R/V KAIREI Final Report

KR17-08C

Sea trial of a full depth ROV "UROV11K" system in the Mariana Trench

2017/05/05 – 2017/05/25

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

Contents

1. General Information

(1) *Cruise number/vessel's name*：KR17-08C (KR17-Murashima) / R/V KAIREI

(2) *Cruise name*：

Sea trial of a full depth ROV "UROV11K" system in the Mariana Trench

(3) *Cruise period*：

2017/05/05 – 2017/05/25

First entry into the EEZ of the FSM and USA (2017/05/12)

Final departure from the EEZ of the FSM (2017/05/18)

Final departure from the EEZ of the USA (2017/05/19)

(4) *Ports (yyyy/mm/dd)*：

Embarkation: Yokosuka, Japan (2017/05/05)

Disembarkation: Imabari, Japan (2017/05/25)

(5) *Sea area of research*：Sagami Bay and the Mariana Trench

2. Researchers

(1) Chief researcher：

Takashi Murashima (JAMSTEC)

(2) Boarding researchers：

Hidehiko Nakajoh, Ken Takai, Shinji Tsuchida, Kazumasa Oguri,

Junichi Miyazaki, Fumitaka Sugimoto, Kihachi Hasebe (JAMSTEC),

Noriyasu Yamauchi (Nippon Marin Enterprises,Ltd.),

Hiroshi Miyake, Tomoyoshi Sanada (Kitasato University),

Manabu Hirose (NHK Enterprises.Inc.),

Kenta Kuroki (Flaner Co.,Ltd.),

Tamotsu Ogawa (NHK),

Daisuke Hongo (NHK Media Technology,Inc.),

Katsutoshi Ishikawa (AIR-CAMERA Inc.)

3. Purpose and results

    (1) Purpose

        The main purpose of this proposed cruise was to observe the bottom of Mariana Trench widely through operating test for a newly developed full depth ROV "*UROV11K*" system. A chemical survey was also carried out with multi sensors (hydrogen, hydrogen-sulfide, oxygen, methane) equipped on the *UROV11K* to understand the animal populations, diversity and the chemical background.

        In summary, the proposed plan included the following research activities.

a) Confirmation of functions of the *UROV11K* system in the deepest sea environment.

b) Observing the bottom and recording the images by the *UROV11K* system

c) Estimating biodiversity and biomass of benthic animals by the baited-lander systems.

d) Chemical measurement by multi sensors (hydrogen, hydrogen-sulfide, oxygen, methane) equipped on the *UROV11K* and the lander.

e) Bathymetry survey using multi-beam echo sounder onboard the *R/V KAIREI*

f) Geophysical survey by means of a gravity meter, and three-component and proton magnetometers

g) Observation around with a submarine caldera

e) and f) were necessary for dives of the *UROV11K* and the lander. Therefore we conducted them before the *UROV11K* and the lander dived.

    (2) Diving points

A) 1,000m class test of the *UROV11*K and the lander (Sagami Bay in Japan)

B) 8,000m class test of the lander (Mariana Trench in the EEZ of the USA)

C) 11,000m class test of the *UROV11K* (Mariana Trench's Challenger Deep in the EEZ of the Federated States of Micronesia (FSM))

