRONAUT), transmissiometer (C-star, WetLabs), and fluorescent meter for colored DOM (Eco-FLD,WetLabs).

4.3.6 Rossetta-multi sampler system

Intelligent Rosette Sampling System with twenty-four submersible arrays (Model 1018, General Oceanics Inc.) was modified to install in the payload space of AUV Urashima. Water samples can be collected in Niskin bottle (0.5L) under autonomous operation controlled by clock or depth sensor of the system. Water-inlet was installed using 125 mm diameter pipe at the front, and the discharge hole was made at bottom of the AUV. Water flow into the payload space was monitored by a digital flowmeter (Model 2030R, General Oceanics Inc.).

Fig. 4.3.2 Rossetta-multi sampler system

4.3.7 Geochemical Sensor

In this cruise, the geochemical sensor was installed on all AUVs used for survey; that is, AE2000a, Tuna-Sand, and Urashima. Details of each installation are as follows.

(1) AE2000a

For hydrothermal plume observations, chemical sensors listed below were attached on AE2000a.

- CTD data logger (RBR XR-620) with Turbidity sensor (Seapoint)
- glass electrode pH sensor (Kimoto electric Co. Ltd., pH 08)

All data were sent to the CTD data logger. Sampling interval was set to be 3 seconds.

(a) (b)

Fig. 4.3.3 Geochemical sensors installed on AE2000a. (a) pH and Turbidity sensor (b) CTD Data logger on left side

(2) Tuna-Sand

For hydrothermal plume observations, chemical sensors listed below were attached on TUNA-SAND.

- data logger (KIMOTO, MC-mini 10) with turbidity sensor (Seapoint)
- glass electrode pH sensor (KIMOTO, PH-08)
- self logging hydrogen sulfide sensor (KIMOTO, H2S-10)

All data were stored every 1 second. Chemical observation was conducted successfully and data was collected during operation of TUNA-SAND.

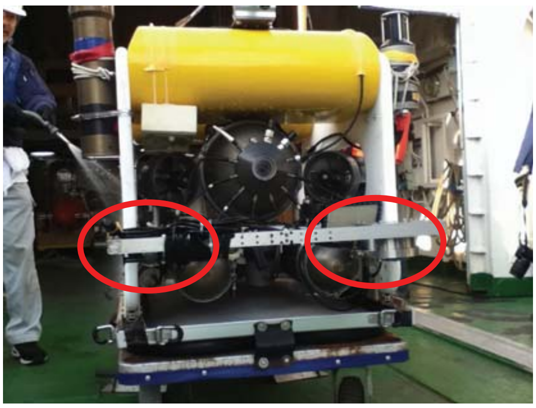


Fig. 4.3.4 Geochemical sensors installed on Tuna-Sand

(3) Urashima

For hydrothermal plume observations, chemical sensors listed below were attached on Urashima.

- CTD data logger (RBR XR-620) with Turbidity sensor (Seapoint)
- glass electrode pH sensor (KIMOTO, PH-08)
- ORP sensor (KIMOTO, ORP-09)
- H2S sensor (KIMOTO, H2S-10)

Sampling interval were set at 3 seconds for CTD data logger, every second for ORP and H2S.

Fig. 4.3.5 Geochemical sensors installed on Urashima

For hydrothermal plume sampling, 32-channnel 50 ml water sampler (KIMOTO, ANEMONE-11) was attached on the Urashima. Water sampling was conducted at pre-programmed interval (every 10 minutes).

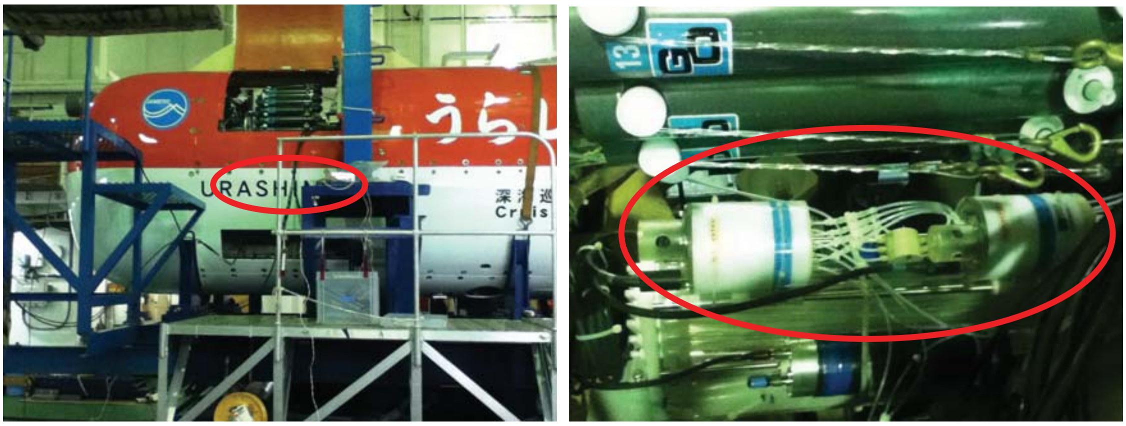


Fig. 4.3.6 Water sampler "ANEMONE"

5. Dive Results

5.1 AE2000a Dive #01

5.1.1 Dive Overview

Started to dive above the region called "Nishihozawa (Refer to Cruise Report KR10-03 for the place-names in No.4 Yonaguni Koll Area)", AE2000a was on duty to cover the southern part of No.4 Yonaguni Knolls following the predetermined dive path. Figure 5.1.1 shows the actual dive trajectory of AE2000a taken by super short baseline (SSBL) positioning system installed in the S/V Yokosuka. As noticeable in the figure, right after passing the waypoint (wp)#11, AE2000a started to surface since the emergency stop function was activated by the running-over decision within the segmented course interval. Summary of the dive #01 is shown below.

Date : 23th Nov., 2011

Location : No.4 Yonaguni Knolls Site, 24°50'N - 24°54'N, 122°40'E - 122°47'E

Purpose : Discovering hydrothermal vent activity

Duration: 3 hrs. 1 min.

Dive Event Log

06:15 Stand by AE2000a
08:35 Operation Check of AE2000a
08:49 Released on the Sea Surface
08:51 Dive Starts
11:50 Dive Finish
12:12 Surface
12:48 Retrieval completed.

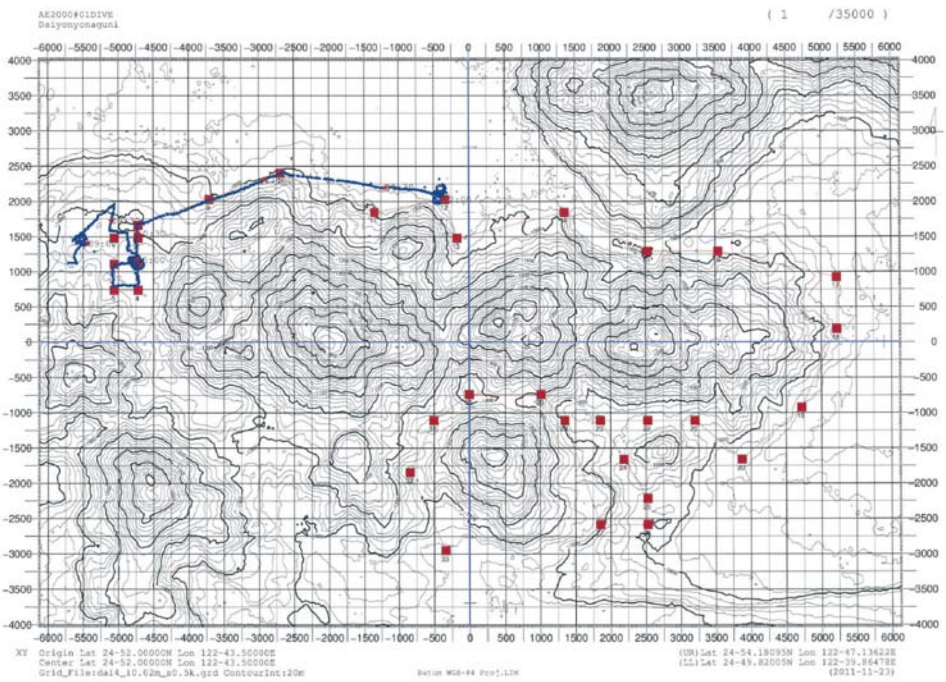


Fig. 5.1.1 Trajectory of AE2000a during dive #01

5.2 AE2000a Dive #02

5.2.1 Dive Overview

Taking the path similar to but moving oppositely to that of the dive #01, dive #02 of AE2000a was planned in the same region that of dive #01. Started to dive above the region called "Myozinsawa ", AE2000a was on duty to cover the southern part of No.4 Yonaguni Knolls following the reference dive path in the counterclockwise manner. In this dive, AE2000a successfully completed the dive without any trouble happened in hardware or software system. Since the planned path was too long however, not reaching the terminal waypoint, AE2000a surfaced with the fully discharged battery. Figure 5.2.1 shows the actual dive trajectory of AE2000a. Summary of the AE2000a dive #02 is shown below.

Date : 27th Nov., 2011

Location : No.4 Yonaguni Knolls Site, 24°50'N - 24°54'N, 122°40'E - 122°47'E

Purpose : Discovering hydrothermal vent activity

Duration: 6 hrs. 6 min.

Dive Event Log

06:15 Stand by AE2000a

07:58 Operation Check of AE2000a

09:13 Released on the Sea Surface

09:14 Dive Starts

15:10 Dive Finish

16:20 Surface

16:41 Retrieval completed.

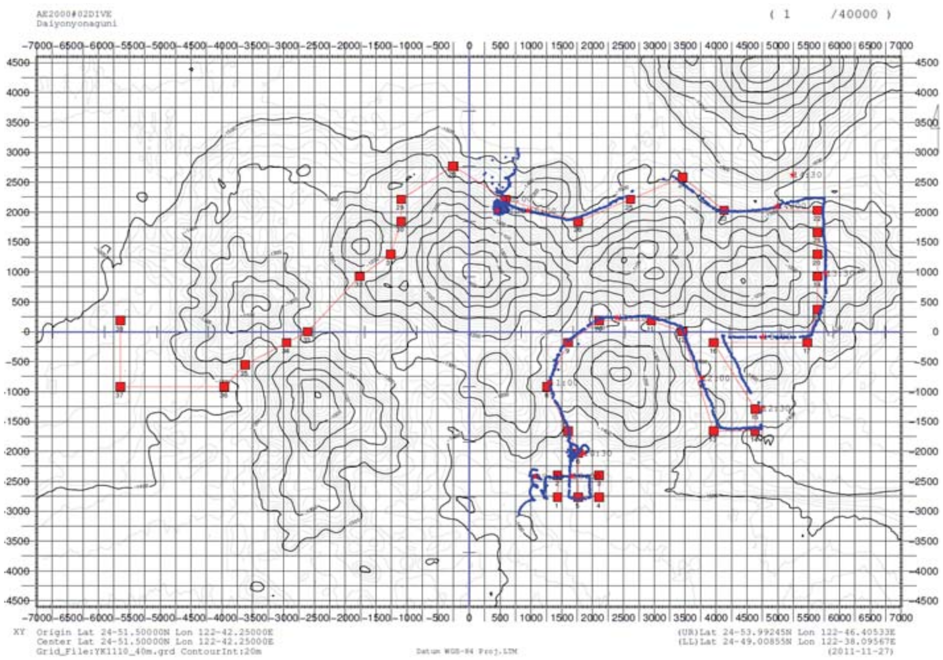


Fig. 5.2.1 Trajectory of AE2000a during dive #02

5.3 AE2000a Dive #03

5.3.1 Dive Overview

After conducting two dives in the southern part of No.4 Yonaguni knoll site, dive #03 of AE2000a was planned to be conducted in the northern part of No.4 Yonaguni knolls. Starting to submerge above the deep flat basin between southern and northern parts of the knolls, dive path was planned to cover the region passing the valleys between peaks. The dive #03 was interrupted right after the vehicle had passed wp #10, since the collision avoidance function in vehicle control architecture worked improperly. Figure 5.3.1 shows the actual dive trajectory of AE2000a. Summary of the AE2000a dive #03 is as follows.

Date : 28th Nov., 2011

Location : No.4 Yonaguni Knolls Site, 24°53'N - 24°58'N, 122°43'E - 122°50'E

Purpose : Discovering hydrothermal vent activity

Duration: 2 hrs. 13 min.

Dive Event Log

06:15 Stand by AE2000a

07:58 Operation Check of AE2000a

09:13 Released on the Sea Surface

09:14 Dive Starts

15:10 Dive Finish

16:20 Surface

16:41 Retrieval completed.

