



Kairei “Cruise Report”

KR17-02

Cross-ministerial Strategic Innovation Promotion Program
(SIP), Sea trials of ASV performance and Acoustic
propagation

Suruga bay and Sagami bay

Feb.12,2017-Feb.21,2017

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

* There is no prescribed format. Images such as photographs may be included.

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1. Cruise Information

1.1. Cruise ID: KR17-02

1.2. Name of vessel: R/V Kairei

1.3. Title of the cruise: Cross-ministerial Strategic Innovation Promotion Program (SIP), Sea trials of ASV performance and Acoustic propagation.

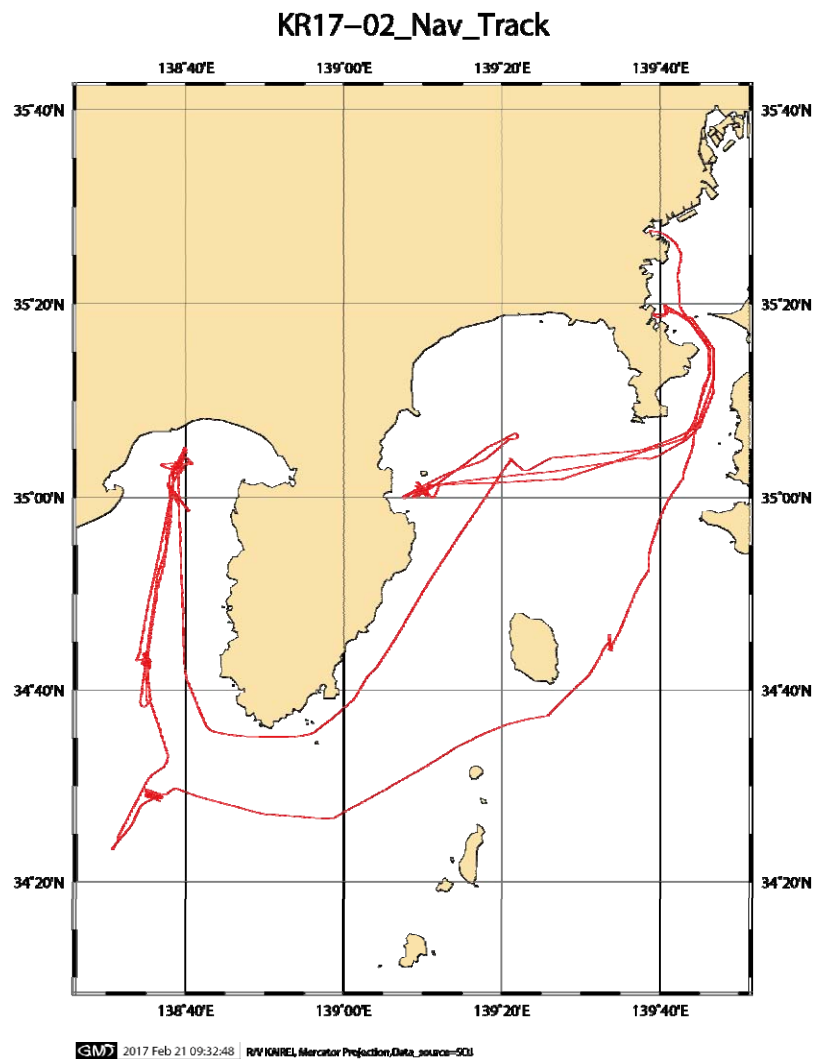
1.4. Title of proposal: Cross-ministerial Strategic Innovation Promotion Program (SIP), Development of acoustic technology for multiple AUVs operation. Exploration performance test by Autonomous Surface Vehicle and mini AUV.

