

UNDERWATER VISIBLE LIGHT COMMUNICATION

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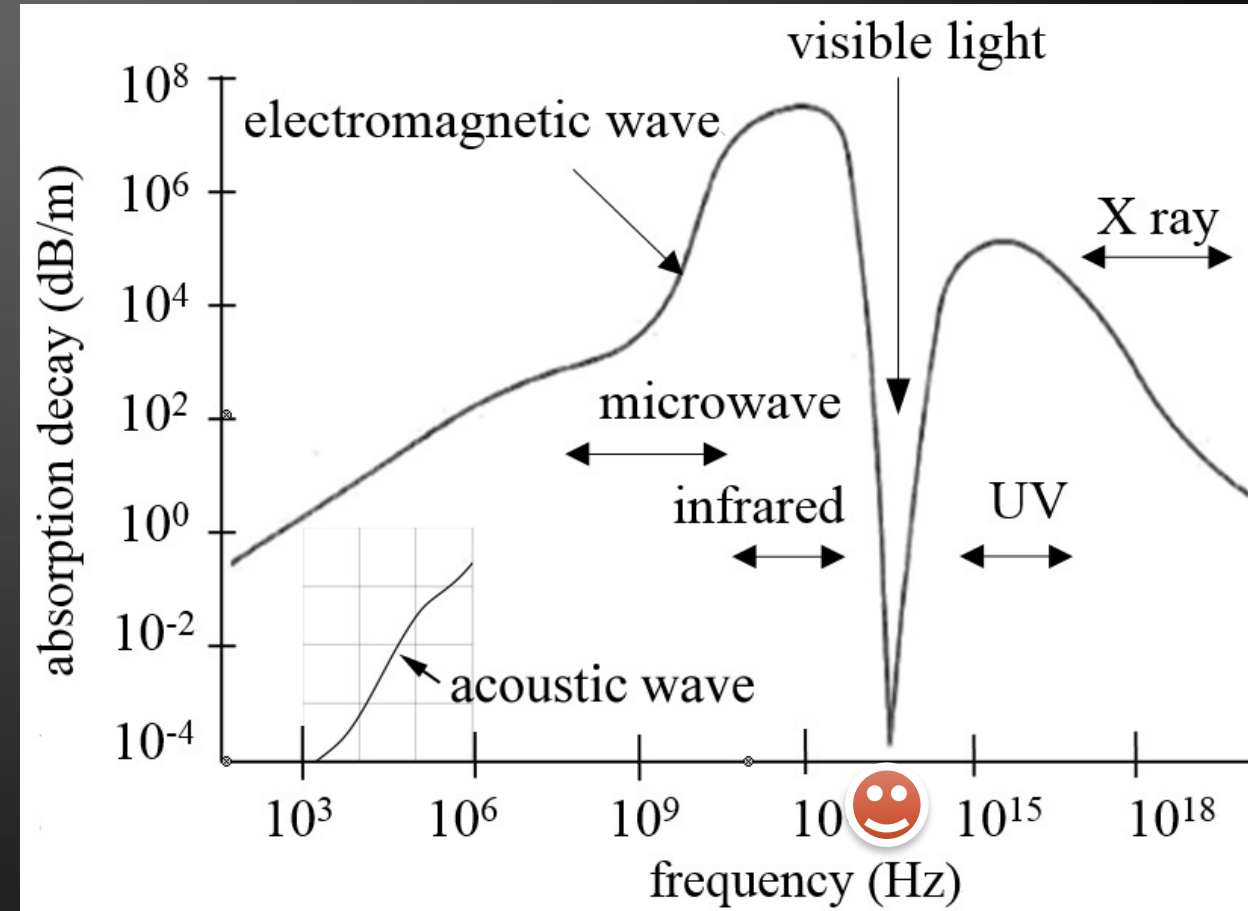


BACKGROUND OF UNDERWATER COMMUNICATION

Electro-magnetic wave is absorbed much in seawater.
→ It propagates few meters.

Acoustic wave is absorbed little, but its frequency is low.
→ The data transmission rate is often under 10kbps.

However, absorption of visible light is low decay, and the frequency is high.