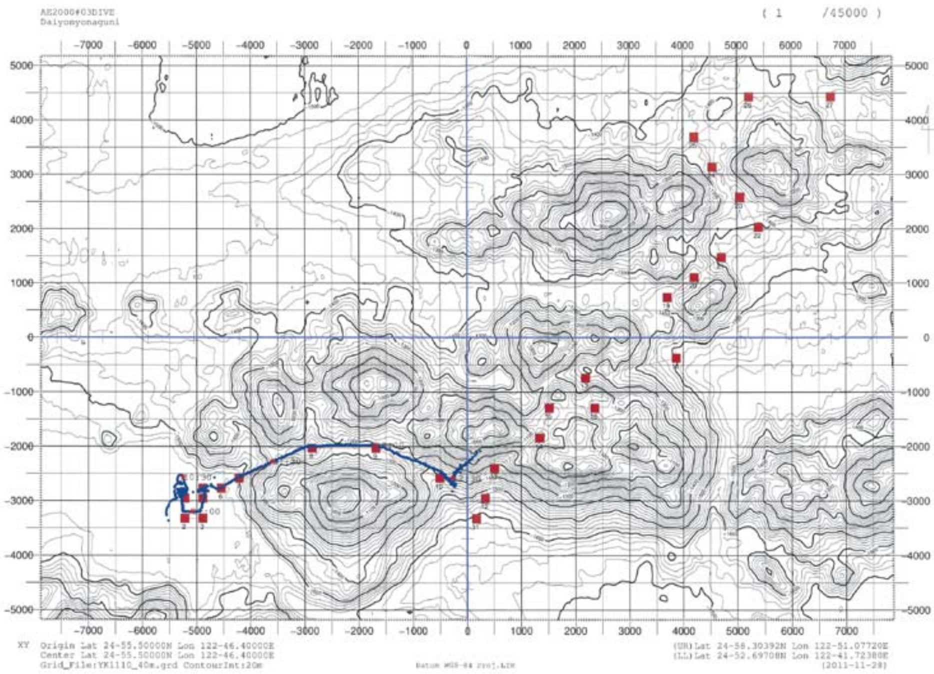


Fig. 5.3.1 Trajectory of AE2000a during dive #03

5.4 AE2000a Dive #04

5.4.1 Dive Overview

Though it was hardly said to be that we had surveyed No.4 Yonaguni knoll site thoroughly, we decided to move to the site of Izena Caldron for the next survey. Located northwest from the main island of Okinawa, Izena Caldron site is far closer to the port of Naha where the YK11-10 cruise was to be terminated. In No.4 Yonaguni knolls site, many dives had been cancelled due to the severe sea state. Therefore, by moving to the Izena site, we can maximize the efficacy of the ship management admitted until the end of our cruise. In this dive, to survey the Izena Caldron site most effectively, we generated the two-layered reciprocating survey path as shown in Fig. 5.4.1. By following the lattice of ascending spiral in the path, on reaching the bottom of the caldron, the vehicle can promptly raise its altitude. Figure 5.4.2 shows the actual trajectory of AE2000a during the dive #04.

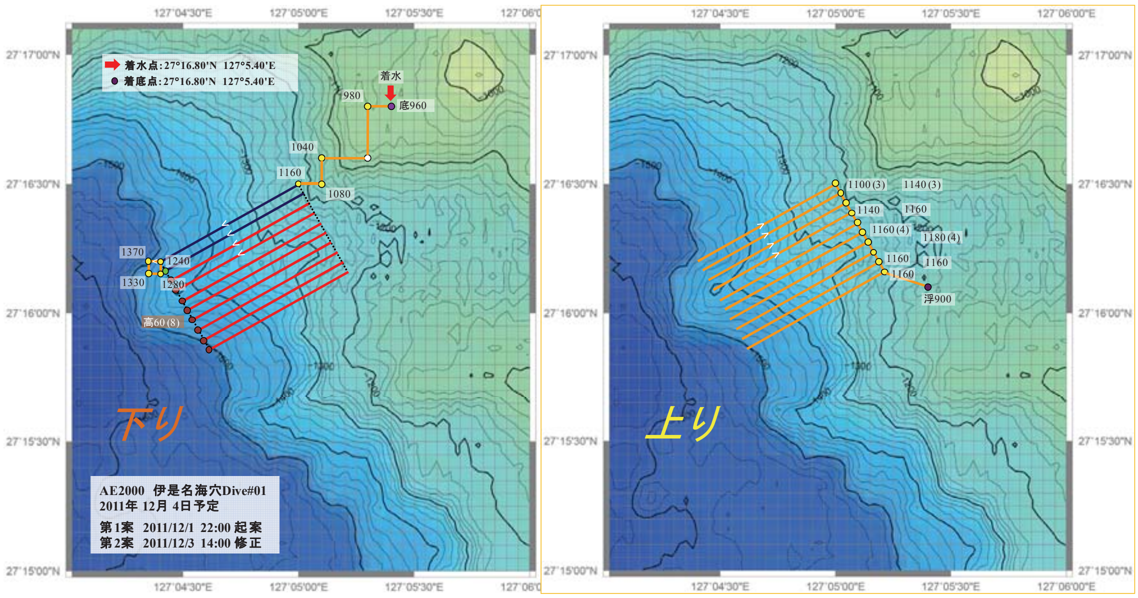


Fig. 5.4.1 Planed trajectory of AE2000a for dive #04 (left: descending / right: ascending)

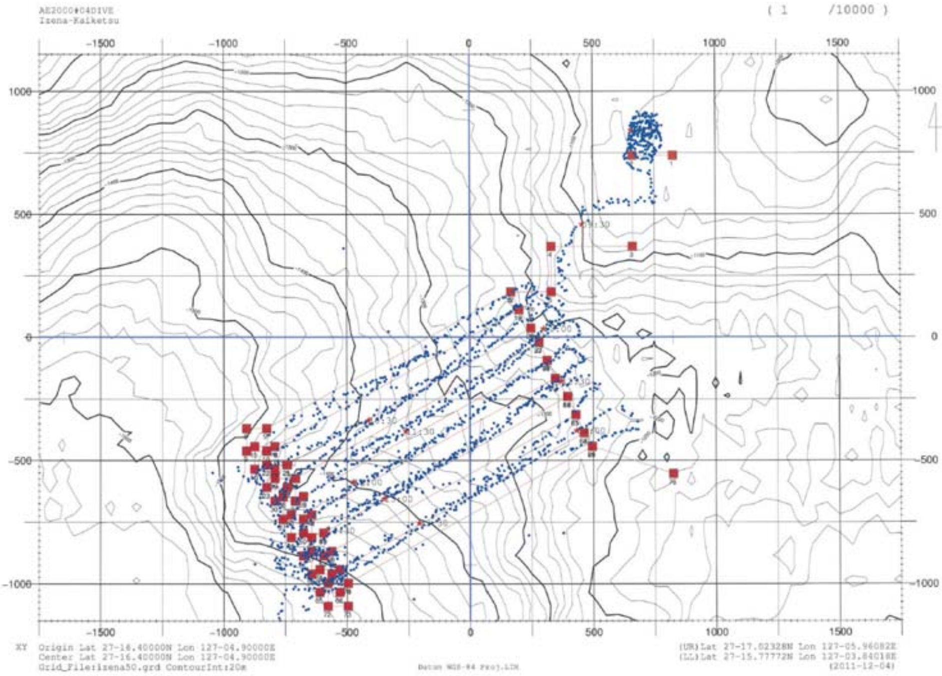


Fig. 5.4.2 Trajectory of AE2000a during dive #04

Summary of the AE2000a dive #04 is as follows.

Date : 4th Dec., 2011

Location : Izena Caldron Site, 27°15'N - 27°17'N, 127°04'E - 127°06'E

Purpose : Discovering hydrothermal vent activity

Duration: 6 hrs. 20 min.

Dive Event Log

06:15 Stand by AE2000a

07:44 Operation Check of AE2000a

08:36 Released on the Sea Surface

08:44 Dive starts

14:36 Send command for mission interruption and surfacing

15:30 Retrieval completed

5.5 AE2000a Dive #05, #06

5.5.1 Dive Overview

The measured data taken from the dive #04 in Izena Caldron showed many clear and evident signs of hydrothermal activity. It is noted, however, that the area of dive #04 shown in 5.4 is included in the so called "Jade deposit", in which the hydrothermal activities are widely known. As mentioned in 3.1, one of the main purposes of this cruise is to discover unknown hydrothermal vents. To achieve this within only a few days left during the cruise, we decided to deploy AE2000a in a different area in the Iheya-Izena site. The area dive #05 and #06 was made is a caldera-like topography consisting of peaks and a basin. Figures 5.5.1 and 5.5.2 show the planned and the actual trajectories of the vehicle for dive #05.

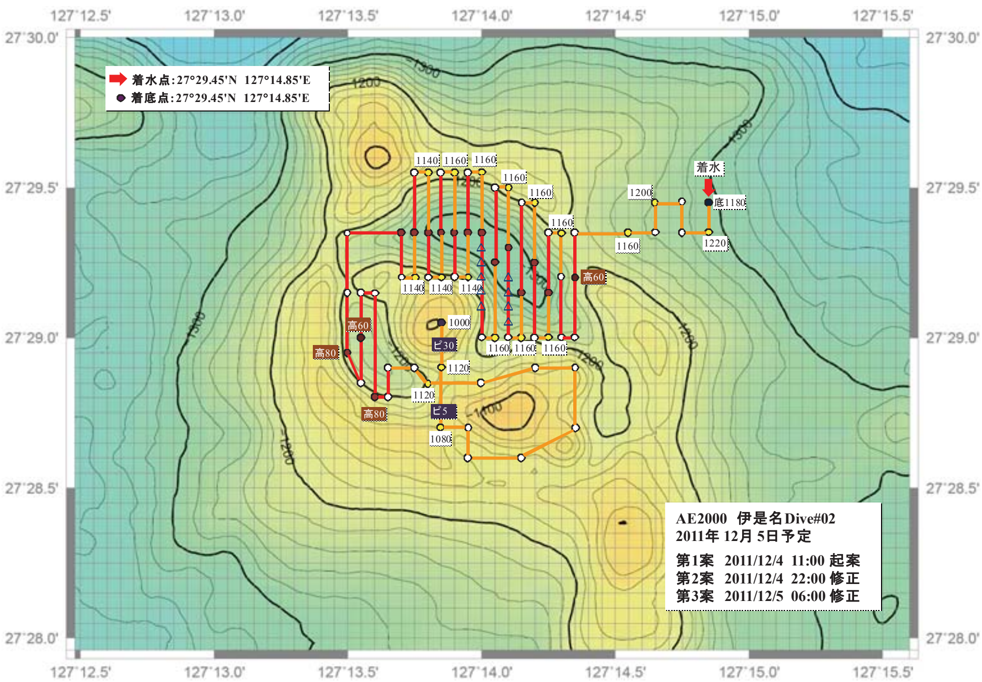


Fig. 5.5.1 Planed trajectory of AE2000a for dive #05

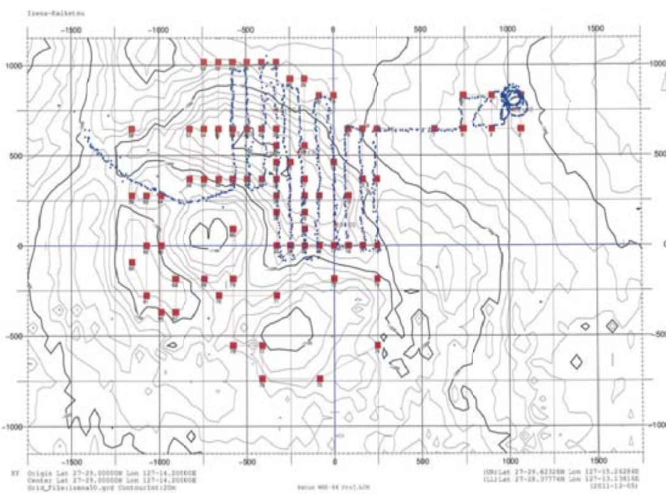


Fig. 5.5.2 Trajectory of AE2000a during dive #05

Summary of the AE2000a dive #05 is as follows.

Date : 4th Dec., 2011

Location : Iheya-Izena Site, 27°28'N - 27°30'N, 127°13'E - 127°15'E

Purpose : Discovering hydrothermal vent activity

Duration: 3 hrs. 8 min.

Dive Event Log

06:15 Stand by AE2000a

07:27 Operation Check of AE2000a

07:43 Released on the Sea Surface

07:45 Dive Starts

10:53 Dive Finish

11:29 Surface

12:16 Retrieval completed.

