



KAIYO Cruise Report”

KY15-03

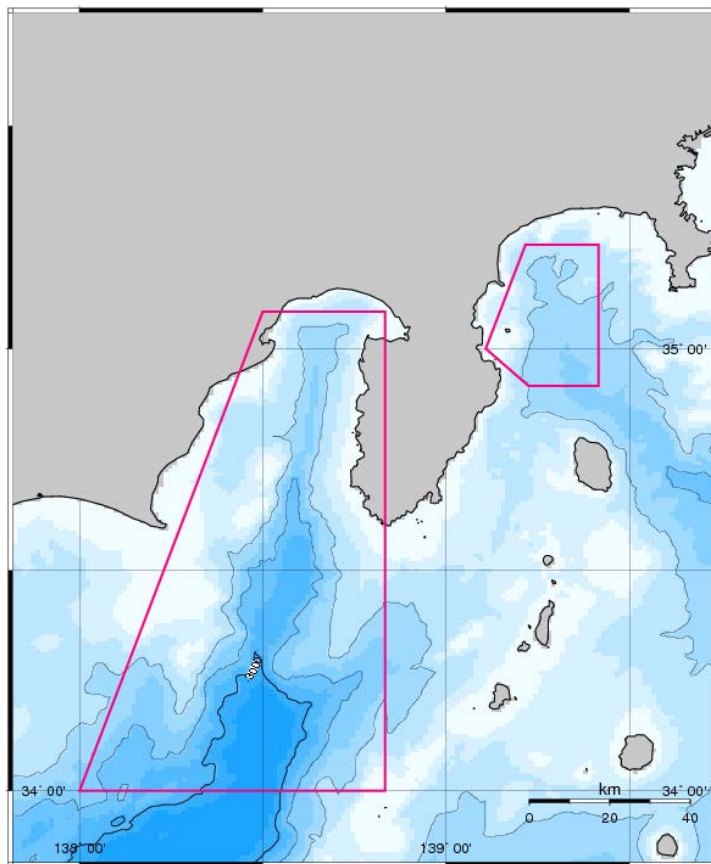
Sea trial of the AUV; Yumeiruka

Feb. 2, 2015 - Feb. 6, 2015

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

1. Cruise Information

- Cruise ID KY15-03
- Name of vessel Kaiyo
- Title of the cruise Sea trial of the AUV; Yumeiruka
- Title of proposal Sea trial of the AUV; Yumeiruka
- Cruise period Feb. 2, 2015 – Feb. 6, 2015
- Ports of departure / arrival JAMSTEC/ JAMSTEC
- Research area Sagami-Bay
- Research Map



- (1) Site #1: Sagami Bay (80 m ~ 1,500 m deep)
(34°55.0'N, 139°13.5'E), (35°00.0'N, 139°06.5'E), (35°14.0'N, 139°13.0'E),
(35°14.0'N, 139°25.0'E), (34°55.0'N, 139°25.0'E)
- (2) Site #2: Suruga Bay and Nankai Trough (200 m ~ 3,000 m deep)
(35°05.0'N, 138°30.0'E), (35°05.0'N, 138°50.0'E), (34°00.0'N, 138°50.0'E),
(34°00.0'N, 138°00.0'E)

2. Researchers

Name	Affiliation	Position
Shojiro Ishibashi	Maritec, JAMSTEC	Chief Scientist
Hiroshi Yoshida	Maritec, JAMSTEC	RePresentative of Scientice Party Scientist
Makoto Sugawara	Maritec, JAMSTEC	Scientist
Frank Fan	Maritec, JAMSTEC	Scientist
Yutaka Ota	Maritec, JAMSTEC	Scientist
Hiroshi Ochi	Maritec, JAMSTEC	Scientist
Yoshitaka Watanabe	Maritec, JAMSTEC	Scientist
Kiyoshi Hirokawa	Mitsubishi Heavy Industry	Chief Engineer
Yoshiaki Yamauchi	Mitsubishi Heavy Industry	Engineer
Toshihiro Tani	Mitsubishi Heavy Industry	Engineer
Kazuki Eguchi	Mitsubishi Heavy Industry	Engineer
Yoshimi Kanako	Mitsubishi Heavy Industry	Technician
Hakuo Nishizato	Mitsubishi Heavy Industry	Technician
Yusuke Nagata	Mitsubishi Heavy Industry	Technician
Kazuhiro Kanayama	Mitsubishi Heavy Industry	Technician
Eisei Goto	Mitsubishi Heavy Industry	Technician
Joji Harada	Mitsubishi Heavy Industry	Technician
Masayoshi Abe	Ryoyu System Giken	Engineer
Kazunari Takahashi	Oki Seatech	Engineer

