



R/V Kairei Cruise Report

KR14-03

Sea trial of new work class ROV
applied for submarine resource exploration

Sagami Bay

February.8, 2014 - February.17, 2014

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

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1. Cruise Information

- 1) Cruise ID : KR14-03
- 2) Name of vessel : R/V Kairei
- 3) Cruise Title : Sea trial of new work class ROV applied for submarine resource exploration
- 4) Chief scientist : Hiroyuki Osawa, MARITEC, JAMSTEC
- 5) Title of proposal : Sea trial of new work class ROV applied for submarine resource exploration
- 6) Representative of the Science Party : Hiroyuki Osawa, MARITEC, JAMSTEC
- 7) Cruise period : 2014/2/8 ~ 2014/2/17
- 8) Ports of call : Yokosuka (Sumitomo Heavy Industries, Ltd)
~ Yokosuka (Sumitomo Heavy Industries, Ltd)
- 9) Experiment Area :

Sagami Bay (water depth of 80m ~ 1,500m)

(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°30.0'E)(34°55.0'N,139°30.0'E)

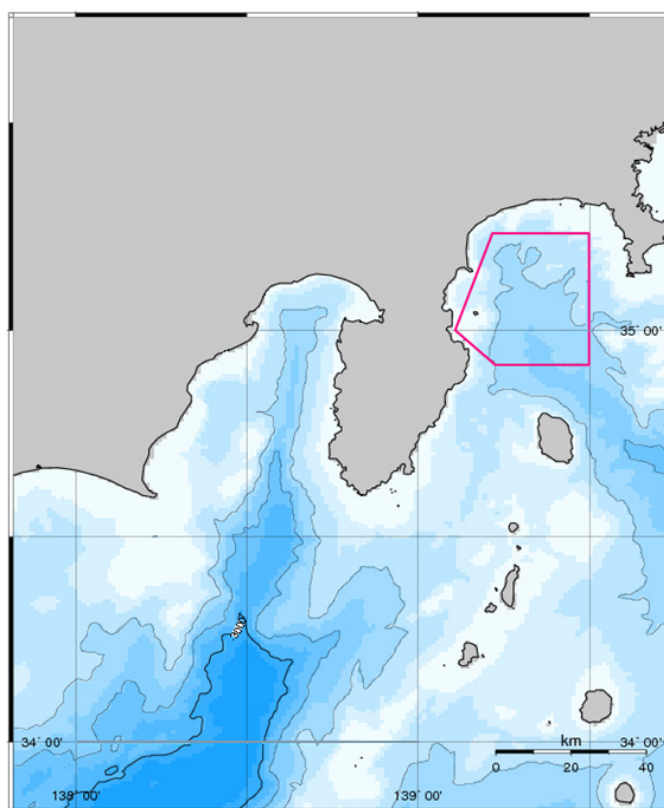


Figure 1: Test areas

2. Researchers

Chief scientist: Hiroyuki Osawa (JAMSTEC)

Science party (List)

Kazuyoshi Hirata (JAMSTEC)

Tsuyoshi Miyazaki (JAMSTEC)

Hidehiko Nakajoh (JAMSTEC)

Hiromi Utsugi (JAMSTEC)

Takao Sawa (JAMSTEC)

Fumitaka Sugimoto (JAMSTEC)

Shinpei Gotoh (JAMSTEC)

Takafumi Kasaya (JAMSTEC)

Hiromichi Suzuki (JAMSTEC)

Masayuki Watanabe (JAMSTEC)

Yuka Masaki (JAMSTEC)

Isao Yamanaka (Mitsui Engineering & Shipbuilding Co., Ltd.)

Masakazu Matsushima (Mitsui Engineering & Shipbuilding Co., Ltd.)

Wataru Murata (Mitsui Engineering & Shipbuilding Co., Ltd.)

Hikari Takahata (Mitsui Engineering & Shipbuilding Co., Ltd.)

Kenta Watanabe (Mitsui Zosen Systems Research Inc.)