Though the dive #05 had been successfully continued covering more than 60% of the target survey region, there happened a malfunction in elevator action which leaded to the interruption of the dive mission and emergency-surfacing. In order to cover the remained region of interest, dive #06 was planned and conducted immediately right after the vehicle had started to surface. The dive #06 was also interrupted however, due to the excessive roll rate indication caused by the erroneous operation of mems-based gyroscope installed in AE2000a.

5.6 Tuna-Sand Dive #66

5.6.1 Dive Overview

Followings are the latitudes and longitudes predetermined for 1) dive start 2) bottom-following start for the Tuna-Sand dive #66.

1) Dive Start Point : 24°52.30'N , 122°40.30'E

2) Bottom-following Start Point : 24°52.70'N , 122°40.60'E

These points had been determined on the basis of the results of dive #01 by AE2000a.

In this dive, TS marked the maximum depth of 1396 m, which is the new record since it was launched in 2007. The previous maximum depth had been 995 m recorded during the dive #46 in the Sea of Japan. During the dive #66, TS took total 175 photo images fully automatically, keeping its altitude to be 2.5 m. Meanwhile, however, some troubles shown below are found.

1) INS Alignment Failure
2) Malfunction in INS measurement during the dive
3) SSBL Positioning Failure due to Vertical Thruster Noise
4) Failure of Horizontal Thruster

After the dive #66, causes of the troubles 1) ~ 3) are clarified. Diagnosis for the trouble 4) were made after completing the YK11-10 cruise.

Figure 5.6.1 shows the trajectory of TS during the dive #66. Figure 5.6.2 is depth profile of the dive trajectory. In Fig. 5.6.3, we can witness the seabed of No.4 Yonaguni site.

Summary of the TS dive #66 is as follows.

Date : 26h Nov., 2011

Location : No.4 Yonaguni Site, 24°51.75'N - 24°53.65'N, 122°39.92'E - 122°41.28'E

Purpose : Focused survey of potential hydrothermal activity

Duration: 4 hrs. 0 min.

Dive Event Log

07:14 Stand by TS
07:32 Start INS Alignment
08:16 Restart INS Alignment
09:07 Alignment finished
09:45 Released on the Sea Surface
09:46 Dive Starts
11:00 Send Surfacing Command
13:46 Surface
14:20 Retrieval completed.

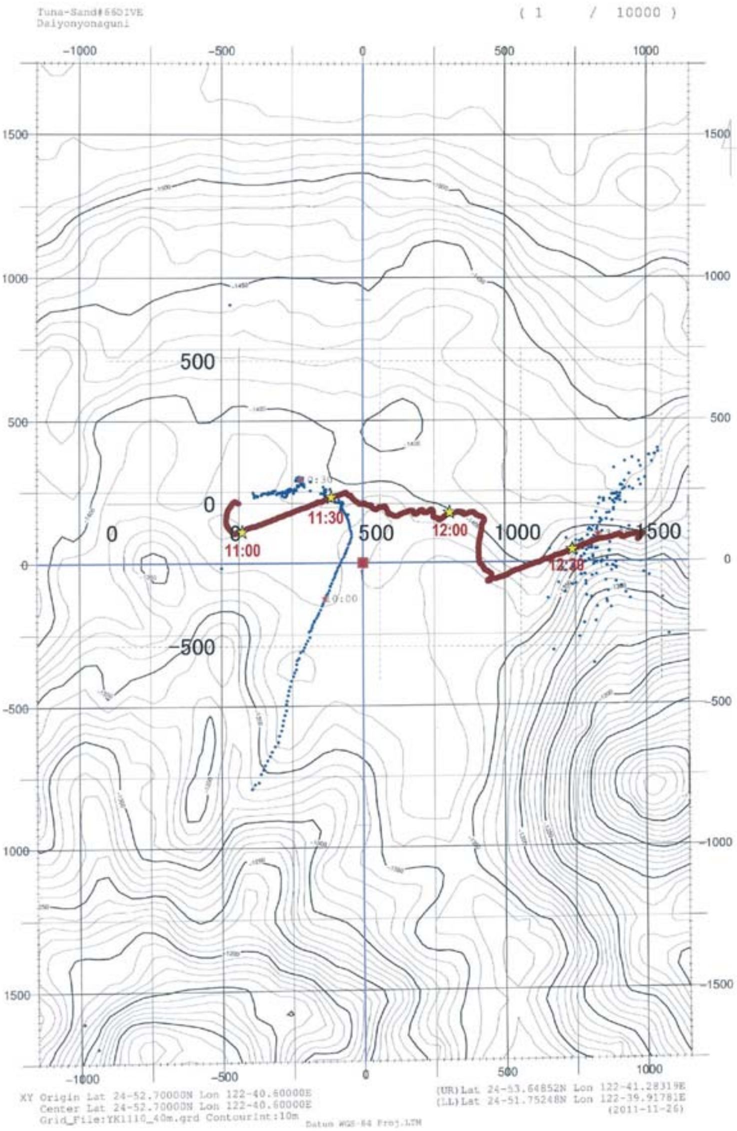


Fig. 5.6.1 Trajectory of TS during dive #66

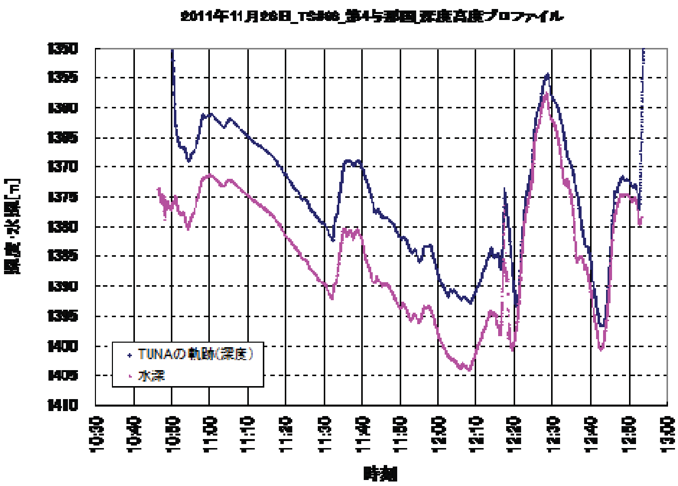


Fig. 5.6.2 Depth profile of the TS dive #66 trajectory

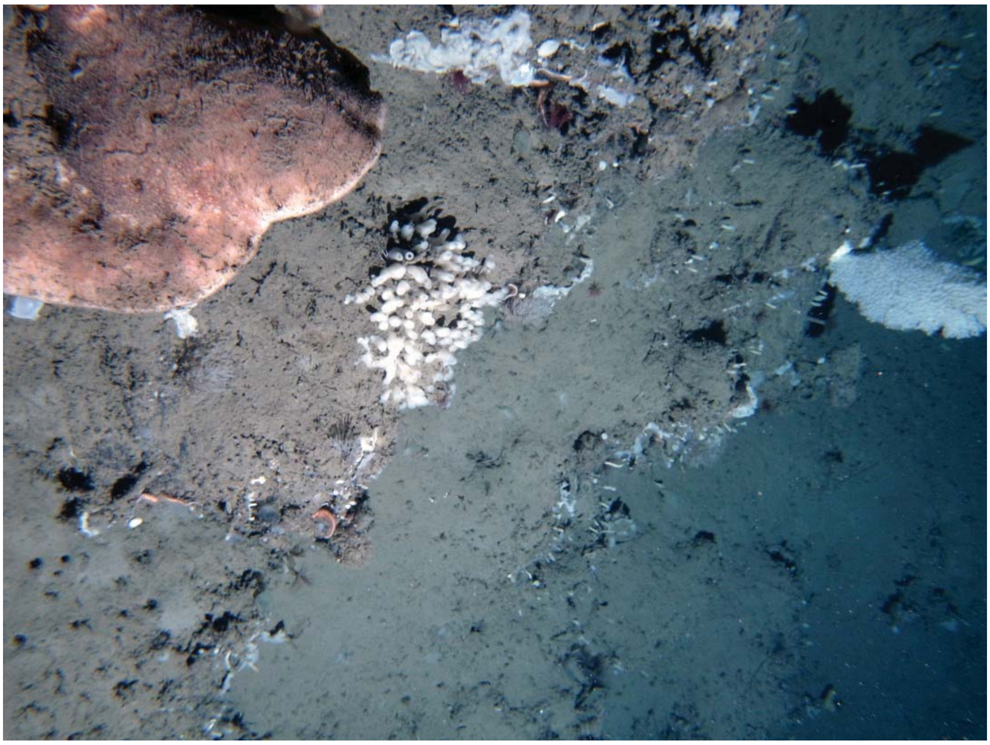


Fig. 5.6.3 A photo image of the seabed taken during TS dive #6

5.7 Urashima Dive #138

5.7.1 Dive Overview

The major purposes of Urashima dive in this cruise are

1) Clarifying the correlation between acoustic image of hydrothermal plume
2) Clarifying water physiology and chemistry using ADCP, Seabat, side scan sonar, water sampling techniques with AUV, and chemical and microbiological analysis.
3) Estimate the chemical and microbiological flux by combination with high accuracy acoustic hydrothermal imaging and chemical and microbial analysis.
4) Image high resolution seafloor and subseafloor structures using Seabat, side scan sonar, sub bottom profiler, and magnetometer.

In order to achieve the dive in No.4 Yonaguni Knoll Site which meets the abovementioned purposes, Urashima was deployed equipped with sensing devices explained in 4.3. Shortly after the start of the dive however, Urashima surfaced unexpectedly due to the failure in the circuit for the ballast control.

Figure 5.7.1 shows the trajectory of Urashima during the dive #138.

Summary of the Urashima dive #138 is as follows.

Date : 25th Nov., 2011

Location : No.4 Yonaguni Site, 24°49.75'N - 24°52.25'N, 122°39.42'E - 122°43.58'E

Purpose : Focused survey of potential hydrothermal activity

Duration: 3 hrs. 7 min.

Dive Event Log

05:59 Turn-on Urashima
07:35 Stand by Urashima
07:58 Released on the Surface
07:59 Dive Starts
09:50 Dive Mission Starts
10:35 Start Surfacing
11:06 Surfaced
11:54 Retrieval Completed

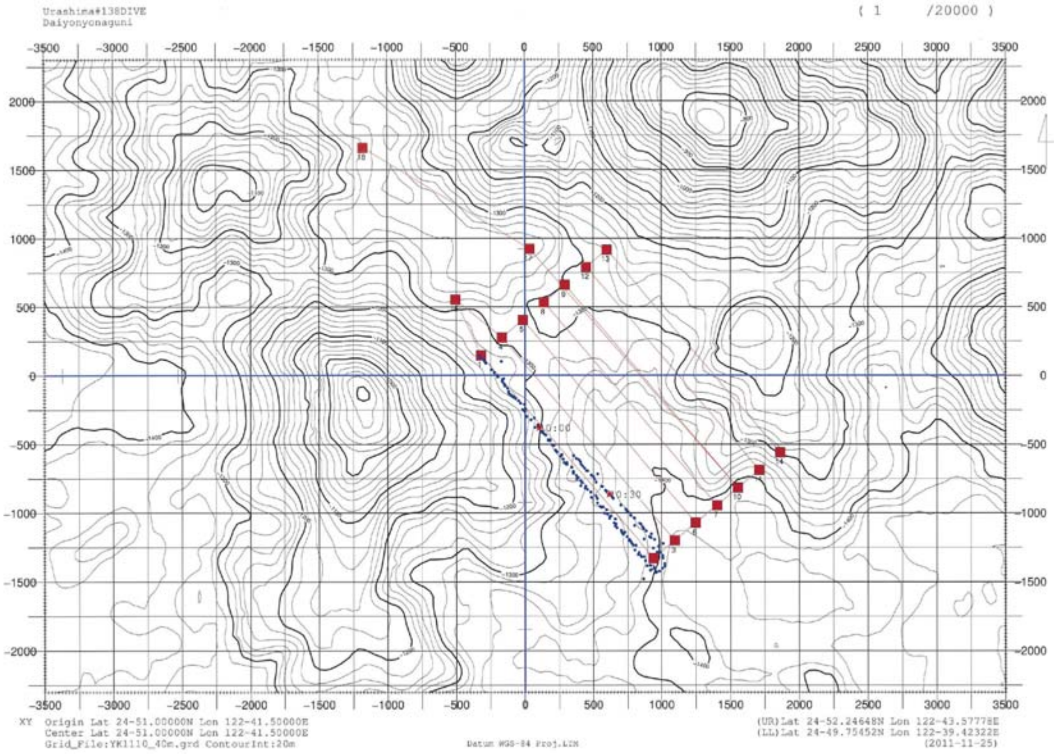


Fig. 5.7.1 Trajectory of Urashima during dive #138

6. Investigation Results

6.1 GeoSwath (Acoustic Imaging Device)

6.1.1 Introduction

The "GeoSwath", one of the bathymetric side scan so called interferometric sonar, produced commercially by Kongsberg GeoAcoustics Ltd. simultaneously acquire bathymetry and side scan data. Each transducer array of GeoSwath is comprised of linearly arranged one transmit and four receive elements and measure some phase differences of echo signals scattered from the seafloor translated to angle of arrivals and finally bathy data. The system mounted "AE2000a" uses 125kHz frequency signals, has just enough size for small size AUV and can get high resolution bathymetry with wide swath. But we need careful handling of AUV motions especially roll to keep off the loss of precision.

