doi : 10.17596/0002724

KAIREI "Cruise Report"

KR17-11 Leg2

Study of adaptive underwater Optical wireless communication with photomultiplier tube

Suruga bay

July 26th, 2017

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

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.

Contents

1. Cruise Information

Cruise ID

KR17-11 Leg2

Name of vessel

Kairei

Title of the cruise

Study of adaptive underwater Optical wireless communication with photomultiplier tube

Title of proposal

Study of adaptive underwater Optical wireless communication with photomultiplier tube

Cruise period

July 26th, 2017

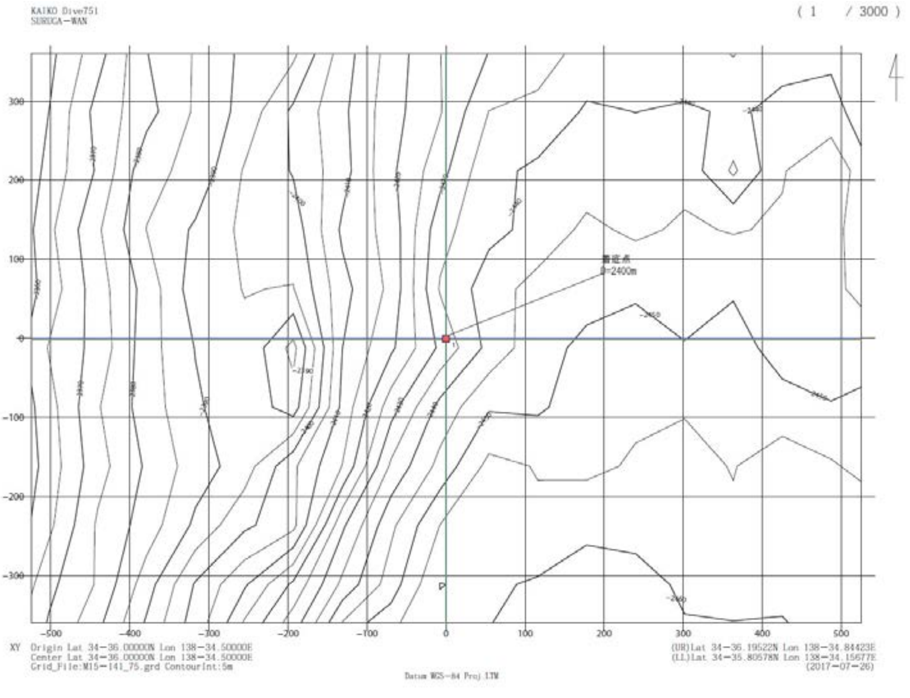
Ports of departure / call / arrival

Yokosuka/Shimidzu

Research area

Suruga bay

Research Map



2. Researchers

Chief scientist [Affiliation]

Takao Sawa [JAMSTEC]

Representative of the science party [Affiliation]

Takao Sawa [JAMSTEC]

Science party (List) [Affiliation, assignment etc.]

Tadahiro Hyakudome [JAMSTEC]

Naoki Nisihmura [SHIMADZU Corp.]

Masahiro Tomisaka [SHIMADZU Corp.]

Kazuma Oowaki [SHIMADZU Corp.]

Yuuki Ebara [SHIMADZU Corp.]

Ryousuke Nishi [SHIMADZU Corp.]

Tatsuya Ishimori [SHIMADZU Engineering Corp.]

Shin Ito [SAS Corp.]

Yoshiaki Kawashima [SAS Corp.]

Naoyuki Aichi [Aiichi Corp.]

Akira Yokoyama [Aiichi Copr.]

Tadashi Murashima [JAMSTEC]

Hidehiko Nakajyo [JAMSTEC]

Tuyoshi Miyazaki [JAMSTEC]

Fumitaka Sugimoto [JAMSTEC]

Yoshimi Yamakita [JAMSTEC]

Shinpei Goto [Tokyo Univ. of Marine Sci. and Tec.]

Yusuke Kozawa [Ibaraki Univ.]