Yorimiti Ito (Technical Service Co., Ltd.)

Toshihiro Hayashi (Nissan Electric Mfg Co., Ltd.)

3. Experiment

3-1. Background

JAMSTEC decided to advance the development of new work class Remotely Operated Vehicle (ROV) applied for various deep-sea explorations such as submarine resource explorations and so on, and it is able to operate at a maximum depth of 7,000m. Its construction started in April 2011 and completed in March 2013. This new ROV was built by Mitsui Engineering & Shipbuilding (MES). This new ROV is the vehicle part of KAIKO system. This new ROV named “KAIKO Mk-IV” in November 2013. The test dive of this new ROV started in October 2013.

3-2. ROV system: KAIKO Mk-IV

KAIKO Mk-IV is a new work class ROV applied for various deep-sea explorations such as submarine resource explorations and so on (Figure 2). Several advanced technologies developed in JAMSTEC, such as INS, buoyancy material, optical / power composite cable and so on, are adapted to this vehicle.

She has a hydraulic power unit (55kW) targeting improvement in its work capability. High performance thrusters and manipulators that are mounted on the vehicle are driven by supplied hydraulic pressure with the hydraulic power unit.

The vehicle's mission is to survey deep ocean areas that are impossible to survey with manned submersibles and deep ocean areas that are dangerous due to complicated topography.

The KAIKO Mk-IV vehicle is capable of diving to a maximum depth of 7,000 m and was deployed from its own launcher, which is also fitted with various operational sensors.

Table 1: Specifications

	Vehicle	Launcher
Length	3.0 m	5.2 m
Width	2.0 m	2.6 m
Height	2.6 m	3.2 m
Weight in air	5,500 kg	5,800 kg
Depth	7,000 m	11,000 m
Payload weight	200 kg (in water), 300 kg (in air)	
Power	3,200 V AC 3 phase from surface vessel via launcher	
Thrusters	forward/reverse: 4, vertical: 3 (total max. thrust force: 3.4kN)	
Payload	SBE-49 CTD (conductivity, temperature and depth) 2 × wide angle colour HDTV cameras, 1 × CCD colour TV camera, 1 × digital still camera (24 megapixels)	CTD (conductivity, temperature and depth), side scan sonar, sub-bottom profiler, monochrome TV camera for monitoring coupling operations,

	1 × wide angle underwater fisheye camera, 1 × 500 W and 2 × 250 W halogen lights, 2 × 400 W HMI lights, DO	secondary cable for monitoring, monochrome TV camera
Manipulators	2 × manipulators (7-function master-slave)	
Navigation	Monochrome TV camera, altimeter, depth sensor, flasher, obstacle avoidance sonar, INS, DVL, ARGOS	Obstacle avoidance sonar, altimeter, depth sensor, compass
Cables	Optical/power composite cable: primary cable: 45 mm (diameter) × 12,000 m secondary cable: 29.5 mm (diameter) × 250 m	Optical/power composite cable: primary cable: 45 mm (diameter) × 12,000 m, secondary cable: 29.5 mm (diameter) × 250 m