6.1.2 Specification and Arrangement

GeoSwath has three types of products in operational frequency, 125 kHz, 250 kHz and 500 kHz. Table 6.1.1 shows the specification of 125 kHz products which we used in this operation. And Fig. 6.1.1 shows the picture of GeoSwath transducers mounted under the AE2000. The clamping angle of transducer is 30 degrees for each side. There is fairing panels backward and forward of transducers to reduce fluid resistance. Table 6.1.2 shows the acquisition parameters of GeoSwath.

Table 6.1.1 Technical specifications of GeoSwath

Sonar Frequency	125 kHz
Maximum Water Depth below transducers	200 m
Maximum Swath Width	780 m
Range	Up to 12 x depth
Resolution Across Track	1.5 cm
Two Way Beam Width	0.9º Azimuth
Depth Resolution	6 mm
Swath Update Rate (max)	Up to 30 per second (range dependent)
Transducer dimensions	540 x 260 x 80 mm
Transducer Weight	11.6 kg (in air) 3.3 kg (in water)

Table 6.1.2 Acquisition parameters

Side Scan Gain	2
Pulse Length	3
Power	7
Ping Length (Range)	390 m

Fig. 6.1.1 GeoSwath transducers mounted on AE2000a platform

6.1.3 Operations and Results

Figure 6.1.2 shows a snapshot of 2D depth profile and side scan waterfall image from GS+ software GUI. Through this software analysis acquired raw data, platform position and motion, depth, sound velocity and tide data can be integrated and output side scan mosaic and bathy grid file.

Figures 6.1.3 and 6.1.4 show the results of three dives operation. It became apparent that 125 kHz GeoSwath can get high resolution data stably when platform keeps altitude from the seafloor about 100m below. Considering safety of AUV, it is easy demands so that we could carry out ideally good operation.

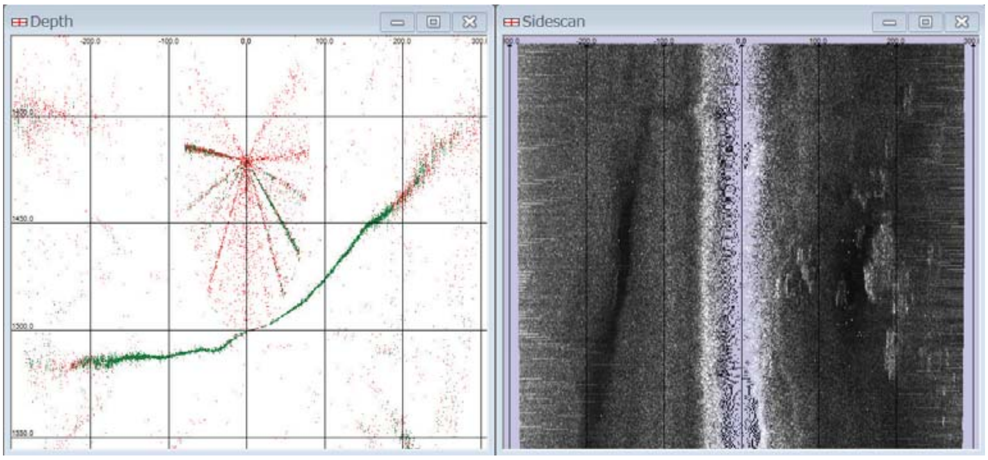
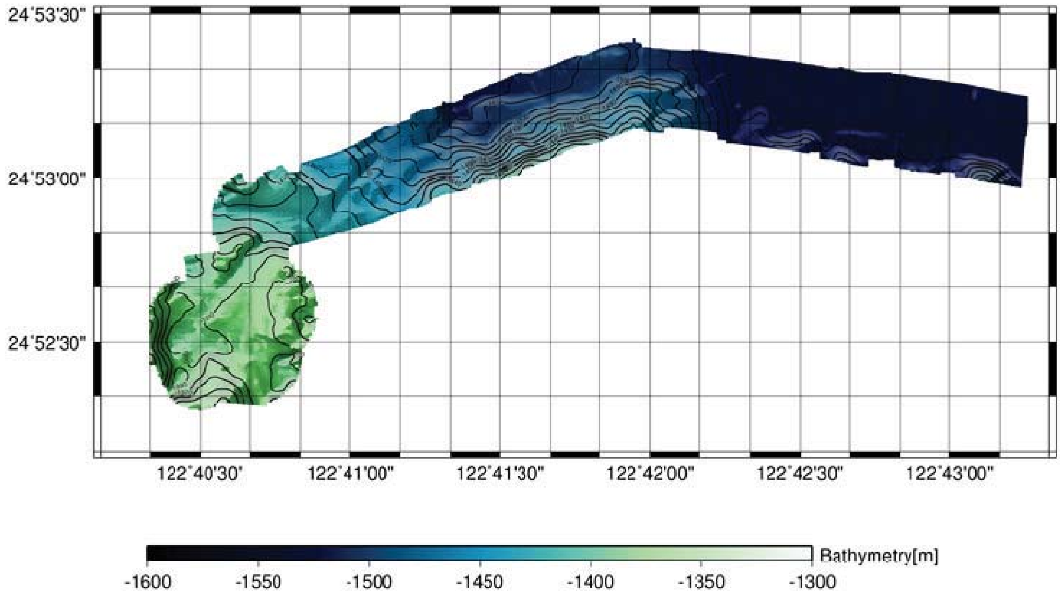
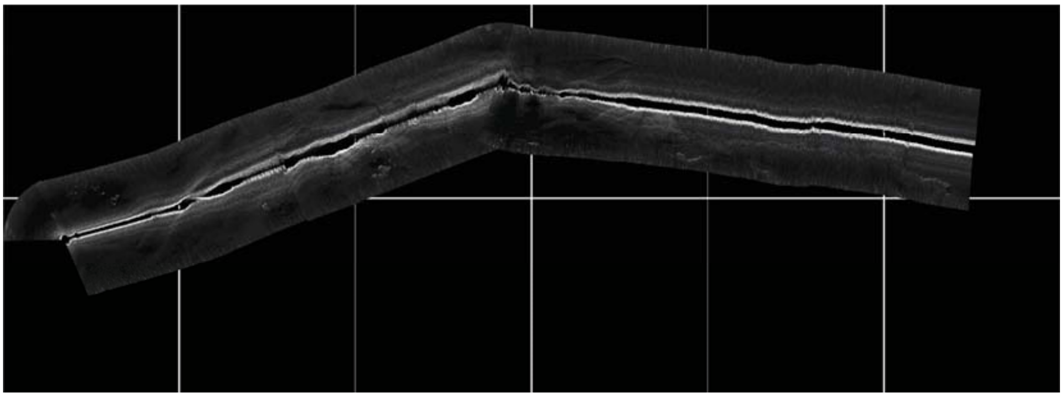
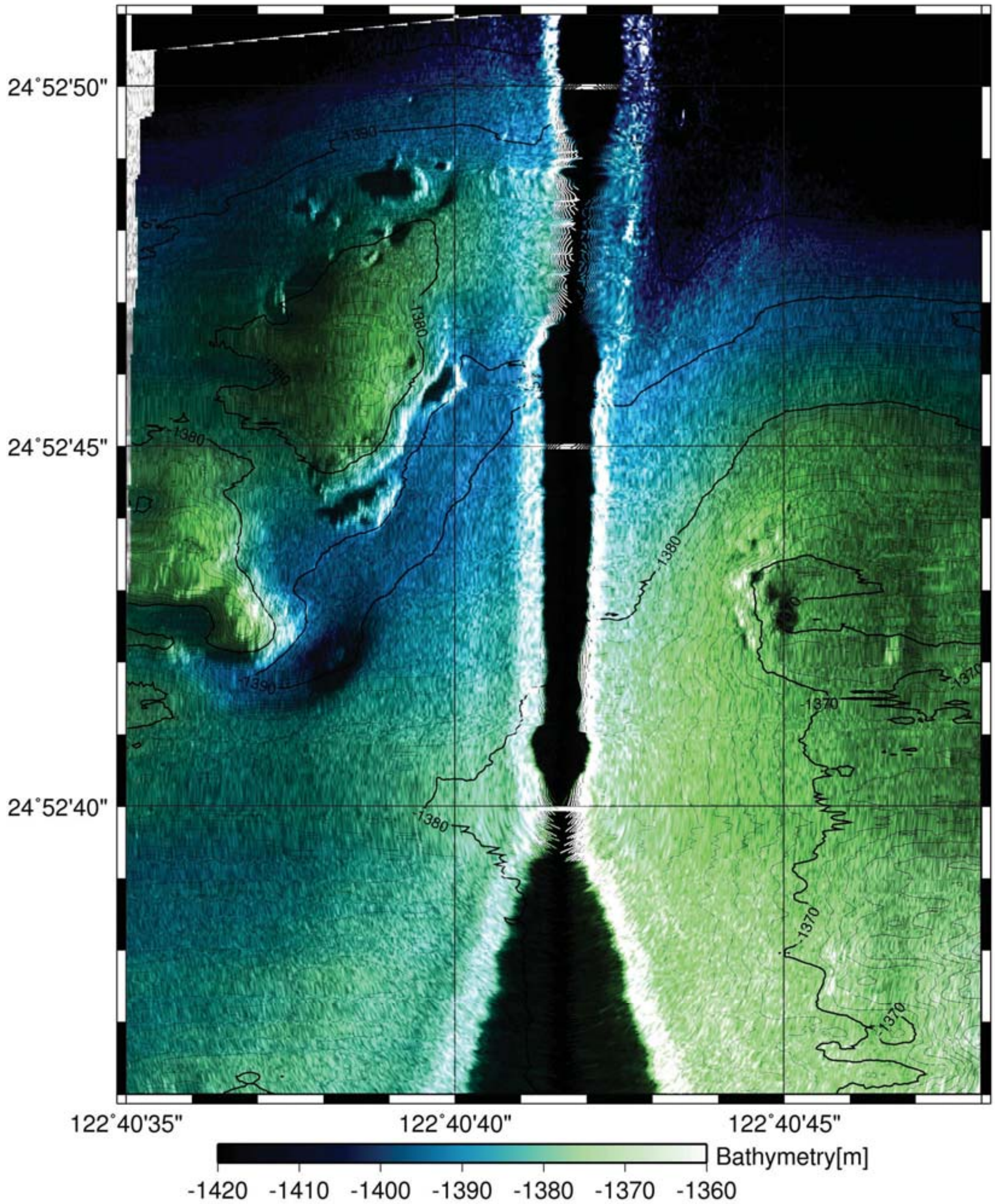


Fig. 6.1.2 Snapshot of GS+ software GUI screen (2D depth profile/left & Side Scan Waterfall/right)



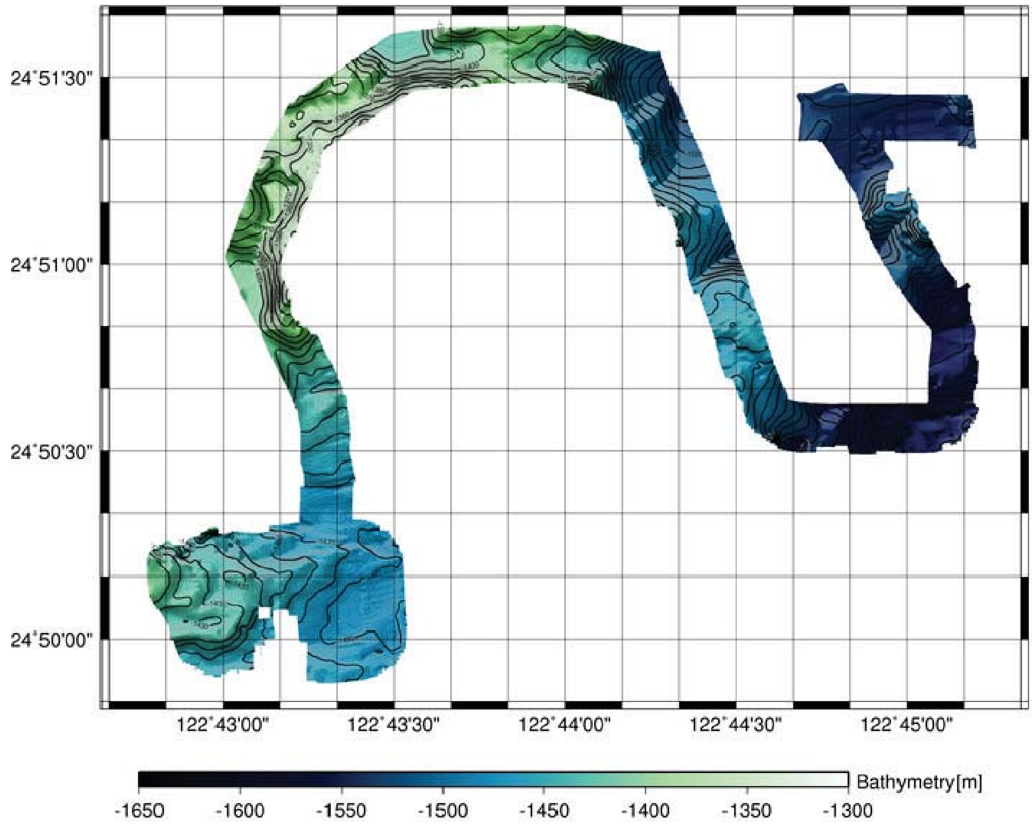
(a) Seafloor map - thick lines show 10 m contour and thin lines show 1m contour