3. Technical Tests

1) Overview

In this sea-trial, we intended to realize degree of the system completion and the system stability first, and to check acoustic communication range and autonomous cruising performance of the AUV. We planned three-days-test but had only two days for test due to bad weather. We thus had two dives (dive #9 and #10). In the first day, Yumeiruka cruised approximately 1 hour for checking acoustic link and scenario cruising by the acoustic remote control. Next day we tried sea floor observation by the interferometry sonar under autonomous control using some cruising scenarios. Details of the cruising and observation tests results are described below.

Table 1: Test Schedule

Date	Action/Place		Plans	Actuals
Feb. 2, Mon.	Pre-testing/ Departing	Yokosuka	Launch/Recover Test@Pier	←
Feb. 3, Tue.	Sea trial	Sagami-Bay	Diving test with acoustic system check	←
Feb. 4, Wed.	Sea trial		Autonomous cruising test by a scenario	←
Feb. 5, Thu.	Sea trial		Autonomous cruising test by a scenario	Evacuation due to bad weather
Feb. 6, Fri.	Arriving/ Unloading	Yokosuka	Unloading shipping items	←

Diving information is listed in Table 2. In the dive #9, one-hour diving test only was performed because we encountered a system trouble in a pre-diving test and then we needed time for fixing it. Performance of the acoustic positioning and the acoustic communication was checked and then autonomous cruising tests supported by the acoustic remote control were carried out. In the dive #10 a set of scenario cruising along about 100 m above underwater sheer cliff was done as observe with interferometry sonar.

Table 2: Dive information

Number	Date, Time	Depth reached
Dive #9	Feb. 3, 2015, 14:17 (launch) ~ 15:07 (Surfacing)	292 m
Dive #10	Feb. 4, 2015, 11:37 (launch) ~ 13:57 (Surfacing)	600 m

Figures 1 is cruising tracks recorded by acoustic navigation system installed in the support ship. We sent 5 autonomous command, got good results. Figure 2 (a) ~ (c) shows a cruising track recorded by the inertial navigation system installed the AUV.

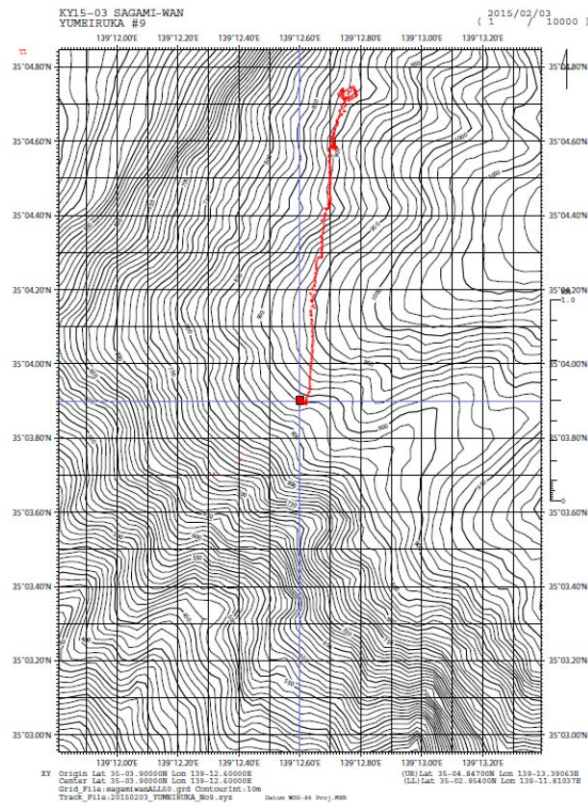
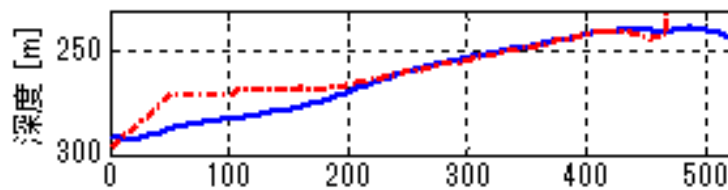
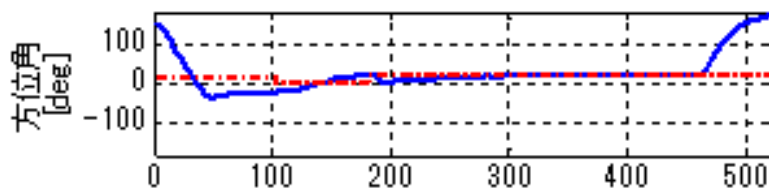