1.5. Cruise period: Feb.12 - Feb.21,2017

1.6. Ports of departure / call / arrival: Port of Yokohama – Yokosuka (JAMSTEC) – Yokosuka (JAMSTEC)

1.7. Research area: Suruga bay and Sagami bay

1.8. Research Map



2. Researchers

2.1. Chief scientist [Affiliation]

Yoshiyuki NAKANO [JAMSTEC]

2.2. Representative of the science party [Affiliation]

Hiroshi OCHI and Tadahiro HYAKUDOME [JAMSTEC]

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Hiroshi OCHI [JAMSTEC]

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Yuichiro DAKE [YANMAR]

Yukihiko KIMURA [YANMAR SHIPBUILDING & ENGINEERING]

Ryosuke KOMINE [SEC]

Hiroyuki MIYAKE [Ryoyu System Engineering]

Takayuki UEMURA [KOWA Corporation]

Youji KOBAYASHI [KOWA Corporation]

Yousuke TAKAHARA [JEPICO]

Fumikuni OSAWA [Hitachi Information & Telecommunication Engineering]

Daiki USHIROMURA [Marine Work Japan]

Keisuke TAKEDA [Marine Work Japan]

2.4. R/V KAIREI Crew

Captain	TAKAFUMI AOKI
Chief Officer	YASUHIKO SAMMORI
2nd Officer	TAKESHI MURAMATSU
3rd Officer	HIDEHIKO KONNO
Chief Engineer	MINORU TSUKADA
1st Engineer	DAISUKE GIBU
2nd Engineer	YOSHINOBU HIRATSUKA
3rd Engineer	YOICHI YASUE
Jr.3rd Engineer	YUNA KAINO
Chief Electronics Operator	HIROYASU SAITAKE
2nd Electronics Operator	TOSHIHIKO YUASA
3rd Electronics Operator	RYUJI ONIKUBO
Boat Swain	KAZUO ABE
Quarter Master	YASUO KONNO
Quarter Master	SHUICHI YAMAMOTO
Quarter Master	YOSHIAKI MATSUO
Quarter Master	DAISUKE YANAGITANI
Sailor	SHO SUZUKI
Sailor	OSAMU MARUO
No.1 Oiler	JUNJI MORI
Oiler	RYOTA SUZUKI
Oiler	MASAKI TANAKA
Oiler	TAKUYA WATANABE
Chief Steward	TORU MURAKAMI
Steward	HIDEO FUKUMURA
Steward	JUN SATO
Steward	KOKI SHINOHARA
Steward	YUDAI KUSUNOKI

3. Ocean test

3.1. Purpose

In Strategic Innovation Promotion Program (SIP), an autonomous surface vehicle (ASV) and multi-user underwater acoustic communication and positioning system are being researched

and developed as elemental technologies to operate multiple autonomous underwater vehicles (AUVs) simultaneously. The purpose of this cruise is ocean test of developed ASV and multi-user underwater acoustic communication and positioning system and acquiring data to improve the perfection and sophisticate the systems.

3.2. Summary

Ocean test for multi-user underwater acoustic communication and positioning system was performed in first half and for ASV was conducted in last half of this cruise. Table 1 shows schedule overview of this cruise. ASV was loaded on board on February 16th, the middle of this cruise.

In first three days of this cruise, ocean test of acoustic communication between sea surface and bottom and acoustic positioning of underwater target from sea surface using an underwater device which was moored on the bottom and a surface device which were floating and towed by “KAIREI” during the test. Three times of tests were implemented at three area of which water depth differ each other in Suruga Bay. The devices are designed to be able to communicate with and position up to three targets (nodes) simultaneously. However, the system software was still unstable, then raw data of received signal by two devices was acquired in this cruise, and communication and positioning function were evaluated with post processing.

In last three days, ocean test of ASV was conducted in Sagami Bay. “EMROV”, a small underwater vehicle, was operated as tracking target for ASV’s functional test. Cruising and maneuvering ability, autonomous cruising function, and tracking function were evaluated. Acoustic noise radiated from ASV was measured at the same time.

Table 1. Schedule overview.