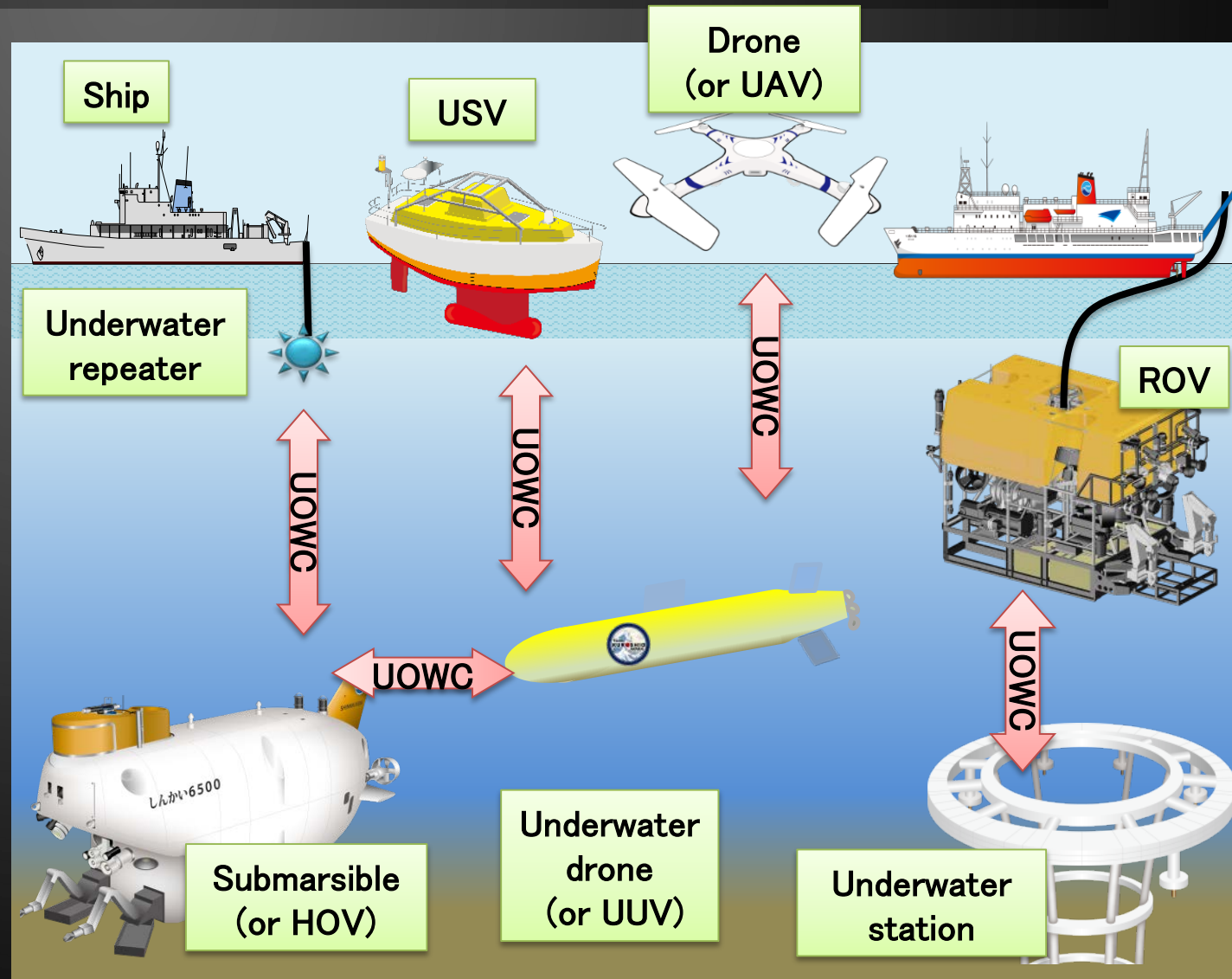


WHAT IS UOWC




Underwater Optical Wireless Communication must use visible light as signal carrier. UOWC is often called instead of UVLC.

The light source is gallium nitride semiconductor in many cases, that shine brightly at low power consumption.

The UOWC is 100 times higher in short range than acoustic communication.