(3) Cruise log

	Date	works	location
1	2017/05/05 (Fri.)	Departure from Yokosuka Cruise for Sagami Bay	Yokosuka (JAMSTEC)
2	05/06 (Sat.)	Operation test of *UOV11K* 　(35°04.3′N, 139°13.3′E) Installation of the lander 　(35°04.3′N, 139°13.3′E)	Sagami Bay (1,000m)
3	05/07 (Sun.)	Recovery of the lander Cruise for the Mariana Trench	Sagami Bay (1,000m)
4	05/08 (Mon.)	Cruise for the Mariana Trench	-
5	05/09 (Tue.)	Cruise for the Mariana Trench	-
6	05/10 (Wed.)	Cruise for the Mariana Trench	-
7	05/11 (Thu.)	Cruise for the Mariana Trench	
8	05/12 (Fri.)	Sea trial of *UROV11K* 　(11°22.3′N, 142°26.0′E)	Mariana Trench (FSM, 11,000m)
		Installation of the lander 　(11°31.1′N, 143°10.1′E)	Mariana Trench (USA, 8,000m)
9	05/13 (Sat.)	Recovery of the lander Installation of the lander 　(11°34.3′N, 143°09.1′E)	Mariana Trench (USA, 8,000m)
10	05/14 (Sun.)	Sea trial of *UROV11K* 　(11°22.3′N, 142°35.5′E) The vehicle stopped rising at 5,320m depth.	Mariana Trench (FSM, 11,000m)
11	05/15 (Mon.)	Recovery of the lander	Mariana Trench (USA, 8,000m)
12	05/16 (Tue.)	Search for the vehicle with the launcher.	Mariana Trench (FSM, 11,000m)
13	05/17 (Wed.)	Installation of the lander 　(11°31.0′N, 143°08.2′E)	Mariana Trench (USA, 8,000m)
14	05/18 (Thu.)	Search for the vehicle with the equipment of the ship.	Mariana Trench (FSM, 11,000m)
15	05/19 (Fri.)	Recovery of the lander Cruise for Imabari, Japan	Mariana Trench (USA, 8,000m)
16	05/20 (Sat.)	Cruise for Imabari, Japan	
17	05/21 (Sun.)	Cruise for Imabari, Japan	
18	05/22 (Mon.)	Cruise for Imabari, Japan	
19	05/23 (Tue.)	Cruise for Imabari, Japan	
20	05/24 (Wed.)	Cruise for Imabari, Japan	
21	05/25 (Thu.)	Disembarkation	Imabari, Japan

(4)   Research Area of KR17-08C

a)   Sagami Bay (Fig.1)

35°02′N   139°15′E,

Research area is indicated by the circle.

b)   Mariana Trench (Fig.2)

11°00'N   142°00'E,   11°50'N   142°00'E

11°50'N   143°30'E,   11°00'N   143°30'E
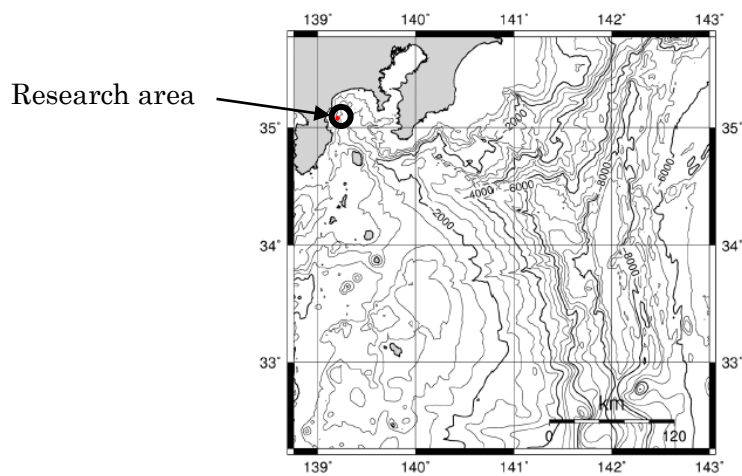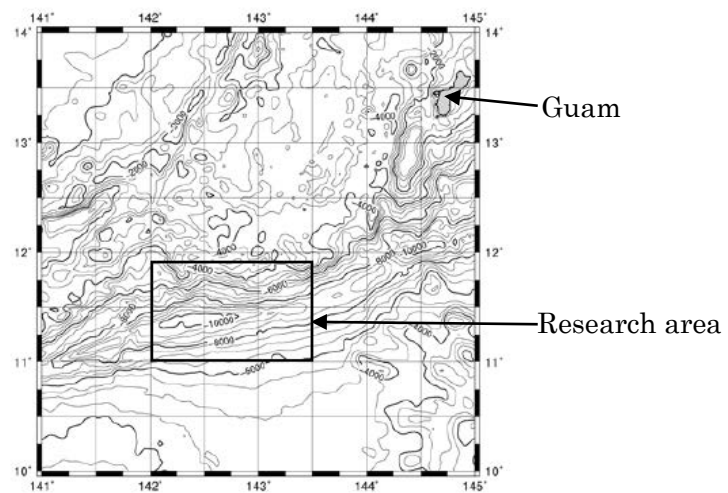
Research area is indicated by the box.