Date	Local Time	Description	Remarks
Feb. 12	9:00	Departure from Yokohama-Shinko port	
	14:22	Operation check of moored device	Hanged from “KAIREI”
	15:54	Operation check of floating device	Hanged from “KAIREI”
Feb. 13	8:30	Deployment of moored device	At Suruga Bay Around 950 meters depth
	9:15	Deployment of towed floating device	
		Ocean test	
	14:30	Recovery of floating device	
	14:38	Calibration of mooring position	-15:10
	15:19	Release moored device	
	16:11	Recovery of moored device	
Feb. 14	8:30	Deployment of moored device	At Suruga Bay Around 2,000 meters depth
	9:59	Deployment of towed floating device	
		Ocean test	

	14:30	Recovery of floating device	
	14:34	Calibration of mooring position	- 15:10
	15:13	Release moored device	
	16:20	Recovery of moored device	
Feb. 15	8:29	Deployment of moored device	At Suruga Bay Around 2,700 meters depth
	9:14	Deployment of towed floating device	
		Ocean test	
	14:00	Recovery of floating device	
	14:31	Calibration of mooring position	- 15:04
	15:06	Release moored device	
	16:20	Recovery of moored device	
Feb. 16	9:00	Return to Yokosuka HQ	
	9:30	Load ASV, EMROV, and Satellite System	
	13:00	Launch test of ASV	
	16:00	Departure from Yokosuka HQ	
Feb. 17	8:00	Pre-meeting	Strong Wind
	8:05	ASV Pre-cruise check	
	10:00	Launch test	
	18:00	Post meeting	
Feb. 18	8:00	Pre-meeting	Sagami bay /Sea-state 3
	8:05	ASV Pre-cruise check	
	10:00	ASV Launch	
		ASV maneuverability test	
	12:00	EMROV Pre-dive check	
	13:30	EMROV Launch	
		AUV tracking test	
	14:30	EMROV on deck	
	15:30	ASV on deck	
	18:00	Post Meeting	
Feb. 19	08:00	Pre-meeting	Sagami bay /Sea-state 2
	08:05	ASV Pre-cruise check	
	10:00	ASV Launch, EMROV Pre-dive check	
		ASV maneuverability test	
	11:00	EMROV Launch	
		AUV tracking test	
	12:00	EMROV on deck	
	15:00	ASV on deck	
	18:00	Post meeting	
Feb. 20		Ocean test was canceled	Strong Wind
Feb. 21	9:00	Return to Yokosuka HQ	