COMMERCIAL UOWC MODEMS

	Sonardyne	Toyo electronics	Daitron technology
Range	Up to 150m	Up to 20m	10m in bi-directional 25m in uni-directional
Speed	Up to 12.5Mbps	Up to 50Mbps(@20m)	10Mbps
Main market	Underwater drone	Diving	Underwater drone
			

LD VS LED

(@VISIBLE WAVELENGTH)

A communication speed can become higher

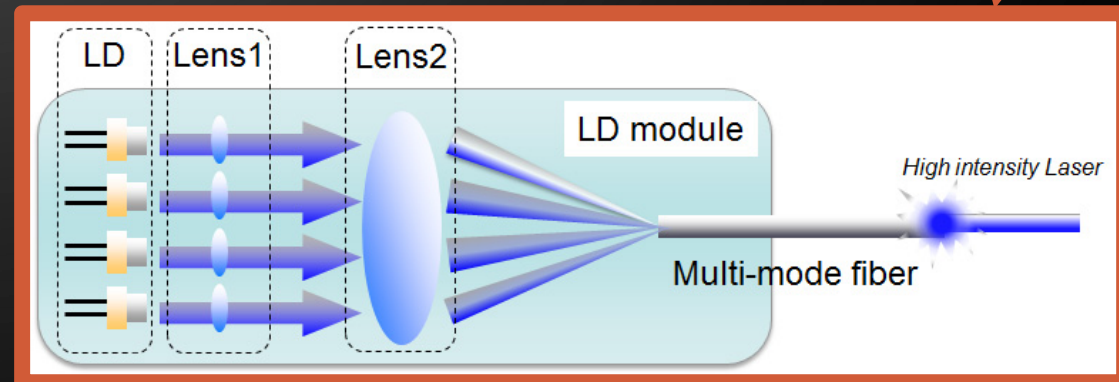
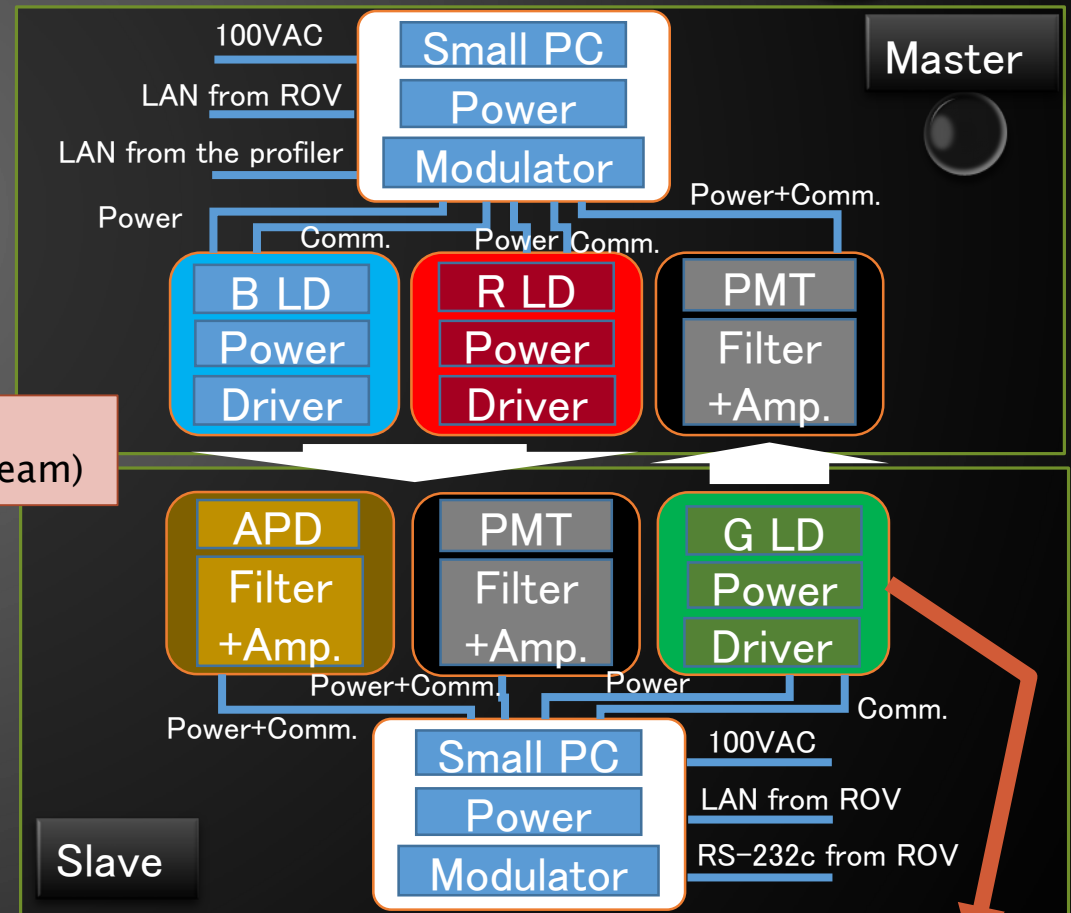
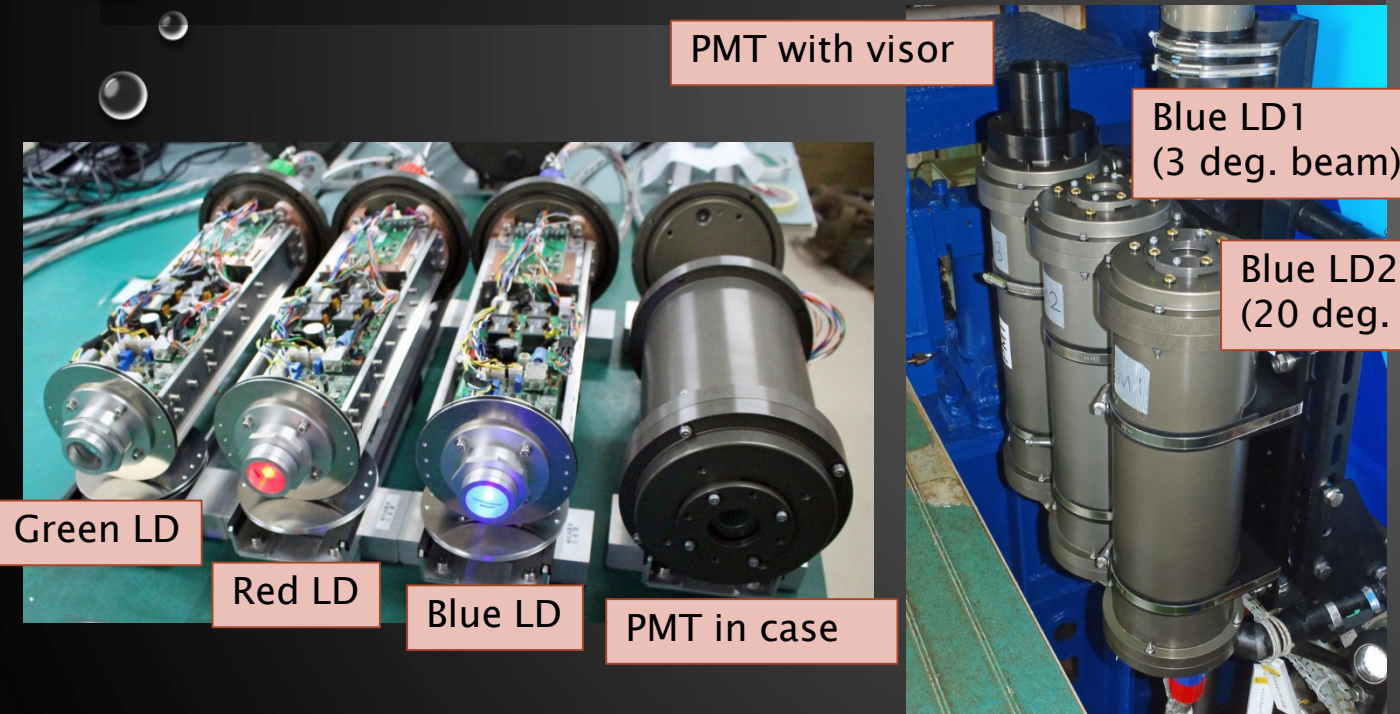
	LED	LD
Response	up to 50Mhz	over 1Ghz
Wavelength bandwidths	approx. 20nm	approx. 2nm
Coherence	incoherent	Coherent