Research area →

Fig.1 Sagami Bay

→ Guam

→ Research area

Fig.2 Mariana Trench

(5) Specifications of the UROV11K and the lander
    a) UROV11K

	Vehicle	Launcher
Length	2.0 m	3.3 m
Width	1.2 m	2.0 m
Height	1.5 m	1.8 m
Weight in air	1,300 kg	2,000 kg
Max. Operating Depth	11,000m	
Power	100V DC (battery)	3,200V AC
Thrusters	forward/reverse: 2, vertical: 2	vertical: 2
Payload	- CTD -4K TV camera, HD (High Definition) TV cameras - LED lights	- CTD -2 × wide angle color TV cameras - halogen lights
Navigation	altimeter, depth sensor, flasher, obstacle avoidance sonar, compass, ARGOS beacon, iridium beacon, transponder	Compass, transponder
Cables	Optical/power composite cable: primary cable: 45 mm (diameter) × 12,000 m optical fiber cable: 1.0 mm (diameter) × 10,000 m 2set	

Fig3 The specification of *UROV11K* system

b)Lander

	Lander
Length	1.0 m
Width	1.0 m
Height	2.0 m
Weight in air	100 kg
Max. Operating Depth	8,500m
Payload	- CTD - 4K TV cameras - LED lights
Navigation	ARGOS beacon, transponder

Fig.4 The specification of the Lander

(6)   Test results of the UROV11K

The *UROV11K* is equipped with newly developed highly sensitive 4K camera, highly sensitive HD camera, and high speed large capacity optical communication device. It has been developed for two main purposes.

The first is to verify a new optical communication system using a combination of CWDM (Coarse Wavelength Division Multiplexing) and DWDM (Dense Wavelength Division Multiplexing). The large-capacity data of 4K video and HD video is transmitted with one optical fiber through this new system.

The other is to verify the launcher/vehicle type UROV system which can be used for large-area survey at ultra-deep sea.

The *UROV11K* reached to 10,899m depth on May 14 2017 during the cruise. The 4K and HD image of the *UROV11K* was confirmed successfully on the ship in real time. During the bottom survey by 4K and HD cameras, we found lots of holothurians sitting on the bottom directed same way, and several swimming amphipods.

After finishing the operation test in the EEZ of the Federated States of Micronesia, the vehicle started rising toward the surface. It gradually slowed down and stopped rising at 5,320 meters depth. Although we made every effort to recover the vehicle, we were unable to recover it. The situation was swiftly reported to the authority of the Federated States of Micronesia through the diplomatic route.

(7)   In situ sensors for hadal zone

In situ sensors are useful for both seeking chemosynthetic community and analyzing chemical background of chemosynthetic animals and microorganisms in deep-sea studies.

However, no sensors were available in the hadal environments because the current sensors were not designed against the pressure subjected at the hadal zone.

We developed two sensors which can use at hadal zone. One was methane sensor system which can measure environmental methane concentration within 40 µmol/L. Another was multi sensor system with mini data logger which can measure environmental hydrogen, hydrogen sulfide and so on within 100 µmol/L, although we prepared only hydrogen sensor in this KR17-08C cruise. We carried out 120MPa pressurizing test on shore and we confirmed the pressure resistance of these instruments expect for the amp of multi sensor system which amplified the signal from grass sensor and deformed but worked normally during pressurizing test.