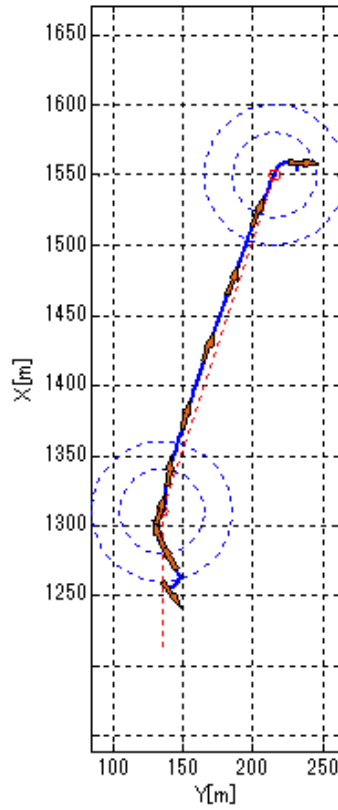
Figure 1: Dive #9 track chart.



(a) Depth control trend



(b) Heading control trend.



(c) Cruising track.

Figure 2. An autonomous cruising result recorded by the INS. Red line and blue line show target value and actual value, respectively.

3) Results in the dive #10

Figure 3 is cruising tracks recorded by acoustic navigation system installed in the support ship. We prepared two scenarios which commanded zig-zag cruising having 7 way points by a depth control and straight cruising along the underwater cliff having 5 way points. Figure 4 (a) ~ (c) shows a cruising track for the scenario #1 (zig-zag). In the figures, red lines denote targets and blue actual results. Depth keeping and heading keeping controls are good. The AUV rightly passes through every way points as shown in Figure 4 (c).

We also obtained observation image recorded by the sonar but left wing data was not clear because the sonar had trouble on the wire connecting in the left wing. Figure 5 shows a post processing bathymetry which is still not clear even after some processing. After finishing the sea trial we promptly fixed this sonar failure.