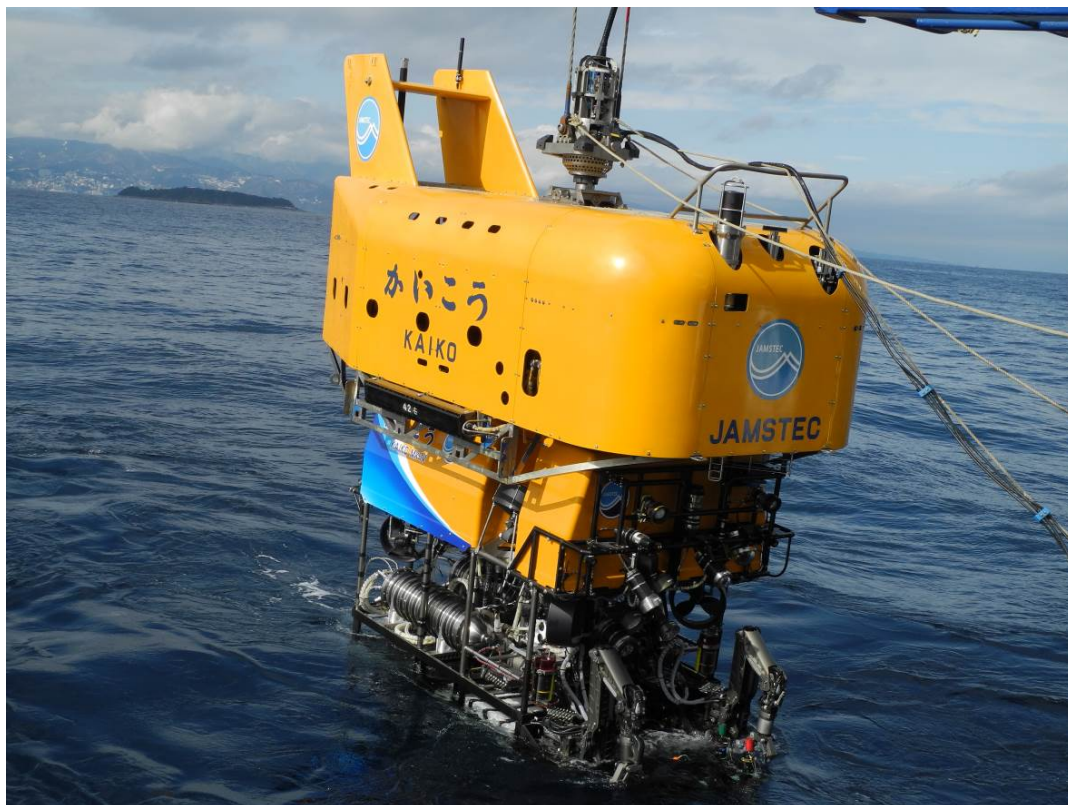


Figure 2: KAIKO Mk-IV (JAMSTEC)

3-3. Cruise Log

KR14-03 Schedule

Date (2014)	Note	Test Area	contents
8, February (Saturday)	Departure		
9, February (Sunday)	Dive #622	Sagami Bay	1) Comprehensive test at sea 2) Auto cruising test 3) Operational test by manipulator
10, February (Monday)	Dive #623	Sagami Bay	1) Comprehensive test at sea 2) Auto cruising test 3) Operational test by manipulator
11, February (Tuesday)			Vehicle maintenance
12, February (Wednesday)			Vehicle maintenance
13, February (Thursday)	Dive#624	Sagami Bay	1) Comprehensive test at sea 2) Auto cruising test 3) Operational test by manipulator system 4) Observation equipment operational test by TDEM system
14, February (Friday)			Vehicle maintenance
15, February (Saturday)			Vehicle maintenance
16, February (Sunday)	Dive#625	Sagami Bay	1) Comprehensive test at sea 2) Auto cruising test 3) Operational test by manipulator 4) Observation equipment operational test by TDEM system
17, February (Monday)	Arrived at YOKOSUKA		Remove fittings

4. Experiment results

4-1. Dive #622

Contents of the dive:

- 1) Comprehensive test at sea
- 2) Auto cruising test
- 3) Operational test by manipulator

Test Area: Off Hatsushima island in Sagami Bay

In this dive #622, we were carried out operational test of KAIKO Mk-IV at the seafloor.

The vehicle cruising tests, which were Auto Heading control, Auto Altitude hold control, Auto Depth control, Auto fixed positioning control and auto cruise control, was tested. We confirmed that Auto cruise control can be overridden at any time with the Joystick if the vehicle is operating in a value different from the set parameter.

We were also carried out work characteristics tests of manipulators by using two MBARI-type cores to grab mud.