(b) Side scan sonar mosaic map



(c) Close-up image of Nishihosawa area

Fig. 6.1.3 Overall view of (a) bathymetric seafloor map, (b) side scan image, and (c) close-up image taken by GeoSwath during AE2000a dive #01



(a) Seafloor map - thick lines show 10 m contour and thin lines show 1m contour

(b) Side scan sonar mosaic map

Fig. 6.1.4 Overall view of (a) bathymetric seafloor map (b) side scan image taken by GeoSwath during AE2000a dive #02

6.2 CTD-Transmissiometer-C-DOM Fluorescent Sensor

To detect the signals of hydrothermal plume anomaly, CTD-DO-pH-transmit-CDOM sensor system is equipped in AUV Urashima. The sensor system is deployed at the front payload space of Urashima just behind the water inlet tube. The sensor systems is constructed from CTD-DO-pH system with rechargeable battery (Ocean Seven 316 plus, IDRONAUT), transmissiometer (C-star, WetLabs), and fluorescentmeter for colored DOM (Eco-FLD,WetLabs). Detailed specs of the sensors are described as the following.

高分解能·小型 CTD 測定器

仕様

測定項目仕様

測定項目	測定範囲	精度	分解能	反応速度	形式
深度	0~1000dbar[1]	0.05%FS 0.01% (オプション)	0.002%	50 ミリ秒	ストレンゲージ
温度	-3~+50°C	0.003°C	0.0002°C	50 ミリ秒	白金測温抵抗体
電導度	0~64mS/cm[2]	0.003mS/cm[2]	0.00025mS/cm[2]	50 ミリ秒	7 極白金セル
溶存酸素[3]	0~50ppm 0~500% sat.	0.1ppm 1% sat.	0.01ppm 0.1% sat.	3 秒(空中) 3 秒	ポーラロ
pH[3]	0~14pH	0.01pH	0.001pH	3 秒	耐圧ガラス
酸化還元[3]	-1000~+1000mV	1mV	0.1mV	3 秒	白金センサー
外部入力	0~5000mV	1mV	0.1mV	50 ミリ秒	

1) [illegible]、40、100、200、500、2000、4000、6000、10000dbar 仕様があります。
2) 標準仕様 [illegible]になります。
3) オプションセンサ となります。

上記測定項目以外にオプションセンサーとして濁度・透過度・蛍光光度・光量子・流向流速などのセンサーを追加可能です。

記録系
- メモリータイプ :CMOS メモリー
- メモリー容量 :512 メガバイト(4,000,000 データ数 7 項目測定時)

電気系
- A/D コンバータ :18 ビット(CTD)分解能
- スキャン速度 :20 または 12 スキャン/秒

インターフェイス
- RS-232C :最大通信速度 38400bps
  :最大ケーブル長 200m(標準仕様)
- FSK :最大通信速度 38400bps(1000m)
  :最大ケーブル長 10000m(9600bps)

バッテリー部
- 内部バッテリー :DC15V-1.8A/h (単三形アルカリ乾電池×10 本 標準仕様)
- 外付バッテリー :DC15V-8A/h 1500m/7000m 耐圧 (単二形アルカリ乾電池×10 本)

ハウジング

耐圧	:1500dbar	4000dbar	7000dbar
寸法	:φ75mm×685mm	φ89mm×685mm	φ89mm×710mm
重量(空中)	:4.0kg	9kg	8.0kg
(水中)	:1.7kg	6kg	4.3kg
材質	:AISI316L	AISI316L	TITANIUM

Fig. 6.2.1 Specifications of the CTD-DO-pH Sensor

WET Labs
www.wetlabs.com

ECO Fluorometer

FL

[redacted]

世界のベストセラー

クロロフィル-a 蛍光光度計

クロロフィル-a の蛍光性は、植物プランクトンの現存量や、水中のクロロフィル濃度の貴重な指標として役立ちます。この測定値は、生物学的な変化の追跡や水塊に含まれる現存量の観測で使われてきました。

有色溶存有機物質

CDOM *ECO*は、マングローブの湿地から貧栄養の海水まで、広範囲に渡る環境でCDOM 蛍光を得ることを可能にします。

ウラニン（フルオレセイン）とローダミン

ECO シリーズの特性は今、フローと染料の追跡研究で利用可能です。注文時に測定感度を指定してください。検出レンジは！万分の一から百万分の一まででです。

フィコエリトリン

植物プランクトン群落の僅かなシアノバクテリアの検出は、赤のシアノバクテリア蛍光の検出を可能にしたフィコエリトリン計の導入により、現在ではより簡単で高価ではなくなりました。

特　徴

[redacted]

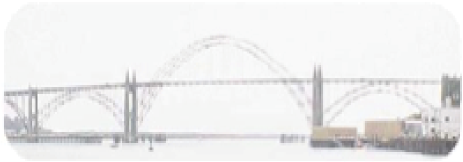
モデル

ECO-FL(RT) … 0~5Vのアナログ信号とRS−232Cシリアル出力の両方で、16．300カウント（概算）のレンジに対応します。このユニットは、電力を供給されると連続オペレーションを行います。

ECO-FLD … 基本的性能は FL(RT)と同じで、6000mの深度まで対応します。

Fig. 6.2.2　Specifications of the fluorescent meter

Transmissometer

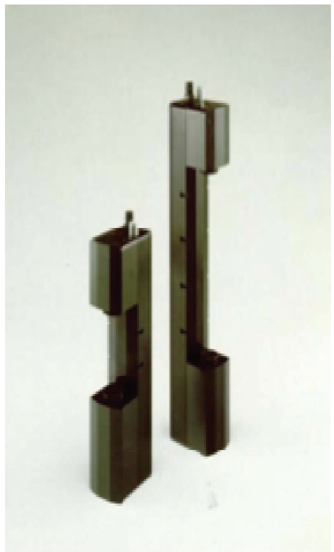


WET Labs
www.wetlabs.com

C-star（一波長水中光束消散方式濁度計）

C-Starは、一波長水中光束消散係数測定のために、低コスト、コンパクト性を提供する高度に統合された光電子デザインで、新しい種類のがっしりとした筐体を取り入れています。

この機器は、フロー・チューブを装着できます。フロー・チューブの採用により、長期係留や航走表面海水の連続測定で使うことができます。C-Starのアナログ出力は、小さなバッテリーで動く多種多様なCTDやロガーへ簡単に接続できます。デジタル・モデルもご利用いただけます。光路長25cmのC-Starは、アルミニュウムまたは共重合体プラスチックの筐体で供給できます。光路長10cmのC-Starは、プラスチックのみです。



C-starの仕様

技術的仕様

光路長25 cm		:47 x 6.4 x 9.3 cm
光路長10 cm		:29.2 x 6.4 x 9.3 cm
空気中の重さ	(25cm)	:2.2 kg（プラスチック）
	(25cm)	:3.6 kg（アルミニュウム）
	(10cm)	:1.5kg（プラスチックのみ）
水中の重さ	(25cm)	:0.5 kg（プラスチック）
	(25cm)	:2.7 kg（アルミニュウム）
	(10cm)	:0.5kg（プラスチックのみ）

電気的仕様

入力電力	:DC7～15 V
電流	:< 40 mA（アナログ）
	:< 80 mA（デジタル）
データ出力	:0～5 volts（アナログ）
	:0～4095 counts（デジタル）
時定数	:0.167 sec
温度誤差	:0.02 パーセントF.S./℃

環境仕様

温度レンジ	:0～30 ℃
耐深度	:600 m（プラスチック）
	:6000 m（アルミニュウム）

光学的仕様

光路長	:25, または10 cm
波長	:370, 470, 530, 650 nm から 波長選択
帯域幅	
(470, 530, 660nm)	:～20 nm
(370nm)	:～10～12 nm

この仕様は、予告無しに変更になることがあります。
(Rev.K)

Fig. 6.2.3 Specifications of the Transmissiometer

6.3 Rossetta-multi sampler system

Intelligent Rosette Sampling System with twenty-four submersible arrays (Model 1018, General Oceanics Inc.) was modified to install in the payload space of AUV Urashima. Water samples can be collected in Niskin bottle (0.5L) under autonomous operation controlled by clock or depth sensor of the system.

Water-inlet was installed using 125 mm diameter pipe at the front, and the discharge hole was made at bottom of the AUV. Water flow into the payload space was monitored by a digital flowmeter (Model 2030R, General Oceanics Inc.). Counts of the screw rotation of flowmeter can convert to distance (meters) and volume (cubic centimeters) using the following equations.

Distance = (difference in counts x rotor constant) / 999999

Volume = distance × (inlet diameter)2 / 4 × 3.14

* Rotor constant of the standard flowmeter (model 2030) is 26873.

These parameters were used to examine the water flow condition in the payload space, and to estimate a quality of water samples, for example contamination with circulation water in the payload due to low water flow rate, etc. The results shown in Table 6.3.1 proved that enough water flow to change the water mass of payload has been kept in the Urashima dives.

Table 6.3.1 Results of flowmeter measurements in YK11-10 cruise

	Dive #138	Dive #139
Distance (m)	1113	1296
Volume (L)	54606	63585

6.4 Quantification of Microbial Cell Density

Microbial cell densities in the seawater samples are quantified on board using flow cytometer (Cell Lab Quanta MPL, Beckman-Coulter). 10 mL of the seawater samples, collected by the CTD-RMS and the Anemone water sampler, were subsampled in sterilized plastic tubes and stored in refrigerator at 4°C until analysis. Flow cytometric analysis were started within 4 hours after sample retrieval on board. 200µl of the subsamples were applied to 96 wells plate and then 10 µl of x40 SYBR Green I (Invitrogen) were added to each well. After ca. 25 min. staining, 50µl of the samples were applied into flow cytometer. Each sample was measured by 2 times.

6.5 Geochemical sensors

Investigation results by geochemical sensors installed on AE2000a, Tuna-Sand, and Urashima are summarized as follows.

(1) AE2000a

The chemical sensors were operated for all 5 dives conducted during this cruise. Chemical observation was conducted successfully and data was collected from all dives. During dive #01 to explore the No.4 Yonaguni Knoll, data logger had a trouble, and resulted in the sampling period of 1.6 second. During the dives #01 - #03 at No.4 Yonaguni Knoll, Izena Caldron, and Iheya-Izena site, pH and turbidity anomalies from hydrothermal plume were observed.