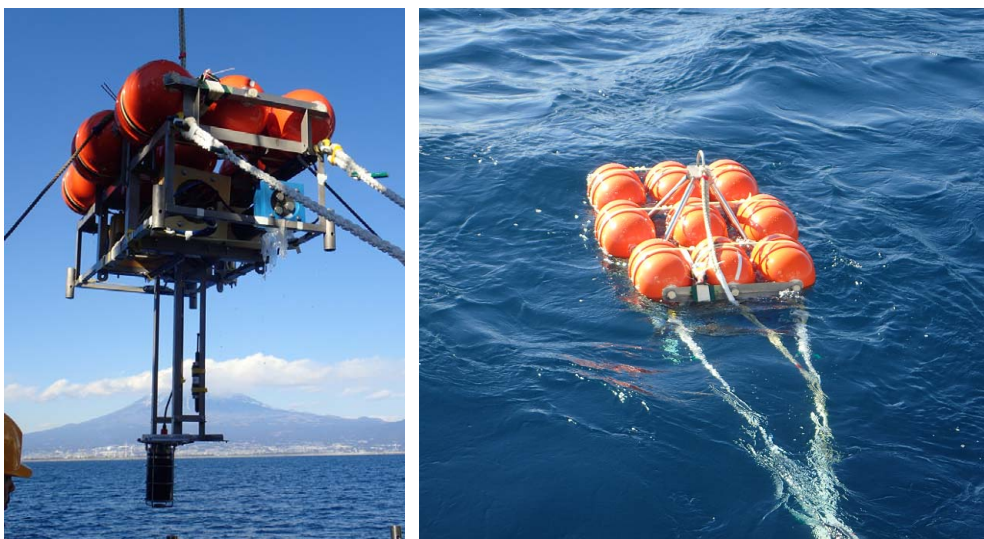
3.3. Instruments

-Experimental devices for test of acoustic communication

Fig. 1 and 2 show pictures of moored device and floating device, and Table 1 shows designed specifications of the multi-user acoustic communication and positioning system. Basically, specifications of the two devices are same. Transducer, a part of the device, is separated and was equipped upward for moored device and downward for floating device respectively. The devices worked with a Li-ion battery. A clinometer, depth sensor, and an acoustic recorder, which worked in stand-alone, were equipped on each device additionally. Furthermore, a GPS and attitude sensor were equipped on the floating device.



Fig. 1. Picture of moored device.



Figs. 2. Pictures of floating device.

Table 2. Specifications of multi-user acoustic communication and positioning system.

Items	Specifications
Range (depth)	3,000 m
Range (nadir angle)	30 ° (communication) 45 ° (positioning)
Frequency	12 - 24 kHz
User number	3 (simultaneously)
Throughput	Simultaneous multi-user mode: 0.17 - 7.7 kbps (Momentary bit rate: 3.2, 6.4 12.8 kbps) High speed mode: 0.25 - 14.3 kbps (Momentary bit rate: 10, 20, 40 kbps)
Positioning	Method: super short baseline (SSBL) Accuracy: 2 % of slant range (random error)
Operation modes	Auto mode: Timing of transmission of signals is automatically controlled Manual mode: Timing of transmission depends on operation