These instruments were equipped on the *UROV11K* and dived at the Mariana Trench on 14 May 2017. When the *UROV11K* reached at 8,800m, the signal of hydrogen sensor showed abnormal values. This suggested that deformed amp or grass sensor was broken at the depth. Therefore, we must continue to

develop the multi sensor system against the hadal zone. However, methane sensor demonstrated normal signal even at the bottom (10,899m) until cutting fiber cable connected to launcher indicating that there were no methane seep in this area but we have succeeded in constructing full-depth methane sensor system.
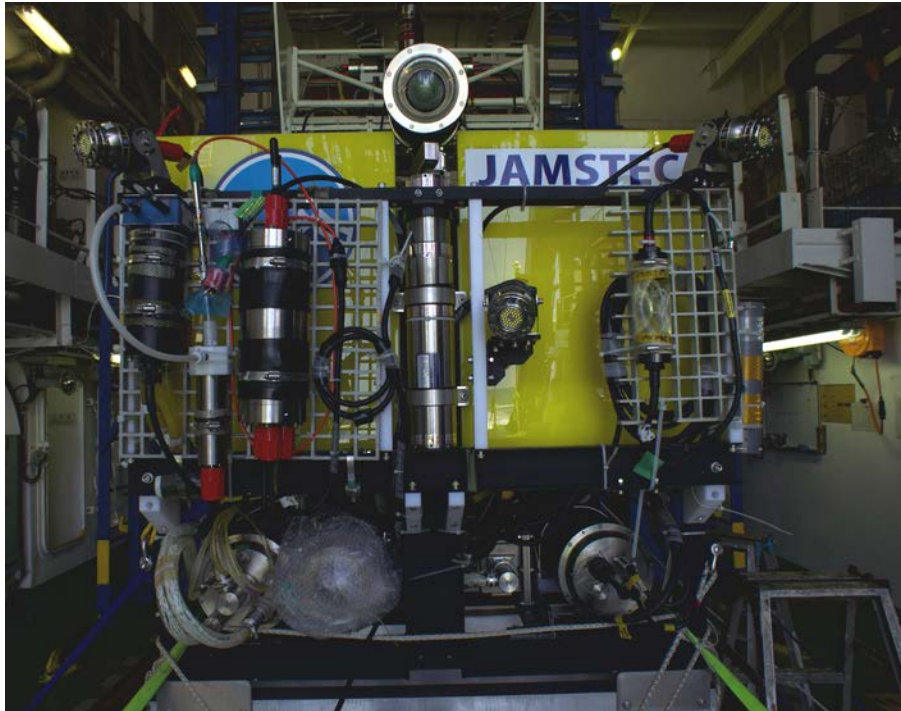

Fig.5   In situ sensor systems equipped on the *UROV11K*

(8)   Results of the Compact hadal lander

   The lander was deployed at the central Sagami Bay and the north edge of the Mariana Trench (Table 1). The results of the deployments and the recorded videos are shown in Table 2. The averaged descending/ascending speeds were 46 and 54 m/min, respectively.

   At 8,146m site (deployment #2), fishes were absent throughout the video recording. Several species of amphipods were appeared around the bait. At 7,498m and 8,178m sites (deployments #3 and #4) in the Mariana Trench, the 4K camera (SONY) recorded deep-sea fish, possibly to be Pseudoliparis sp. At the former site, the several individuals of the fish appeared during the recording. On the other hand, only one fish was confirmed at the latter site. At least two kinds of amphipods (*Hirondellea gigas* and *Princaxelia jamiesoni*) were abundant and several large mysidaceans (about 5cm in total length) were observed at all sites.

Table 1. The date, time, locations and depths of four lander deployments.