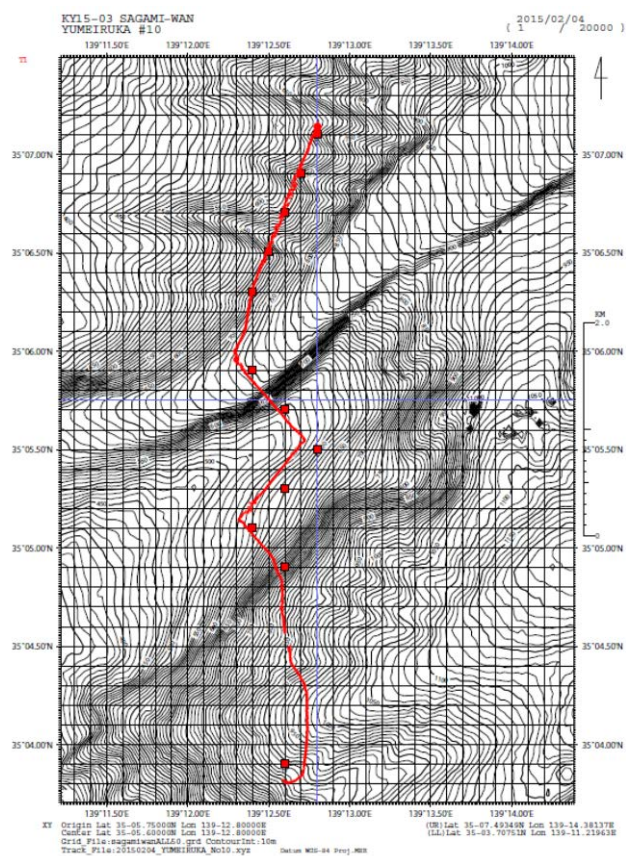


Figure 3. Whole cruising track of #10 recorded by the acoustic navigation system.

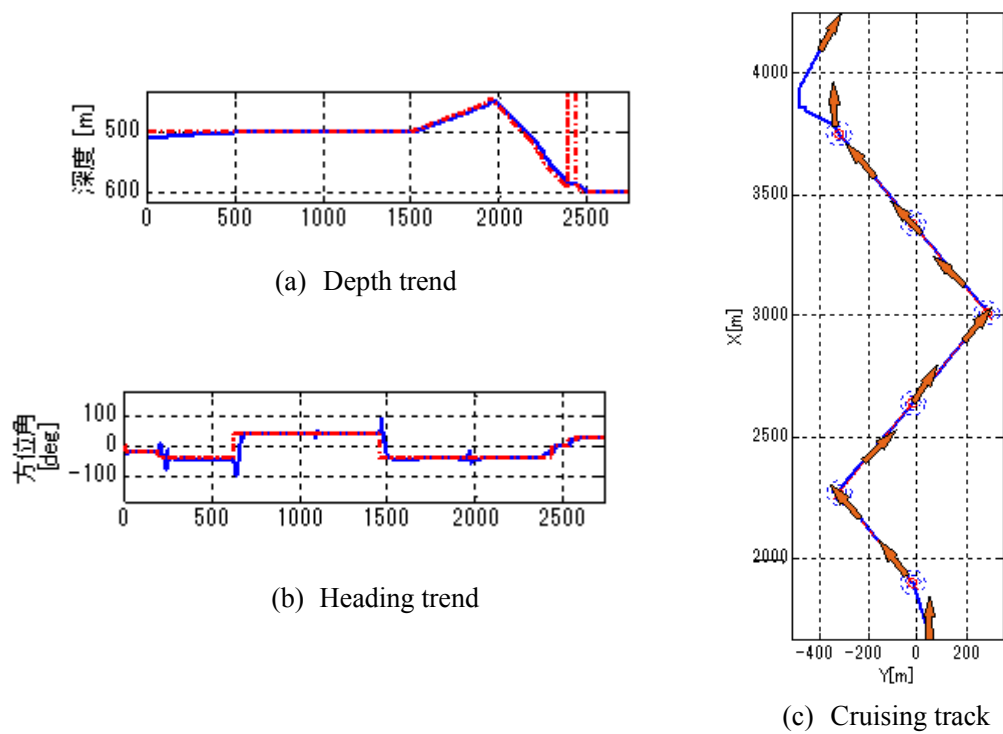


Figure 4: Dive #10 track chart.

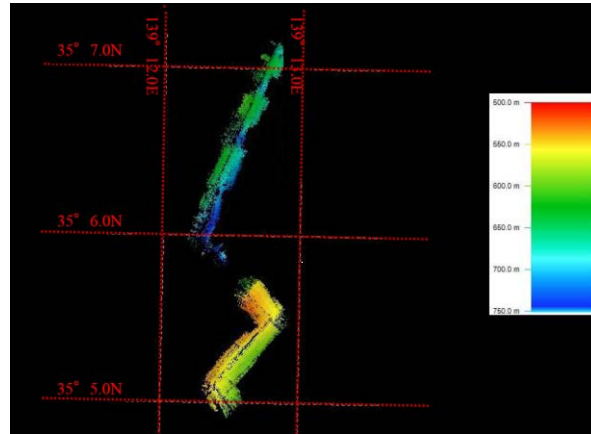


Figure 5: Bathymetry post-processed.