3. Observation

3.1 Purpose, Objectives, background

We develop an underwater wireless optical communication (UWOC) modem using laser diode(LD) that emits visible light. The modem make an Ethernet connection to/from an underwater vehicle to establish underwater internet of things (IoT) in near future.

Because radio wave will attenuate highly in sea water as electro conductor, acoustic communication usually used for underwater wireless communication. But the sound speed is low around 1500 m/s, and the frequency is one to three figures in unit of kHz. These facts mean acoustic communication don't become high speed like a radio communication theoretically. If we transfer 1M bytes of a picture on acoustic communication, 14 minutes will be cost.

Around 450 nm light has low absorption in clear water, but the wave length of the most low absorption become long, and the absorption increase as suspended particles like marine-snow grow. In addition, ships and underwater vehicles is usually unstable by disturbance of ocean wave and current. The instability make axis alignment of collimated light such as laser difficult, and results in loss of wireless optical link. But just expanding the laser beam, communication range becomes too short for practical use.

Human occupied vehicles (HOV) have been used from dawn of underwater vehicles. Someone must ride into HOV, but remotely operated vehicles (ROV) will operated from mother ship by tether cables. ROV have changed underwater working especially in deep water. Now autonomous underwater vehicles (AUV), or underwater drone, are rapidly spreading with development of computers and batteries. The underwater drones load many observation tools and acquire large size of data during a mission, but the data is just stored in the drones until surfaces or landing. Nevertheless to say, it's caused by lack of high speed wireless communication. If we can use UWOC, large amounts of data such as sonar images and camera images can be transfer to/from other vehicle, mother ships and ocean bottom stations.

3.2 Observations, Activities

I. Communication trials with the underwater wireless optical communication system, loaded on ROV'KAIKO'

II. Water profiling with CTD and special instruments for optical transparency and reflectivity

III. Water sampling

3.3 Methods, Instruments

I. Underwater wireless optical communication systems are loaded on launcher and vehicle of ROV'KAIKO'. After the ROV dives to 700m depth, the vehicle is released from the launcher and descends up to 850m while optical wireless communications by the system.

II. CTD and special instruments for optical transparency and reflectivity are in the sample basket of the Vehicle and profiling underwater continuously through the dive.

III. A pair of 5l water sampling bottle are set behind of the robot arm of the vehicle and sample waters in the trial.

3.4 Research results

Around 700m depth at 9:28, the vehicle was released and began descent. The vehicle and launcher were kept the same horizontal position whole the trial. The sea water at the trial filed isn’t clear and we found much amounts of marine snow (fig. 1), but the optical wireless communication was steady. The vehicle went away from the vehicle step by step, the blue light as a carrier signal from the underwater optical wireless system became small and weak to been seen (fig. 2).Finally we confirmed the optical communication at 120m distance in 20 Mbps speed and remote desktop connection at 100m distance.

Fig. 1 many suspended particles were seen in the trial field.

Fig. 2 blue light like a star was carrier light from the vehicle,
and green light like a jet was carrier light from the launcher.

4. Future plans

All devices equipped Wi-Fi or Ethernet, including smartphones, can use the underwater wireless optical systems theoretically. We continue the development of the underwater optical wireless communication and challenge world first underwater Wi-Fi network.

Appendix

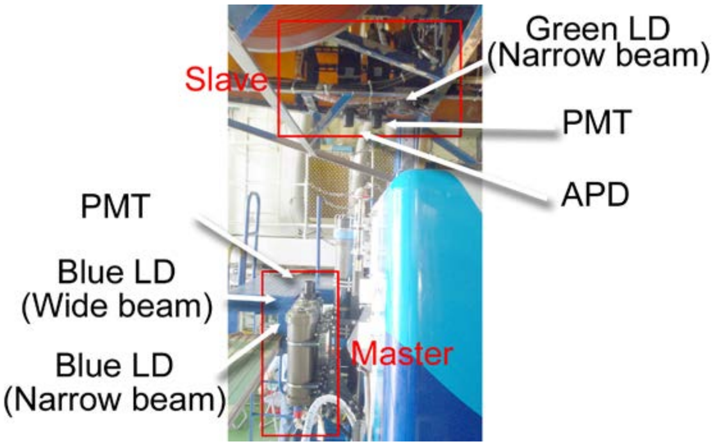
A. List of observation equipments

A.1 ROV 'Kaiko'