Deployment #1, Sagami bay

Date	Time (UTC)	Longitude	Latitude	Depth (acoustic signal)	Remarks
2017/5/6	06:03:00	35–04.3239N	139–13.2435E	1070m	Hang up
	06:05:00	35–04.3172N	139–13.2357E	0m	Lander at sea surface
	06:05:00	35–04.3166N	139–13.2349E	0m	Release
	06:21:56	35–04.2963N	139–13.2282E	1068m	Confirm landing
	06:23:00	35–04.3344N	139–13.2903E	1078m	Fixed landed location
2017/5/7	22:53:20	35–04.1952N	139–13.1334E	1049m	Tracking start
	22:55:03	35–04.2143N	139–13.1550E	1055m	Send release command (1)
	23:01:33	35–04.2412N	139–13.1805E	1059m	Reset (1)
	23:01:59	35–04.2419N	139–13.1797E	1060m	Reset (2)
	23:03:00	35–04.2411N	139–13.1798E	1058m	Send release command (2)
	23:08:43	35–04.2439N	139–13.1781E	1058m	Comfirm ascending
	23:25:47	35–04.2620N	139–13.1830E	1060m	Confirm at sea surface
	23:49:48	35–04.5256N	139–13.3083E	1052m	Hang up
	23:55:08	35–04.5565N	139–13.3133E	1042m	Lander on deck

Deployment #2, Mariana Trench

Date	Time (UTC)	Longitude	Latitude	Depth (acoustic signal)	Remarks
2017/5/12	03:47:16	11–31.2733N	143–10.3046E	8137m	Top buoy at sea surface
	03:47:47	11–31.2732N	143–10.3075E	8146m	Hang up
	03:49:28	11–31.2731N	143–10.3155E	8148m	Lander at sea surface
	03:49:33	11–31.2731N	143–10.3157E	8148m	Release
	07:05:00	11–31.1936N	143–09.8733E	8049m	Confirm landing
		11–31.2342N	143–09.9510E	8104m	Landed (tentative location)
	07:23:44	11–30.7016N	143–09.9845E	8064m	
	08:23:12	11–30.7300N	143–10.1702E	8052m	
2017/5/13		11–31.1015N	143–10.0652E	8146m	Fixed landed location
	05:00:02	11–31.0573N	143–10.0576E	8089m	Send release command (1)
	05:03:08	11–31.0845N	143–10.1100E	8094m	Send release command (2)
	05:03:30				Comfirm ascending
	22:33:10	11–31.0618N	143–09.5822E	8094m	Confirm at sea surface
	22:58:48	11–31.1255N	143–09.4783E	8091m	Hang up
	23:00:20	11–31.1298N	143–09.4793E	8093m	Lander on deck

Deployment #3, Mariana Trench

Date	Time (UTC)	Longitude	Latitude	Depth (acoustic signal)	Remarks
2017/5/14	05:52:59	11–34.5057N	143–09.5429E	7459m	Hang up
	05:54:06	11–34.5048N	143–09.5418E	7464m	Lander at sea surface
	05:54:09	11–34.5048N	143–09.5420E	7464m	Release
	08:53:19	11–34.5395N	143–08.9269E	7393m	Confirm landing
		11–34.5408N	143–0..8921N	7459m	Landed (tentative location)
	09:10:58	11–34.0091N	143–09.0797E	7526m	Calibration start
	10:05:27	11–34.1422N	143–09.2741E	7465m	Calibration end
		11–34.3447N	143–09.0968E	7498m	Fixed landed location
2017/5/15	21:48:02	11–34.1607N	143–08.3009E	7541m	TRACKING START
	21:52:29	11–34.2171N	143–08.4827E	7556m	Send release command (1)
	21:53:02	11–34.2249N	143–08.5148E	7556m	Comfirm ascending
	22:32:03	11–34.4051N	143–08.9081E	7556m	Reset (1)
	22:32:41	11–34.4072N	143–08.9046E	7556m	Reset (2)
	00:12:18	11–34.2707N	143–08.5855E	7556m	Confirm at sea surface
	00:33:17	11–34.3028N	143–08.4661E	7556m	Hang up
	00:35:02	11–34.3067N	143–08.4469E	7556m	Lander on deck