-Configuration of mooring system

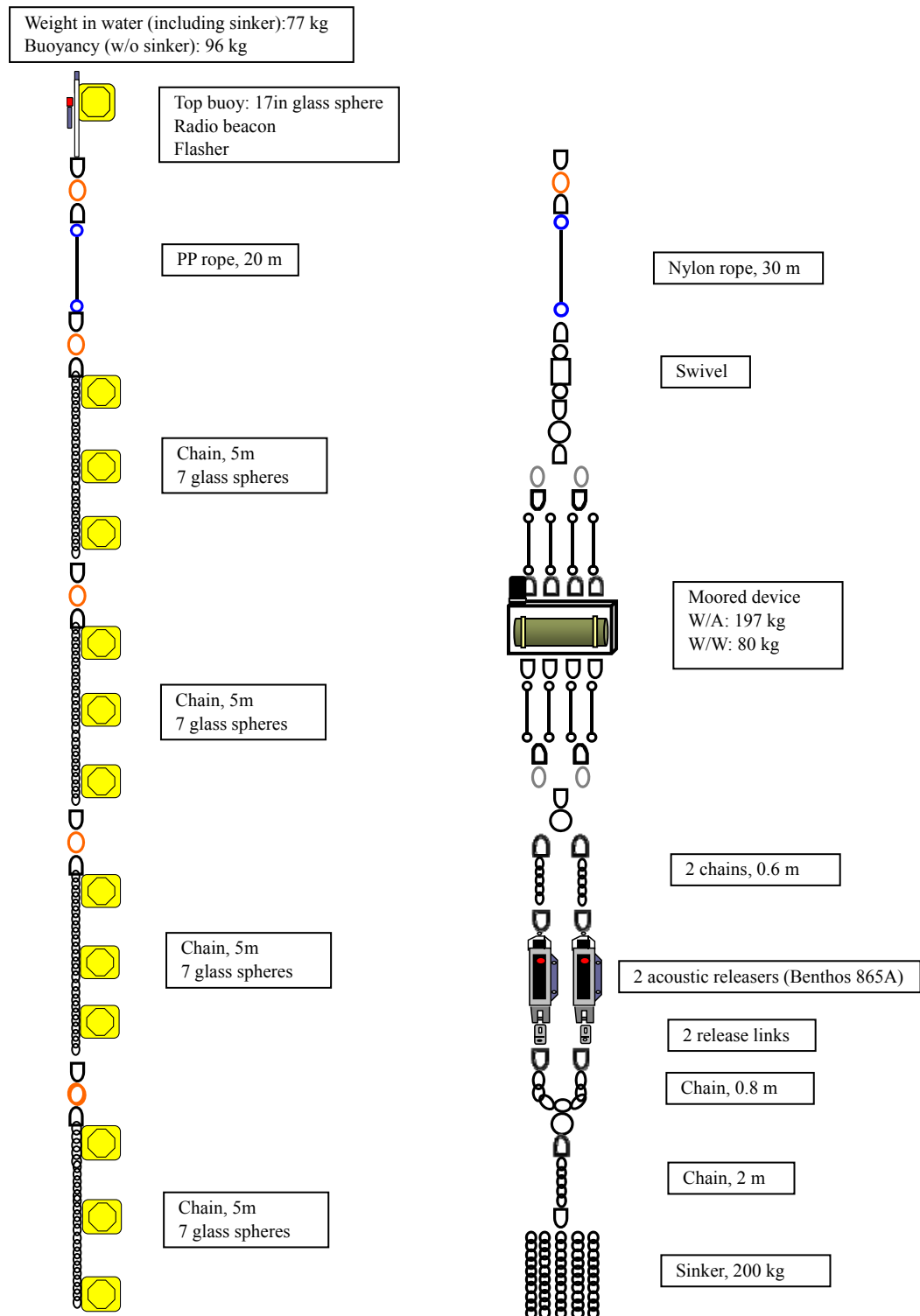


Fig. 3 Configuration of mooring system.

-ASV

Fig. 4 shows a picture and Table 3 shows specifications of the ASV. The ASV was monitored and controlled on board with satellite, wireless LAN, and VHF communication system during the ocean test. An acoustic communication and positioning system, which was temporally equipped on the ASV, was allocated on lifting and lowering device on which the equipped device can be at around 1.5 meters depth under the ASV in order to reduce influence of noise and bubbles near sea surface.



Fig. 4 Picture of ASV

Table 3. Specifications of ASV.

Items	Specifications
Type	Autonomous surface vehicle
Size	4.45 x 1.95 x 1.8 m
Weight	1,800 kg
Cruising speed	0 - 5 kt
Endurance	48 hours (@ 3 kt)
Power system	Diesel engine (11 kW)
Actuator	Azimuth thruster x 1
	Lifting and lowering device (for underwater acoustic system)
Communication systems	Satellite
	Wireless LAN
	VHF radio communication
	Underwater acoustic communication (for AUV)

Navigation systems	Satellite compass (GPS, attitude sensor) Automatic identification system (AIS) (not in use) Super short baseline (SSBL) acoustic positioning (for AUV)
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-EMROV

“EMROV” was a small vehicle and loaded on board to be operated as tracking target for evaluation of ASV’s function.



Fig. 5 Picture of EMROV

Table 4. Specifications of EMROV.

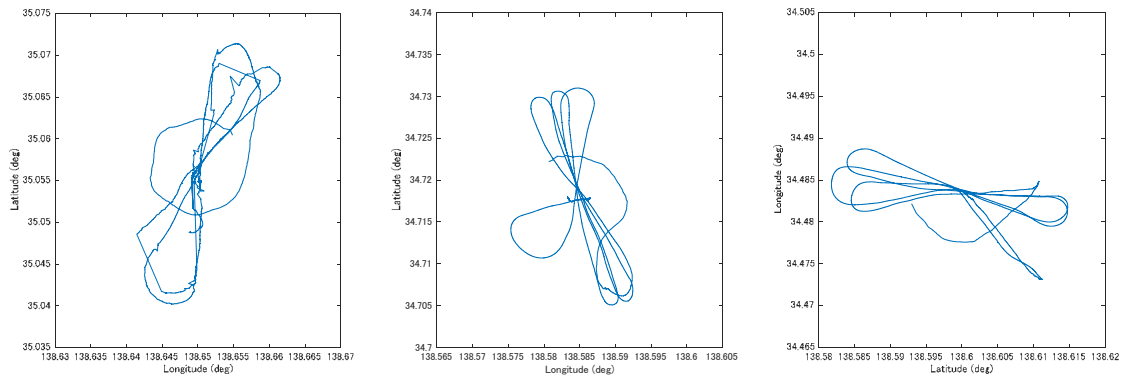
Items	Specifications
Size	2.1 x 0.68 x 0.67 m
Weight	150 kg
Operation depth	Up to 740 m
Cruising speed	2 kt max.t
Endurance	3 hours
Battery	Li-ion battery (25 V, 30 Ah)
Operation modes	AUV UROV (untethered remotely operated vehicle with thin optical fiber)
Actuators	Tilt thruster x 2 Vertical thruster x 1
Communication systems	Optical fiber up to 3 km Underwater acoustic communication
Navigation systems	Attitude sensor Doppler velocity log (DVL) Acoustic positioning system Flasher
Observation devices	CTD (RBRconcerto-CTD) HD camera (FCB-H11)