	Launcher	Vehicle (*KAIKO Mk-IV*)
Length	5.2 m	3.0 m
Breadth	2.6 m	2.0 m
Height	3.2 m	2.6 m
Weight in the air	5.8 tons	5.5 tons
Maximum diving depth	11,000 m	7,000 m
Payload weight	-	300 kg in air, 200 kg in water
Tow speed	Up to 1.5 knots	0 to 1.0 knots
Research and observational equipment	CTD, side scan sonar, and sub-bottom profiler	Two video cameras, digital still camera, two high definition video cameras, video camera with a wide-angle fisheye lens, compact monitoring video camera, lights, CTD, and dissolved oxygen meter
Navigational equipment	Obstacle detecting sonar, monochrome video camera	Thrusters, obstacle detecting sonar, altimeter,

	for monitoring the Launcher/Vehicle connection, video camera for monitoring the secondary cable, altimeter using the primary wave from the sub-bottom profiler, compass, and depth meter also used for the CTD sensor	inertial navigation system, Doppler Velocity Log, depth meter, monochrome rear view video camera, video camera for monitoring the Launcher/Vehicle connection, and ROV-Homer
Operational equipment	-	Two manipulators with seven degrees of freedom
Cables	Optical/power composite cables (12,000 meter-long primary cable with a diameter of 45 millimeters and 250 meter-long secondary cable with a diameter of 29.5 millimeters)	

A.2 The Underwater optical wireless communication system

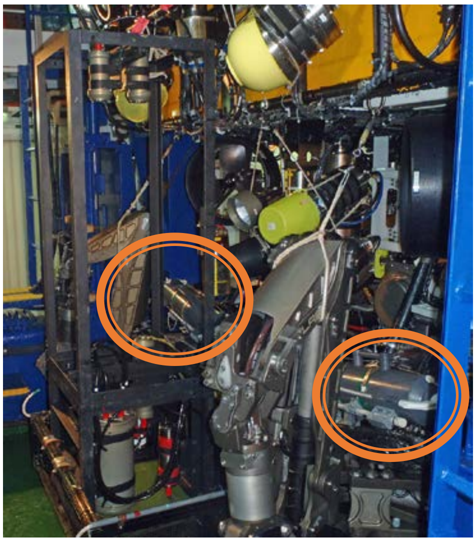


Weight[kg]	40 (in air)
Power consumption[w]	350 max.
Wavelength[nm]	450, 525, 640
Output light power[w]	>5
Beam angle[deg]	variable (depending on lenses)
Operation depth[m]	1000 max.
Range[m]	>50
Communication speed	25 Mbps max.
Communication protocol	100M Ethernet (TCP and UDP)

A.3 CTD and special instruments for optical transparency and reflectivity (Underwater optical profiler)

Weight[kg]	60 (in air)
Dimension[m]	1.5L x 0.4W x 0.4H
Measurement items	Attenuation(@ 460, 525 and 625[nm]) Scatter(@ 370, 400, 435, 470, 505, 525, 550, 590 snf 635[nm]) Conductivity, Temperature, Depth, Dissolve oxygen, Salinity, Chlorophyll and Turbidity

A.4 Water sampling bottole



Niskin 5l (General Oceanic inc.)