Table 2: Dive log (Dive #622)

Data	Local Time	Note	Description
9, February	13 : 05	KAIKO dove and started her operation.	
	13 : 11	KAIKO began to dive into the sea.	
	14 : 18	The separation of the vehicle and launcher.	
	14 : 34	New vehicle landed on the sea bottom (D=1,008m).	
		Maximum dive depth in this operation was 1008m.	
	15 : 59	New vehicle left the sea bottom (D=997m).	
	16 : 18	The vehicle was combined with a launcher again.	
	17 : 06	KAIKO surfaced.	
	17 : 18	Recovered KAIKO and finished the operation.	

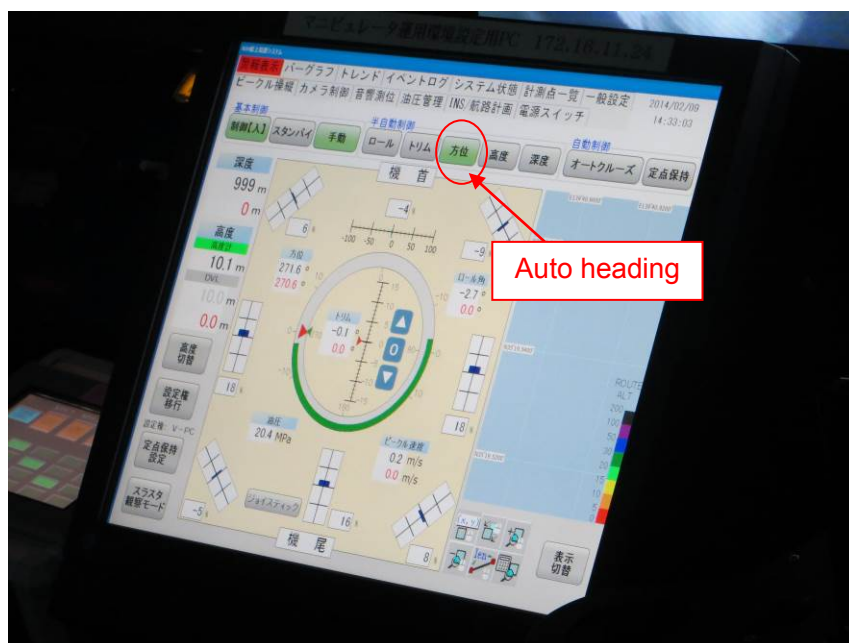


Figure 3 Screenshot of vehicle's auto heading control operation



Figure 4 Sampling operation test by MBARI-type core sampler

4-2. Dive #623

Contents of the dive:

- 1) Comprehensive test at sea
- 2) Auto cruising test
- 3) Operational test by manipulator

Test Area: Off Hatsushima island in Sagami Bay

In this dive #623, we were carried out auto cruising control test at the bottom of the sea. In addition, we performed the cruising test with the launcher towing mode as operation training. Vehicle cruise control test was tested by traveling to draw a figure of eight pattern on the seabed. We have installed the marker in the seabed for the manipulator operation training.

Table 3: Dive log (Dive #623)

Data	Local Time	Note	Description
10, February	09 : 05	KAIKO dove and started her operation.	
	09 : 12	KAIKO began to dive into the sea.	
	10 : 16	The separation of the vehicle and launcher.	
	10 : 31	New vehicle landed on the sea bottom (D=1,009m).	
		Maximum dive depth in this operation was 1,015m.	
	14 : 32	New vehicle left the sea bottom (D=745m).	
	14 : 47	The vehicle was combined with a launcher again.	
	15 : 27	KAIKO surfaced.	
	15 : 40	Recovered KAIKO and finished the operation.	