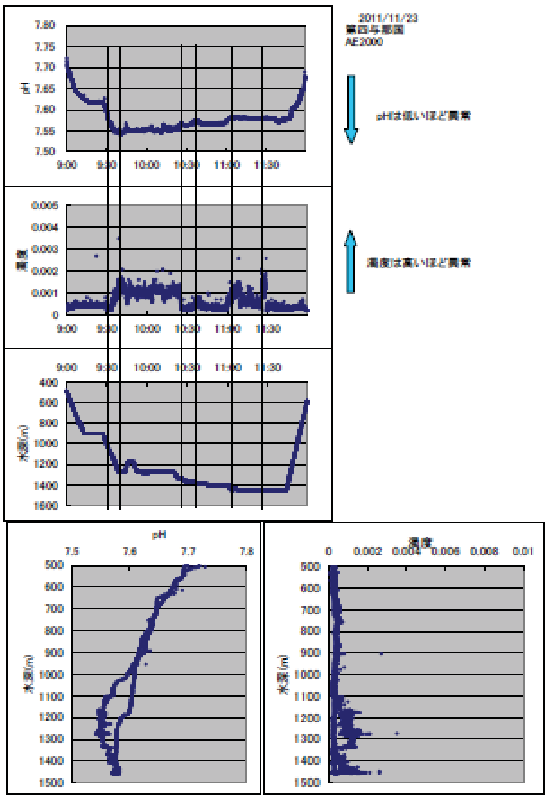
(2) Tuna-Sand

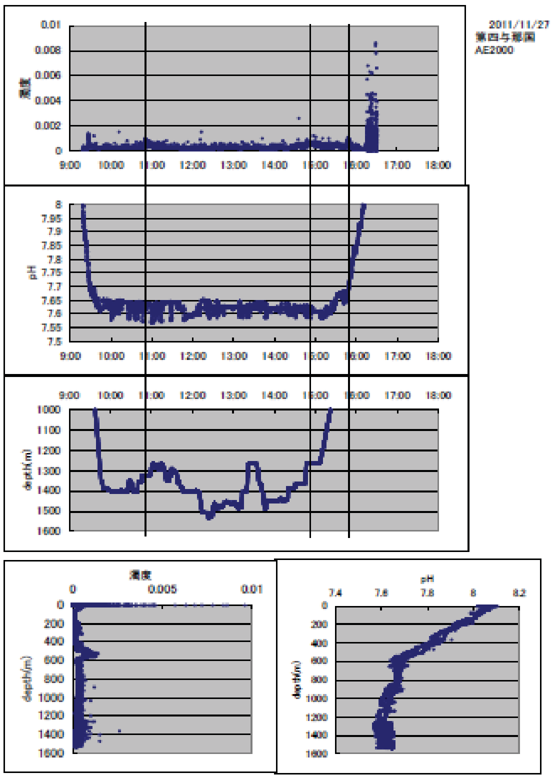
Chemical observation was conducted successfully at No.4 Yonaguni Knoll and data was collected from the dive. Small turbidity anomaly was observed during the operation. pH anomaly was not observed.

(3) Urashima

Chemical observation was conducted successfully at No.4 Yonaguni Knoll and data was collected from the dive. Turbidity and pH anomalies were observed during the operation.

The geochemical sensors were operated for all 3 dives conducted during this cruise. Figures 6.5.1 ~ 6.5.3 show pH, turbidity, and depth profiles measured by the geochemical sensor during the dives.





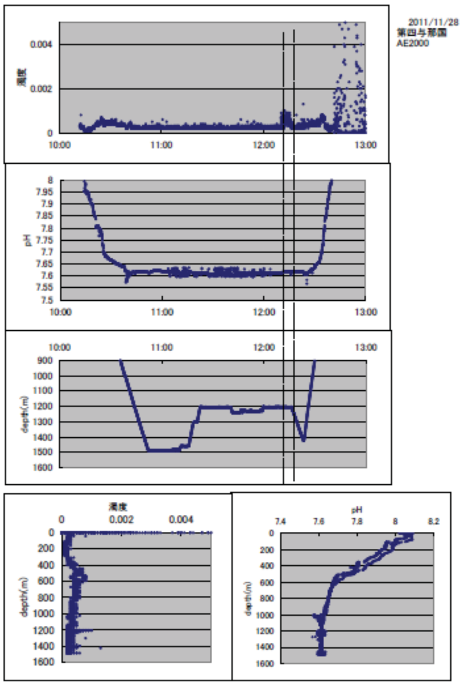


Fig. 6.5.1 Profiles of pH, turbidity, and depth measured during No.4 Yonaguni Site survey dives (AE2000a).

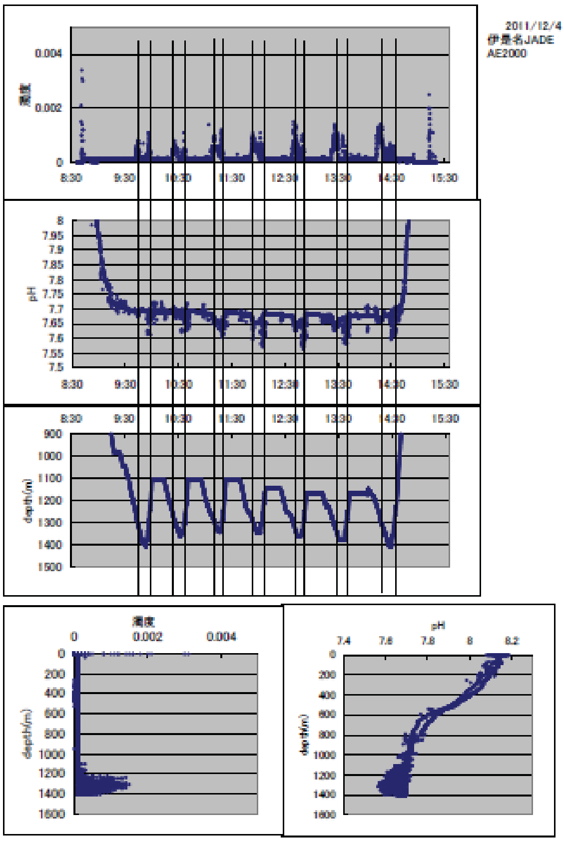


Fig. 6.5.2 Profiles of pH, turbidity, and depth measured during Izena (Jade) Site survey dive (AE2000a).

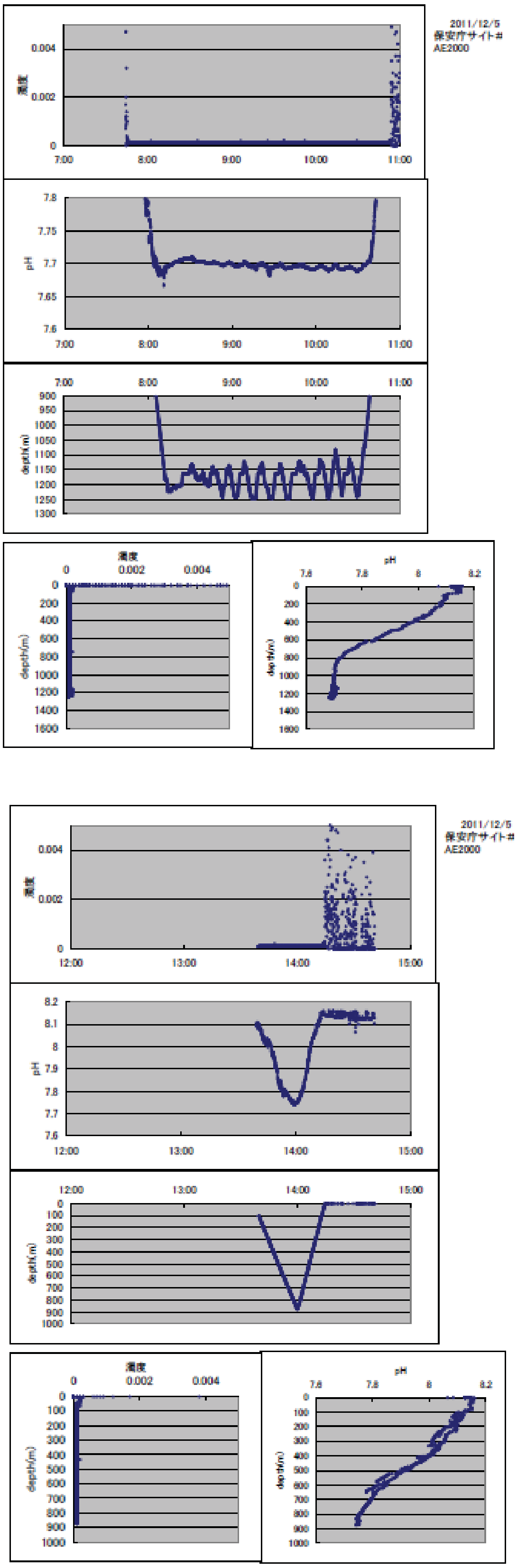


Fig. 6.5.3 Profiles of pH, turbidity, and depth measured during Iheya-Izena Site survey dive (AE2000a).

6.6 Magnetometer

Hydrothermal vent activities are possible cause of demagnetization in the small scale, so anomalous magnetic signals have been observed around past and present hydrothermal vent site. Near-bottom magnetic survey by using an AUV is an effective method to reveal the detail magnetic anomaly signatures of ocean floor such as those around hydrothermal vent sites. In order to detect signals of hydrothermal altered rock in the No. 4 Yonaguni Knoll, the measurement of total intensity and three components of the geomagnetic field are conducted by using AUV Urashima with four three-axis fluxgate type and an Overhauser type magnetometer. In the result, almost survey plan was called off except 2 miles due to machine trouble. We only achieved the first stable measurement of total magnetic force by using Urashima with Overhauser type magnetometer.

Table 6.6.1 list the specifications of the magnetometers installed on Urashima. In Fig. 6.6.1 and Table 6.6.2, installation arrangements of the magnetometers are described. In the figure and table, FG represents flux gate magnetometer, while OH means Overhauser type magnetometer. Figure 6.6.2 shows the overall configuration of the magnetometer system.

Table 6.6.1 Specifications of magnetometers installed in Urashima

	Fluxgate	Overhauser
Model	Bartington MAG-03H	Marine Magnetics Explorer
Dynamic range	±70000 nT	20000 nT ～ 70000 nT
Resolution	0.01 nT	0.001 nT
Sampling interval	0.1 sec (10Hz)	0.25, 0.5, 1, 3, 5, 10 sec
Accuracy	0.4 nTp-p@10Hz	

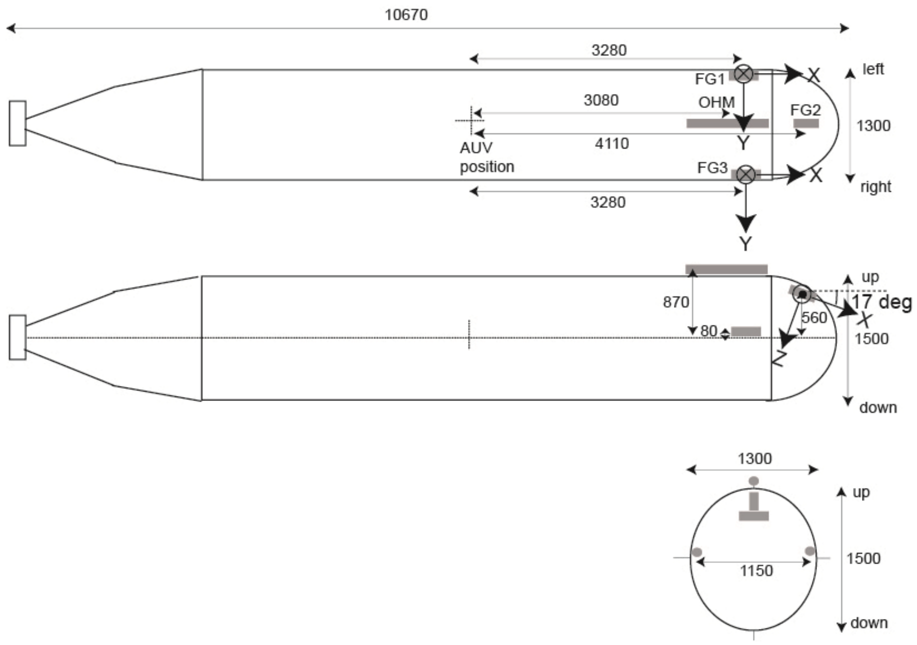


Fig. 6.6.1 Installation arrangements of magnetometers in Urashima

Table 6.6.2 Installation positions of magnetometers in Urashima

Sensor			X (cm)	Y (cm)	Z (cm)
FG1	Front	Left	328	-57.5	-8
FG2	Front	Center	411	0	-56
FG3	Front	Right	328	57.5	-8
OHM	Front	Center	308	0	-87
X direction is forward and Z direction is downward.					

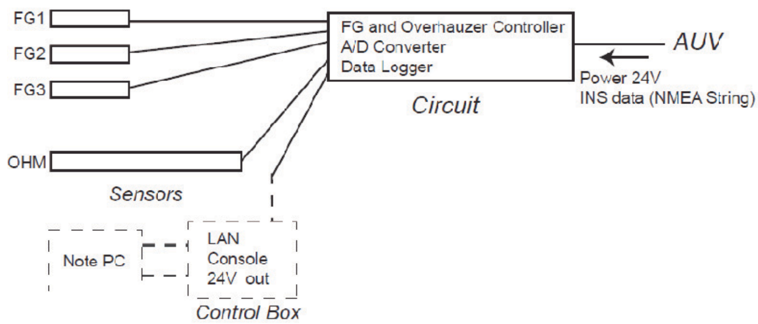


Fig. 6.6.2 Overall configuration of the magnetometer system installed in Urashima

Figure 6.6.3 to 6.6.14 show time sequence of magnetic anomalies obtained from the data taken by Urashima dive #138. Figures 6.6.15 to 6.6.20 are the raw magnetometer data taken by Urashima dive #138.