B. Dive information

Dive No. 751

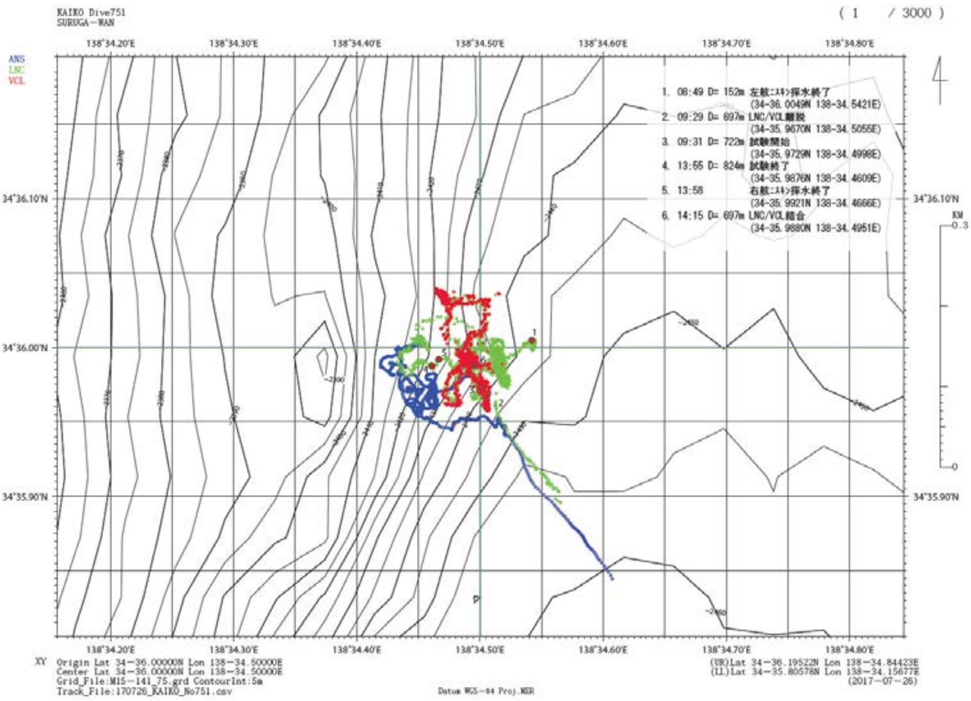
Date: 2017/7/26

Dive Area: Suruga Bay

Dive log

Time	Depth(m)	Event	Latitude/Longitude
8:30		Hoisted up	
8:35		Sea surface	
8:40		High voltage was supplied	
8:43		System check at 150m	
8:49	152	Water was sampled with left Niskin bottle	34−36.0049 N 138−34.5421 E
8:51		Descend	
9:22		End of descend	
9:29	697	Vehicle was released from launcher	34−35.9670 N 138−34.5055 E
9:31	722	Trial was started	34−35.9729 N 138−34.4998 E
13:55	824	Trial was finished	34−35.9876 N 138−34.4609 E
13:58	824	Water was sampled with right Niskin bottle	34−35.9921 N 138−34.4666 E
14:15	c697	Vehicle was docked docked with launcher	34−35.9880 N 138−34.4951 E
14:18		Ascend	
14:55		High voltage was cut	
15:04		Sea surface	
15:16		On deck	

Dive tracks


KAIKO Dive751
SURUGA－WAN
(1 / 3000)
ANS
LNC
VCL
4
1. 08:49 D= 152m 左舷ニスキン採水終了
(34-36.0049N 138-34.5421E)
2. 09:29 D= 697m LNC/VCL離脱
(34-35.9670N 138-34.5055E)
3. 09:31 D= 722m 試験開始
(34-35.9729N 138-34.4998E)
4. 13:55 D= 824m 試験終了
(34-35.9876N 138-34.4609E)
5. 13:58 右舷ニスキン採水終了
(34-35.9921N 138-34.4666E)
6. 14:15 D= 697m LNC/VCL結合
(34-35.9880N 138-34.4951E)
138°34.20'E
138°34.30'E
138°34.40'E
138°34.50'E
138°34.60'E
138°34.70'E
138°34.80'E
34°36.10'N
34°36.00'N
34°35.90'N
KM
0.3
0
XY
Origin Lat 34－36.00000N Lon 138－34.50000E
Center Lat 34－36.00000N Lon 138－34.50000E
Grid_File:M15－141_75.grd ContourInt:5m
Track_File:170726_KAIKO_No751.csv
Datum WGS－84 Proj.MER
(UR)Lat 34－36.19522N Lon 138－34.84423E
(LL)Lat 34－35.80578N Lon 138－34.15677E
(2017－07－26)