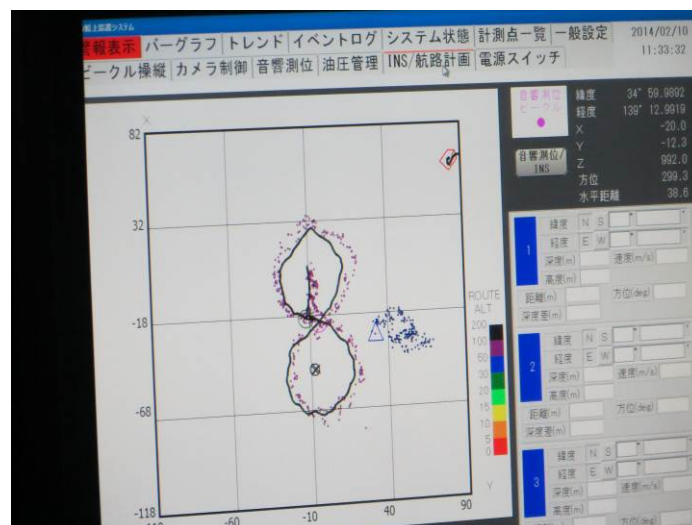


Figure 5: Figure-eight track chart by manual cruising



Figure 6. Installing the marker at the sea bottom

4-3. Dive #624

Contents of the dive:

- 1) Comprehensive test at sea
- 2) Auto cruising test
- 3) Operational test by manipulator
- 4) Observation equipment operational test by TDEM system

Test Area: Off Hatsushima island in Sagami Bay

In this dive #624, we were carried out operational test of KAIKO Mk-IV at the seafloor. The Mk-IV landed on the sea bottom, then, we started to measure by using TDEM (time domain electromagnetic methods) system. The procedure in each point is as follows.

- 1) Mk-IV placed the receiver unit of TDEM system on the seabed.
 - 2) Mk-IV moved about 10m away from the receiver unit.
 - 3) We recorded the data at R/V KAIREI.
 - 4) Mk-IV moved to next measurement point.
- After all measurement was finished, the receiver unit of TDEM system was recovered.

Table 4: Dive log (Dive #624)

Data	Local Time	Note	Description
13, February	07 : 42	KAIKO dove and started her operation.	
	07 : 49	KAIKO began to dive into the sea.	
	08 : 58	The separation of the vehicle and launcher.	
	09 : 10	New vehicle landed on the sea bottom (D=990m).	
		Maximum dive depth in this operation was 1000m.	
	14 : 51	New vehicle left the sea bottom (D=759m).	
	15 : 06	The vehicle was combined with a launcher again.	
	15 : 59	KAIKO surfaced.	
	16 : 07	Recovered KAIKO and finished the operation.	



Figure 7: Receiver unit of TDEM system



Figure 8: Recovering the measurement system

4-4. Dive #625

Contents of the dive:

- 1) Comprehensive test at sea
- 2) Auto cruising test
- 3) Operational test by manipulator system
- 4) Observation equipment operational test by TDEM system

Test Area: Off Hatsushima island in Sagami Bay

In this dive #625, we were carried out operational test of KAIKO Mk-IV at the seafloor. The Mk-IV landed on the sea bottom, then, we started to measure by using TDEM (time domain electromagnetic methods) system. The procedure in each point is as follows.

- 1) Mk-IV placed the receiver unit of TDEM system on the seabed.
- 2) Mk-IV moved about 10m away from the receiver unit.
- 3) We recorded the data at R/V KAIREI.
- 4) Mk-IV moved to next measurement point.

After all measurement was finished, the receiver unit of TDEM system was recovered. Then, she left the sea bottom.

Table 5: Dive log (Dive #625)

Data	Local Time	Note	Description
16, February	07 : 31	KAIKO dove and started her operation.	
	07 : 38	KAIKO began to dive into the sea.	
	08 : 32	The separation of the vehicle and launcher.	
	08 : 45	New vehicle landed on the sea bottom (D=805m).	
		Maximum dive depth in this operation was 805m.	
	11 : 33	New vehicle left the sea bottom (D=757m).	
	11 : 48	The vehicle was combined with a launcher again.	
	12 : 34	KAIKO surfaced.	
	12 : 44	Recovered KAIKO and finished the operation.	