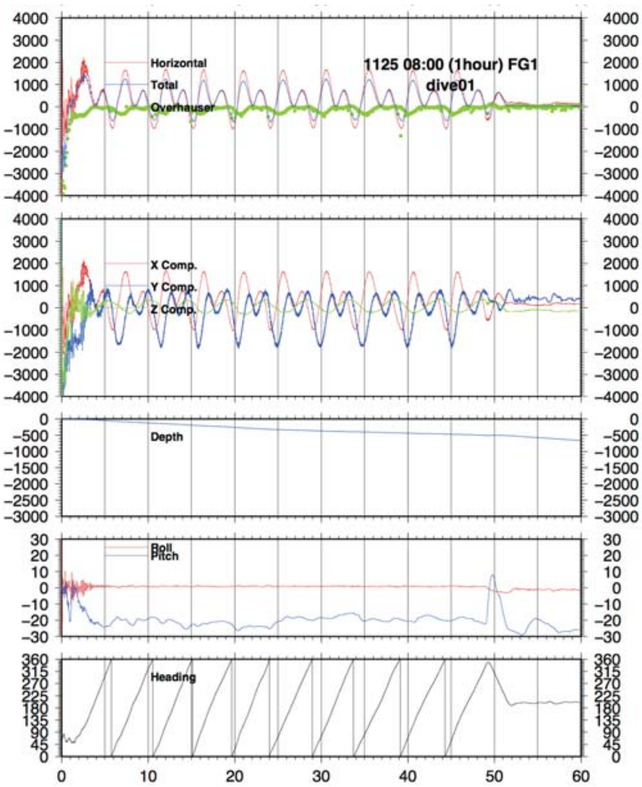


Fig. 6.6.3 Magnetic anomaly estimated from FG1 and OHM data of dive #138 from 08:00 to 09:00

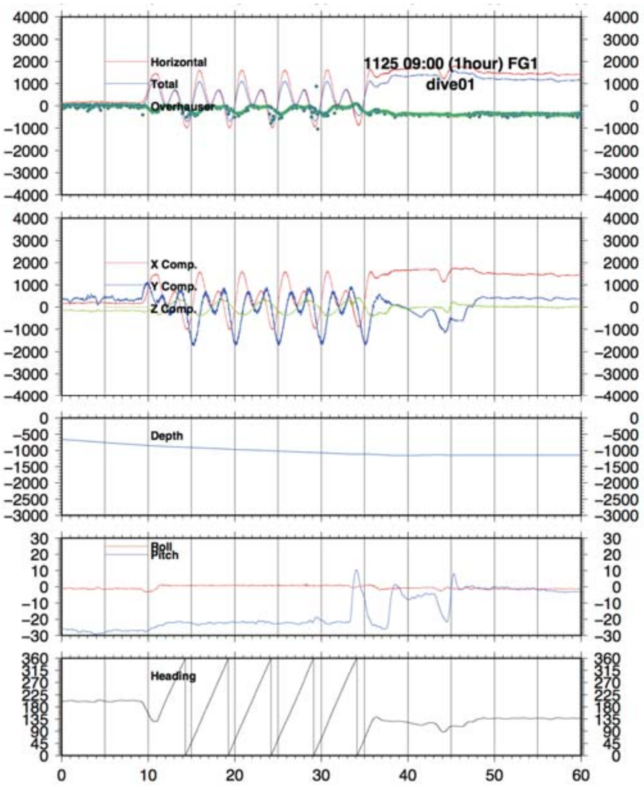


Fig. 6.6.4 Magnetic anomaly estimated from FG1 and OHM data of dive #138 from 09:00 to 10:00

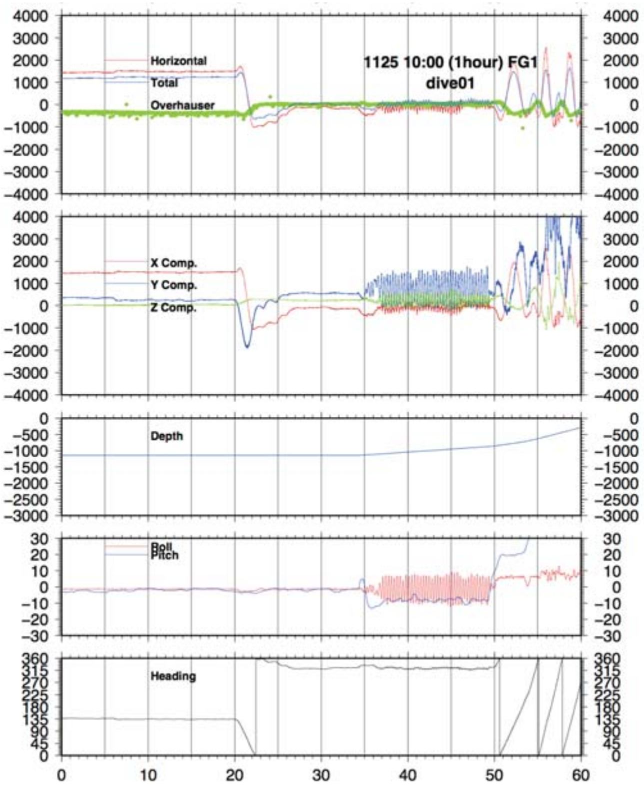


Fig. 6.6.5 Magnetic anomaly estimated from FG1 and OHM data of dive #138 from 10:00 to 11:00

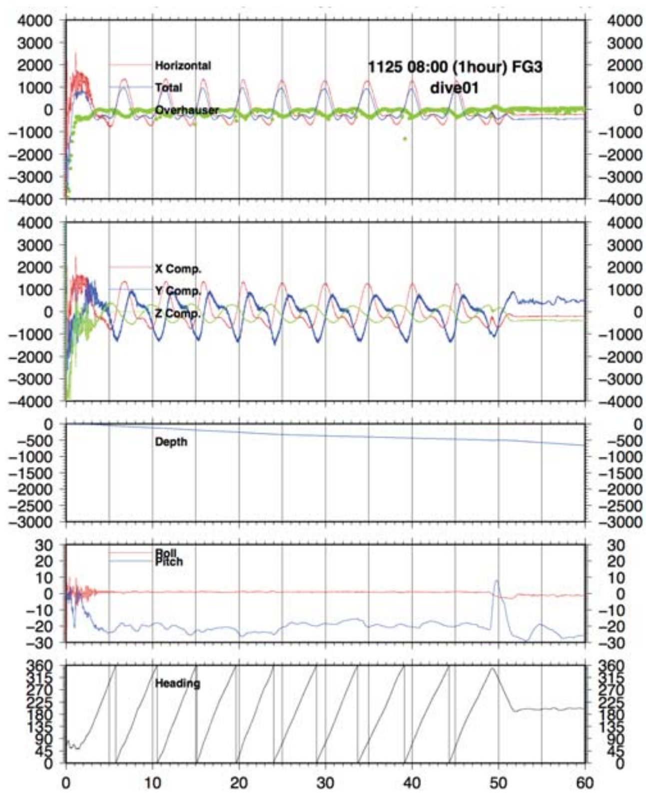


Fig. 6.6.6 Magnetic anomaly estimated from FG3 and OHM data of dive #138 from 08:00 to 09:00

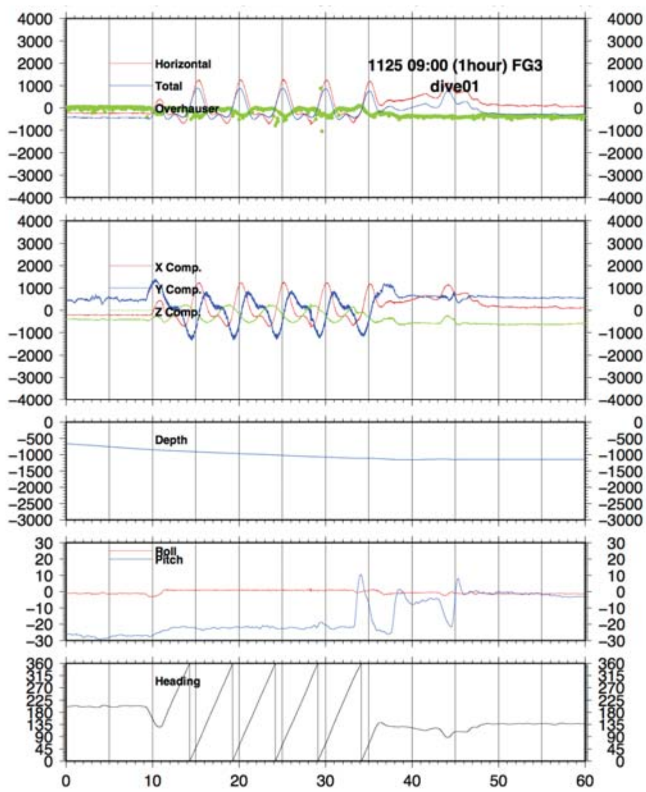


Fig. 6.6.7 Magnetic anomaly estimated from FG3 and OHM data of dive #138 from 09:00 to 10:00

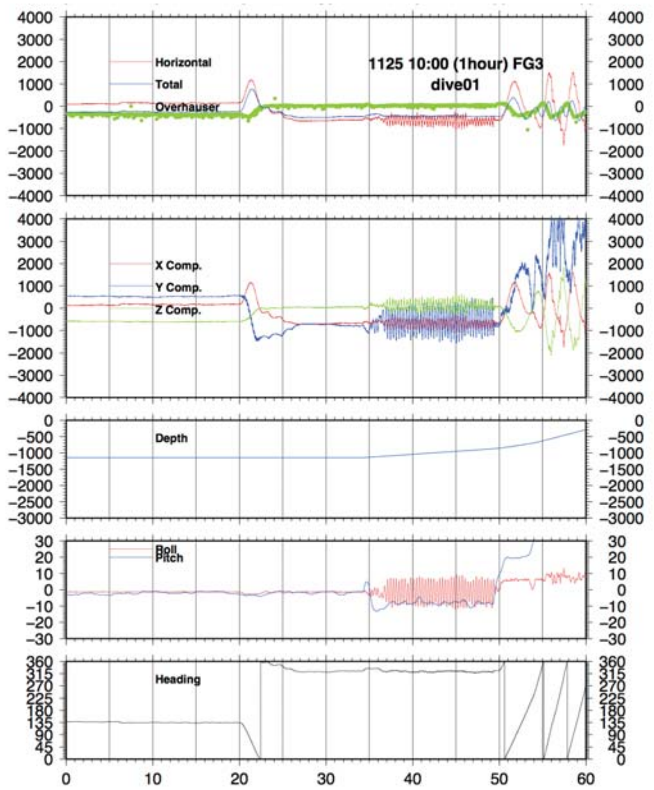


Fig. 6.6.8 Magnetic anomaly estimated from FG3 and OHM data of dive #138 from 10:00 to 11:00