3.4. Ocean tests for multi-user acoustic communication and positioning system

The ocean tests were performed in three areas of which the water depth differs each other in three days. Table 5 shows calibrated point and depth where the underwater device was moored. The floating device was towed by R/V “KAIREI” at around 200 meters away from the R/V to reduce influence of noise radiated by the R/V. Ocean tests were performed around four and half hours a day. Acoustic signal for communication and positioning was transmitted from the floating device and moored device repetitively during the ocean tests. Evaluation of communication and positioning are achieved in post processing as mentioned above. Figs. 6 show movement of the floating device measured by GPS equipped on the device. The floating device made round-trip of several times in order to vary geometric condition between the moored and floating devices. Horizontal distance between the two devices was up to around 1500 meters and the geometric condition was varied as shown in Fig. 7. Various types of signals were transmitted from the devices during cruising.

Table 5. List of ocean tests.

Date	Test No.	Mooring point		Depth
Feb. 13	#1	35°03.3671' N,	138 °38.9810' E	948.88 m
Feb. 14	#2	34°43.0432' N,	138 °35.0323' E	1968.22 m
Feb. 15	#3	34°29.0150' N,	138 °35.9789' E	2734.76 m



Figs. 6 Movement of floating device in ocean test #1 (left fig.) to #3 (right fig.).

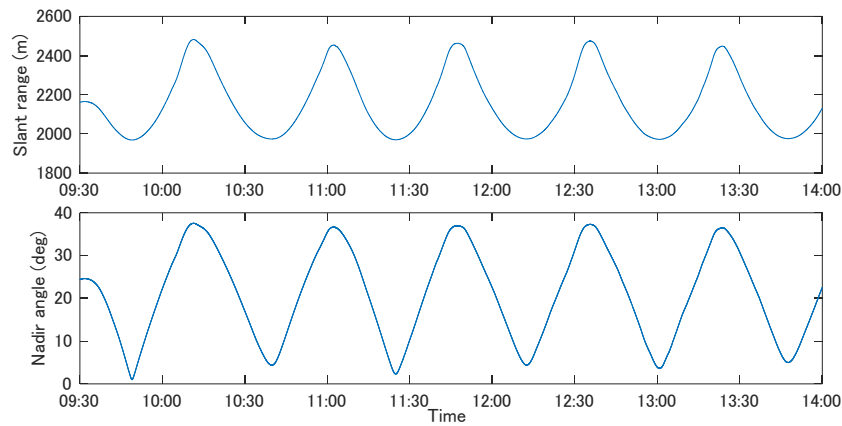


Fig. 7 Variation of geometric condition between moored and floating devices in ocean test #2.