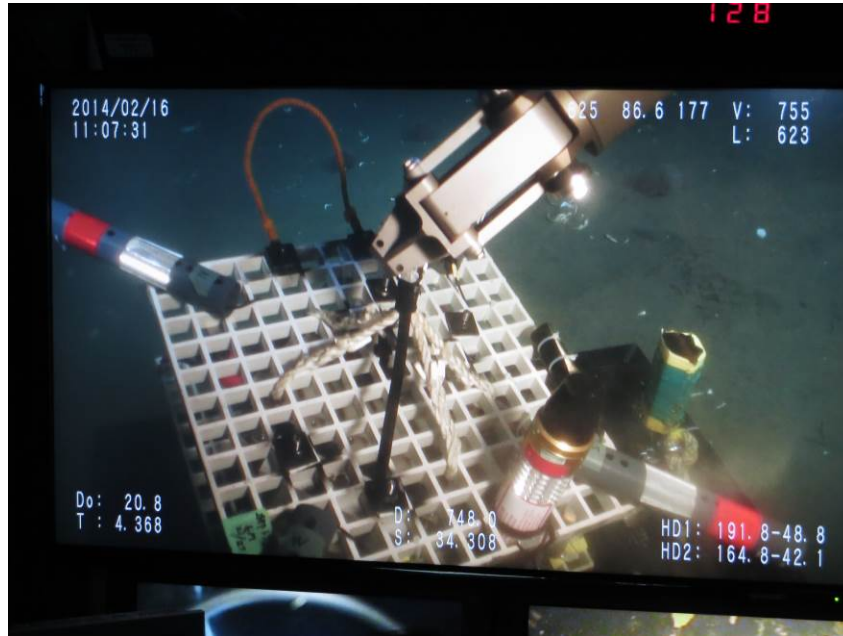


Figure 9: Installation and recovery of the measurement system

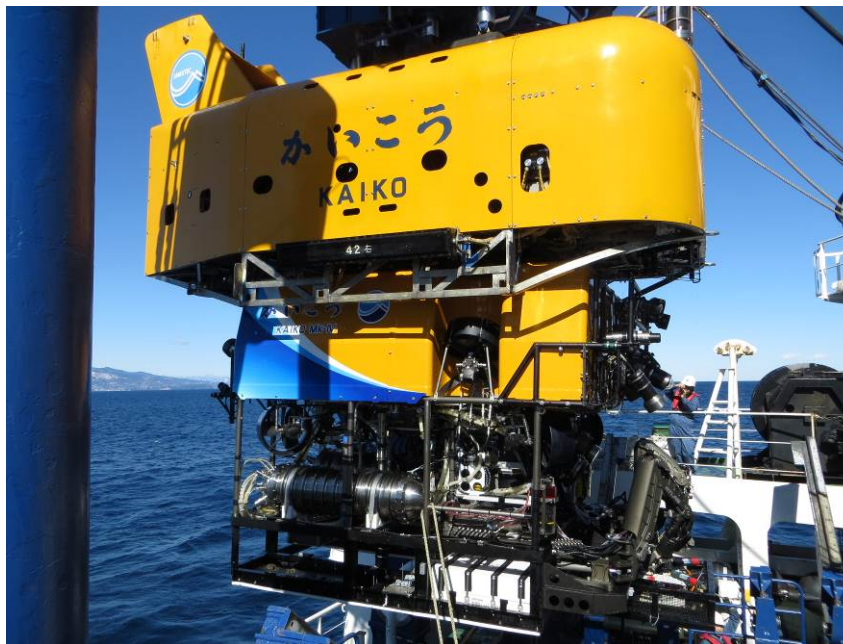


Figure 10: Recovered KAIKO system (Mk-IV and launcher) and finished the operation.

5. Summary

The third sea trial of new ROV (KAICO Mk-IV), which was connected launcher part of “KAICO 7000II” system, during KR14-03 cruise was carried out four dives with purpose of all devices of connections test, cruising test, operation test by using manipulators and confirmatory test for the vehicle’s operation method after her construction. We were also carried out a comprehensive test that simulates the operation of resource exploration by mounted a TDEM (time domain electromagnetic methods) system in the payload.

6. 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