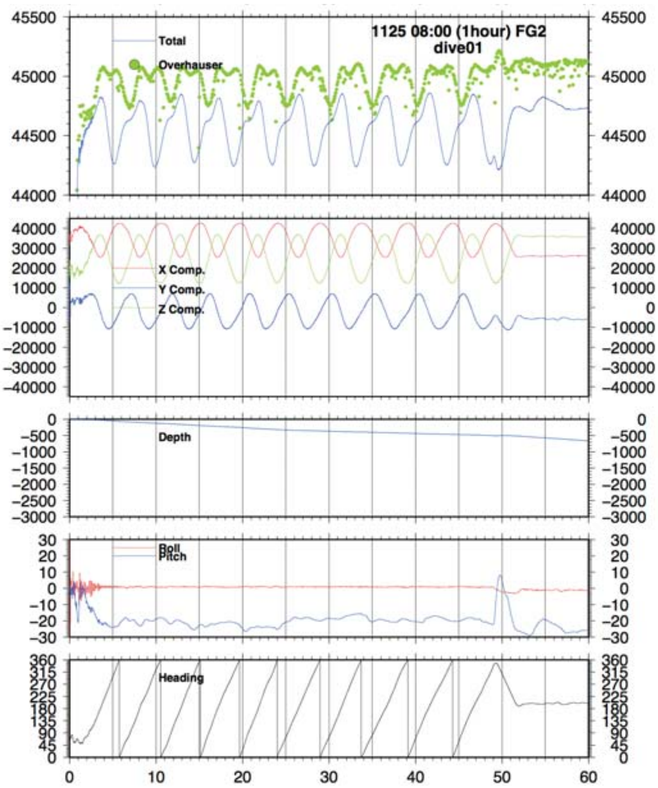


Fig. 6.6.9 Raw FG2 and OHM data of dive #138 from 08:00 to 09:00

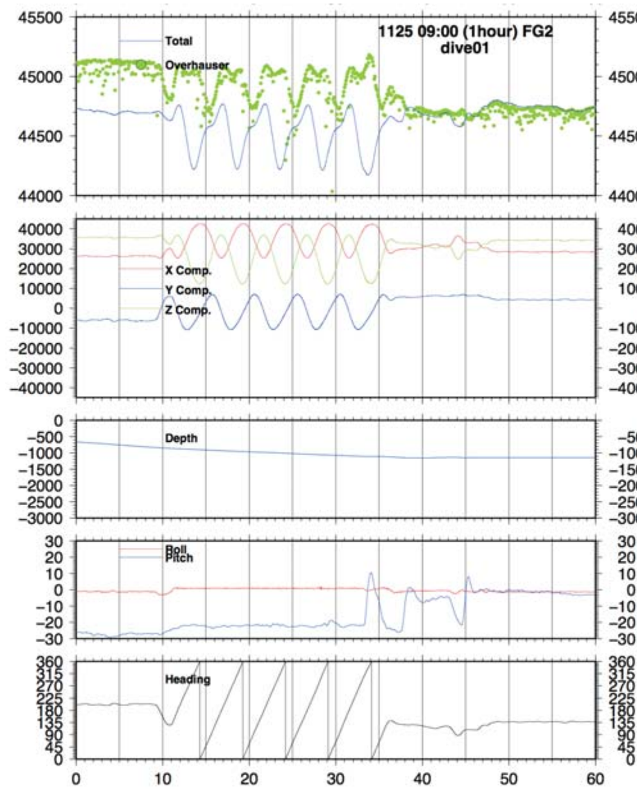


Fig. 6.6.10 Raw FG2 and OHM data of dive #138 from 09:00 to 10:00

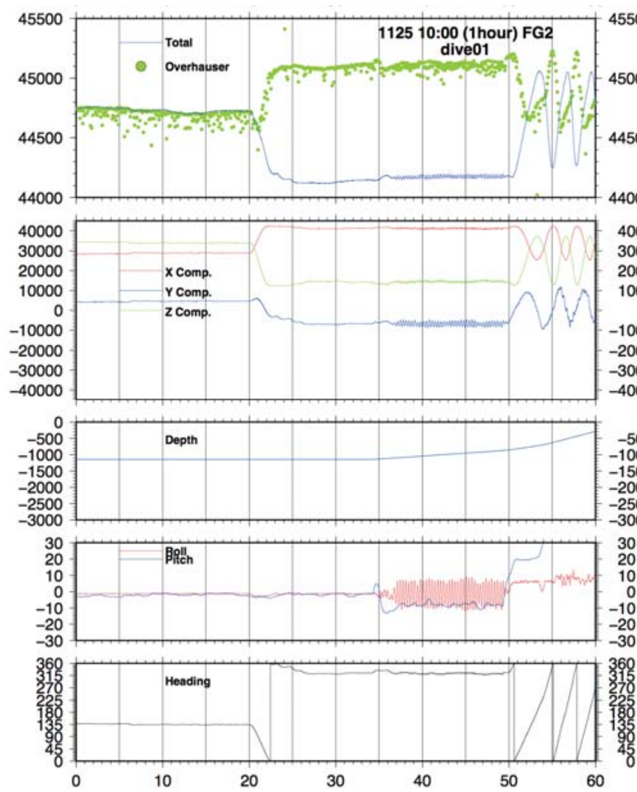


Fig. 6.6.11 Raw FG2 and OHM data of dive #138 from 10:00 to 11:00

7. Future Works

Water Geochemistry and Microbiology

砂村倫成(東京大学)

Unfortunately, I could not obtain chemical anomaly of sensor signals, ADCP anomaly of Plume signals, and hydrothermal plume sample in this cruise because of the bad weather and trouble of AUV Urashima. However, we collected several reference deep sea samples around the hydrothermal plume. I subsampled 100 mL of water sample, fixed with formaldehyde (final conc. 3.4%) in refrigerator for 12 hours, and microbial cells in the sample were filtered on 0.2µm pore sized polycarbonate membrane filter. These samples will be stained by CARD-FISH and determined the density of sulfur oxidizing plume microbe SUP05 and methylotrophs. Together with the cell density results and samples of previous cruise (KT09-16, CTD-CMS survey with R/V Tansei-maru), I will try to analyze the outline of plume specific microbial distribution.

岡村慶・野口拓郎(高知大学)

- pH: pH was measured using pH electrode (Radiometer, PHC2401) by monitoring electric motivation force (E.M.F.) of the electrode. pH electrode was calibrated by seawater buffers (TRIS and AMP). Water temperature was also measured during calibration. Total pH scale was calculated from the E.M.F. value.
- Alkalinity: Alkalinity was measured using automated open-cell titrator (KIMOTO: TLED-09) by colorimetric titration with Bromo Cresol Green (BCG). 50 ml of seawater sample was taken by hole pipette. Alkalinity was calculated by non-linear least square method from absorbance ratio during titration. Certified Reference Material (CRM # 104) was used to calibrate the TLED-09.
- TCO2: Concentration of total inorganic carbon (TCO2) was measured by using NDIR detector.

Geophysics

藤井昌和(東京大学)

I will analyze surface geophysical survey data and very a few near bottom magnetic data obtained by AUV Urashima. Because the submarine survey is conducted incompletely, I estimate surface bathymetry and magnetic structure as the foundation for the future.

I will be back to No.4 Yonaguni Knolls to survey the structure of magnetization.

8. Notice on Using

This cruise report is a preliminary documentation as of the end of the cruise.
This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.
Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.

Acknowledgment

The author would like to express thanks to all officers and crew members of S/V "Yokosuka", Captain Shinya Ryono, heading the list. Thanks to their every effort, all dives were successfully achieved without any serious accident.

Appendix

A-1 Cruise Photos

支援母船「よこすか」

ベイブリッジと横浜港

那覇港からの乗船研究者達と

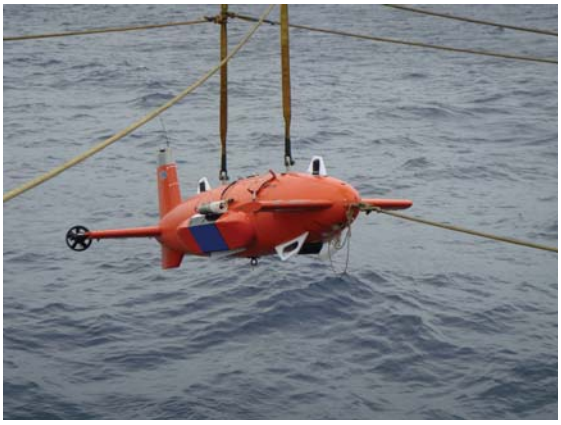
歓迎する先攻部隊研究者達

航海の成功を祈りながら乾杯

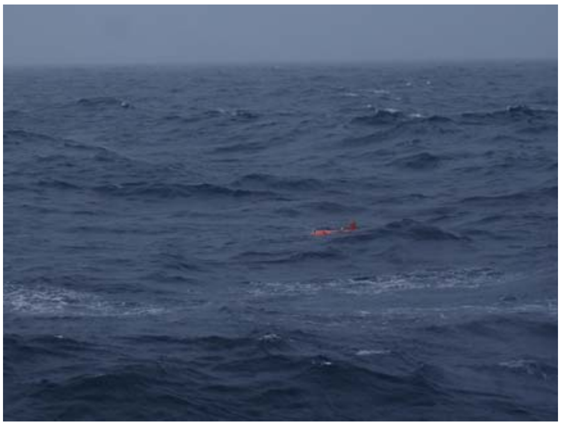
良いお酒だ!


AE2000a : 夜明けからの潜航準備作業

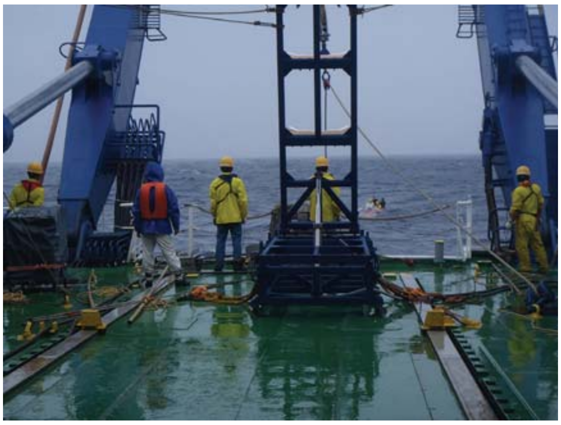

AE2000a : 潜行準備完了、吊り上げ


AE2000a : 水面まで吊り下げ

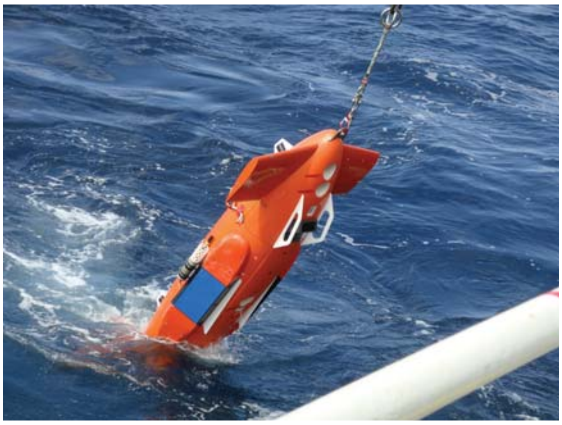

AE2000a : 着水、潜行開始


AE2000a : 任務完了、浮上

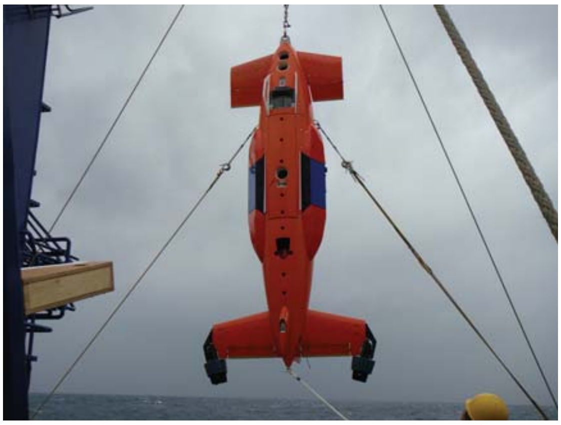

AE2000a : スイマーによる回収準備



AE2000a : ホイストによる牽引



AE2000a : 水面からの揚収

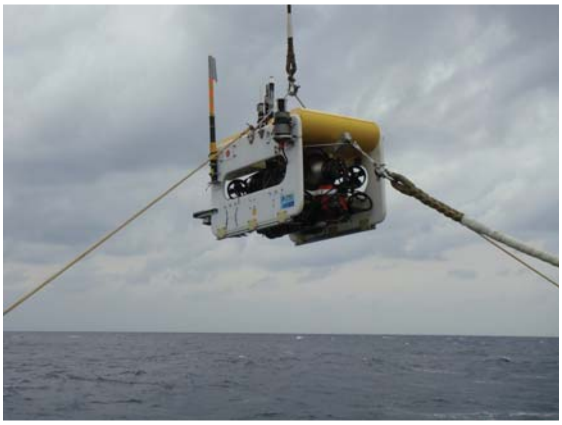


AE2000a : 一本釣りによる吊り上げ

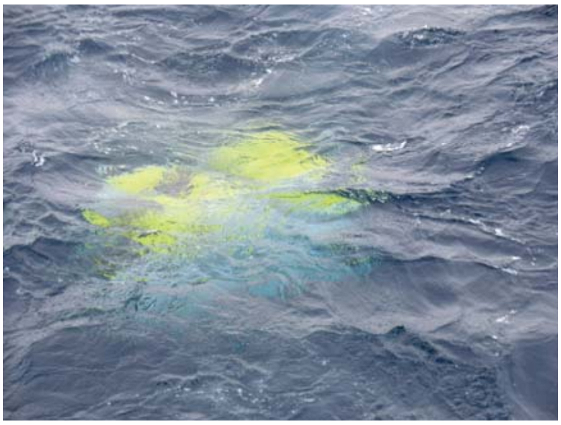
AE2000a : 着座、回収完了

首席研究員 : 憩いのひととき

Tuna-Sand : 潜行準備



Tuna-Sand : 吊り上げ、着水準備



Tuna-Sand : 着水、潜行開始

Tuna-Sand : 任務完了、浮上

Tuna-Sand : 吊り上げ、海面から揚収

Tuna-Sand : 回収完了


うらしま ： 潜行準備作業


うらしま ： 吊り上げ


うらしま ： 着水


うらしま ： 潜行開始

うらしま ： 揚収


うらしま ： 着座、回収完了