Deployment #4, Mariana Trench

Date	Time (UTC)	Longitude	Latitude	Depth (acoustic signal)	Remarks
2017/5/16	23:35:26	11–31.0094N	143–08.5484E	8186m	Hang up
	23:37:44	11–31.0124N	143–08.5524E	8145m	Release
	23:42:00				Tracking interval 8s→64s
2017/5/17	02:37:00				Tracking interval 64s→16s
	02:55:15	11–30.9611N	143–08.0202E	8156m	Confirm landing
		11–31.0455N	143–08.1133E		Landed (tentative location)
	03:06:20	11–30.7473N	143–08.2322E	8252m	Calibration start
	04:00:24	11–30.7696N	143–08.5893E		Calibration end
		11–30.9781N	143–08.1869E	8217m	Fixed landed location
2017/5/18	20:47:16	11–30.9197N	143–07.8709E	8180m	Tracking start
	21:00:01	11–30.9215N	143–07.9833E	8183m	Send release command (1)
	21:00:35	11–30.9196N	143–07.9816E	8183m	Send release command (2)
	21:01:22	11–30.9190N	143–07.9837E	8176m	Send release command (3)
	21:06:43	11–30.9196N	143–08.0293E		Reset (1)
	21:07:35	11–30.9204N	143–08.0343E	8180m	Reset (2)
	21:09:24	11–30.9228N	143–08.0368E	8180m	Reset (3)
	21:09:59	11–30.9247N	143–08.0355E	8180m	Reset (4)
	21:10:36	11–30.9259N	143–08.0341E	8180m	Send release command (4)
	21:16:22	11–30.9629N	143–08.1628E	8180m	Reset (1)
	21:17:02	11–30.9668N	143–08.1722E	8180m	Reset (2)
	21:21:18	11–30.9778N	143–08.1829E	8180m	Reset (3)
	21:21:54	11–30.9792N	143–08.1798E	8180m	Reset (4)
	21:22:32	11–30.9820N	143–08.1759E	8180m	Reset (5)
	21:23:02	11–30.9833N	143–08.1733E	8180m	Reset (6)
	21:23:50	11–30.9853N	143–08.1691E	8180m	Send release command (5) Confirm ascending
	21:28:29	11–30.9840N	143–08.1638E	8180m	Reset (1)
	21:29:01	11–30.9833N	143–08.1618E	8180m	Reset (2)
	21:29:38	11–30.9822N	143–08.1582E	8180m	Reset (3)
	21:30:05	11–30.9818N	143–08.1550E	8180m	Reset (4)
	21:31:38	11–30.9801N	143–08.1401E	8180m	Tracking interva16s→64s
	23:18:46	11–30.9408N	143–07.9133E	8180m	Tracking interva64s→16s
	23:54:19	11–30.9119N	143–07.8670E	8180m	Confirm at sea surface
2017/5/19	00:10:32	11–30.9068N	143–07.8377E	8180m	Hang up
	00:12:10	11–30.9107N	143–07.8289E	8180m	Lander on deck

Table 2. The depth, locations and video sequences of the deployments. The depths of deployments #1~3 are obtained by acoustic response time the transponder installed on the lander and #4 was by CTD.

Deployments	Date (UTC)	Latitude	Longitude	Depth	Video sequences (GoPro)	Video sequences (Handycam 4K)
1	2017/5/6	35-04.3344N	139-13.2903E	1078m	11min x 5	60min x 8
2	2017/5/12	11-31.1015N	143-10.0652E	8146m	10 min x 5	183min x 2, 142min x 1
3	2017/5/14	11-34.3447N	143-09.0968E	7498m	-	60min x 8
4	2017/5/17	11-30.9781N	143-08.1869E	8178m (CTD)	10 min x 5, 41sec x 1	53min x 12