4) Specifications of Yumeiruka

Yumeiruka is the AUV equipped with a canard-X rudder. The highly maneuverable AUV will be utilized for underwater resources exploration. Its constant motion control allows a magnetic sensor and/or synthetic aperture sonar to enhance performance. Table 2 shows its specifications.

Yumeiruka has a streamline shape to reduce hydro resistance. Its frame is made from aluminum alloy. The mechanically-formed syntactic forms attached into the frame make the vehicle buoyant. The syntactic forms also form vehicle outer shape. Its whole surface is covered with separated thin fiber-reinforced plastics (FRPs). Cross arranged four 400 Watts direct drive thrusters at rear make propulsion. The thrusters generate maximum speed of 3 knots. Two X-rudders are mounted on the bow and the stern to control the vehicle highly maneuverable. Its controllable speed with the rudders is between 2 and 3 knots. The rudder area and aspect ratio were optimized by the balance between the control range of the simultaneous heading and course control and the rudder overhang length from the body. Fig. 1 shows the device arrangement of Yumeiruka. A buoyancy compensator adjusts the vehicle weight to near-neutral. The compensator consists of a pressure hull with capacity of 30 liters, an oil bladder, a pump and valves. Its buoyancy is adjusted by transferring the oil between the pressure hull and the bladder. It can be automatically controlled by a mission scenario. A small inertial navigation system (INS) consisting of three ring laser gyros developed by Japan Aviation Electronics Industry, Ltd. and JAMSTEC enables high accuracy positioning of the vehicle with a 300 kHz Doppler velocity log (DVL), a global positioning system (GPS) and acoustic navigation systems (ANSs). Its navigation modes, a DVL-INS hybrid mode and so on, are automatically or manually selected. The AUV system has a super short base-line (SSBL) acoustic positioning system. Other sensors for navigation are an altimeter and a depth meter. The vehicle is equipped with a depth meter, model 8B and a CTD, SBE49 but the vehicle system gives priority to the model 8B as depth

data measured. Both the DVL and an altimeter measure altitude and the DVL has priority as well. These pair sensors constitute a redundancy system.

Table 2: Specifications of *Yumeiruka*

ITEMS	VALUES
Maximum depth rating	3,000 m
Cruising speed	2 knot
Length	5.0 m
Weight	2.7 tons
Endurance	16 hours
Scientific payload	70 litters (100 kg)
Observation items	IF sonar, Synthetic Aperture Sonar, SBP, CTD meter , Fluoro & turbidity meter, pH meter

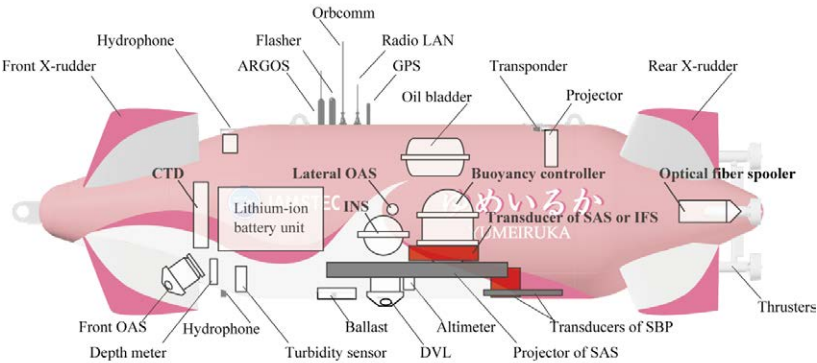


Fig. 5: System arrangement.

4. Notice on Using

Notice on using: Insert the following notice to users regarding the data and samples obtained.

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.