3.5. ASV performance tests

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Test Point: Suruga bay

Sea-state: 3, Wind: 5-6m/s

- Test for consecutive Launch and Recovery of ASV and AUV
- Test for AUV tracked by Acoustic navigation system of ASV
- Tracking test of ASV, when AUV cruising
- Test for satellite communication and wireless LAN communication
- Test for vehicle maneuver

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- Test for consecutive Launch and Recovery of ASV and AUV
- Test for AUV tracked by Acoustic navigation system of ASV
- Tracking test of ASV, when AUV cruising
- Test for satellite communication and wireless LAN communication
- Test for vehicle maneuver
- Measuring vehicle noise



Fig.8 Scene of ASV cruising

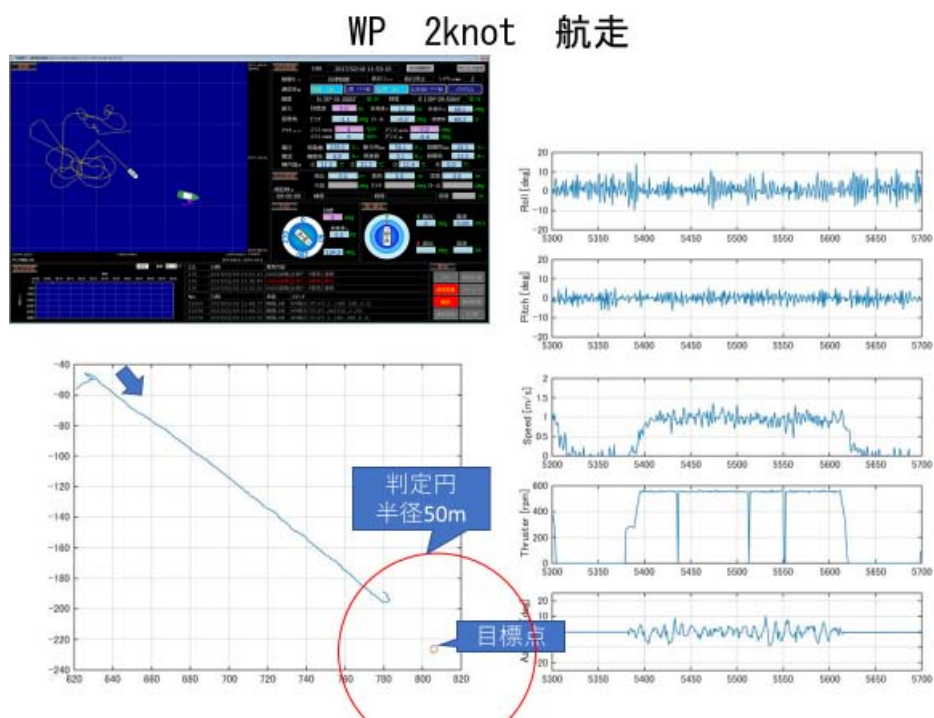


Fig.9 Test result of way point control

AUV捕捉

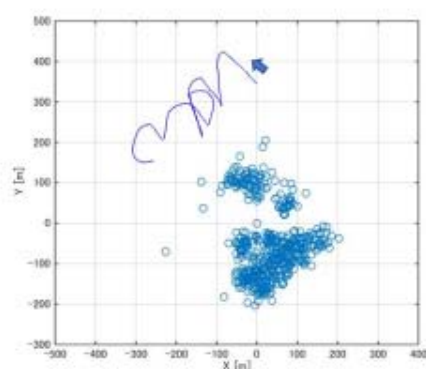
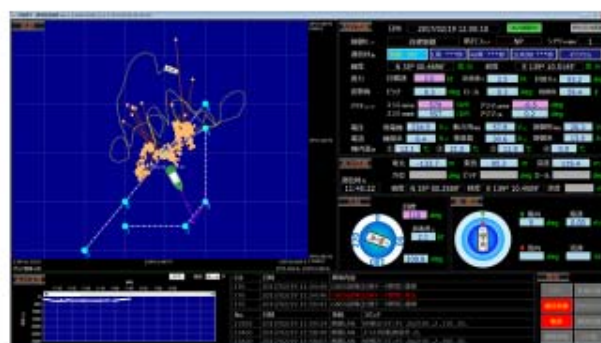


Fig.10 Test result of AUV tracking

4. Acknowledge

We are grateful thank to all crew of “R/V Kaiei” for the safe navigation and support for the sampling and observation.

5. 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.