A Narrow bandpass filter can be used In front of a detector

External noise, such as sun light, is removed efficiently

A light distribution can be controlled with simple optical system easily (and more sharp beam can be made).

OUR PROTOTYPE MODEM FOR UOWC

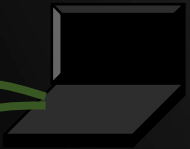


Weight of the master or the slave	A total of 40 kg in air
Power consumption	350 W max.
Wavelength	450, 525, 640 nm
Max. output light power	>5 w
Beam angle	variable (depending on lenses)
Operation depth	up to 1000 m
Communication range and speed	>120 m @ 20Mbps in the sea >190 m @ 32kbps in the pool
Communication protocol	100M Ethernet (TCP, UDP)

UOWC ACROSS THE WATER SURFACE AND BETWEEN VEHICLES



Control PC



Mirror for a turn

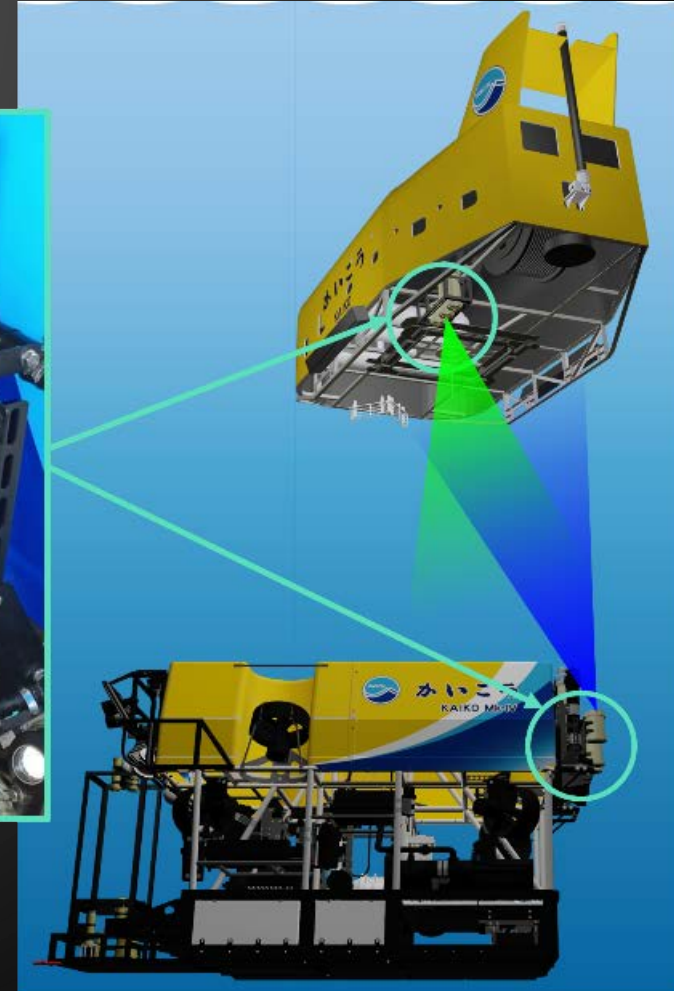


Periscope

Pool



UWOC modem



Successful bi-directional underwater communication over 100m range at 20Mbps with an underwater optical wireless communication modem

~This is a major breakthrough to establish underwater optical Wi-Fi and the IoT~

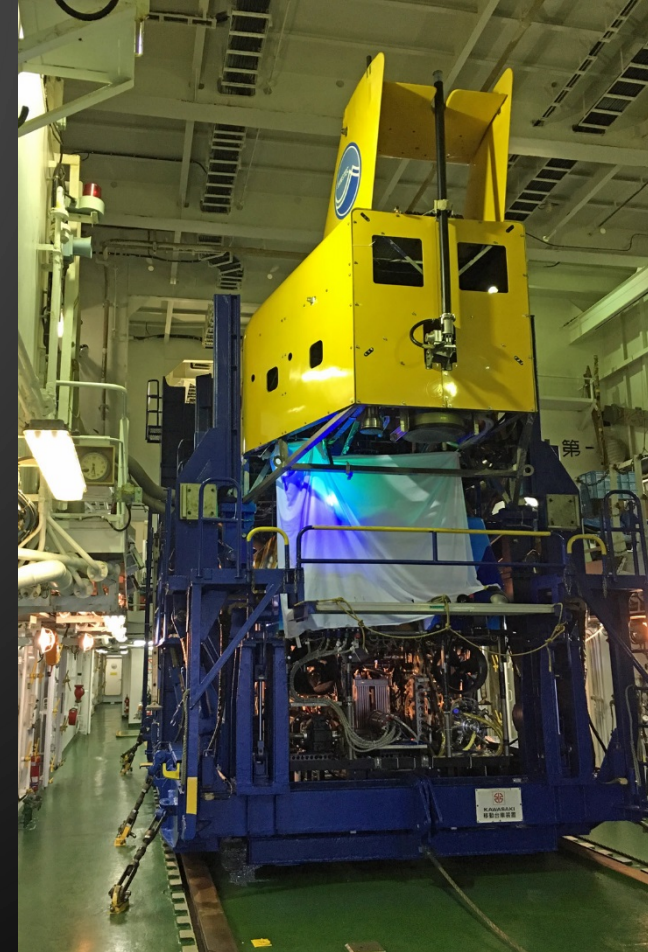
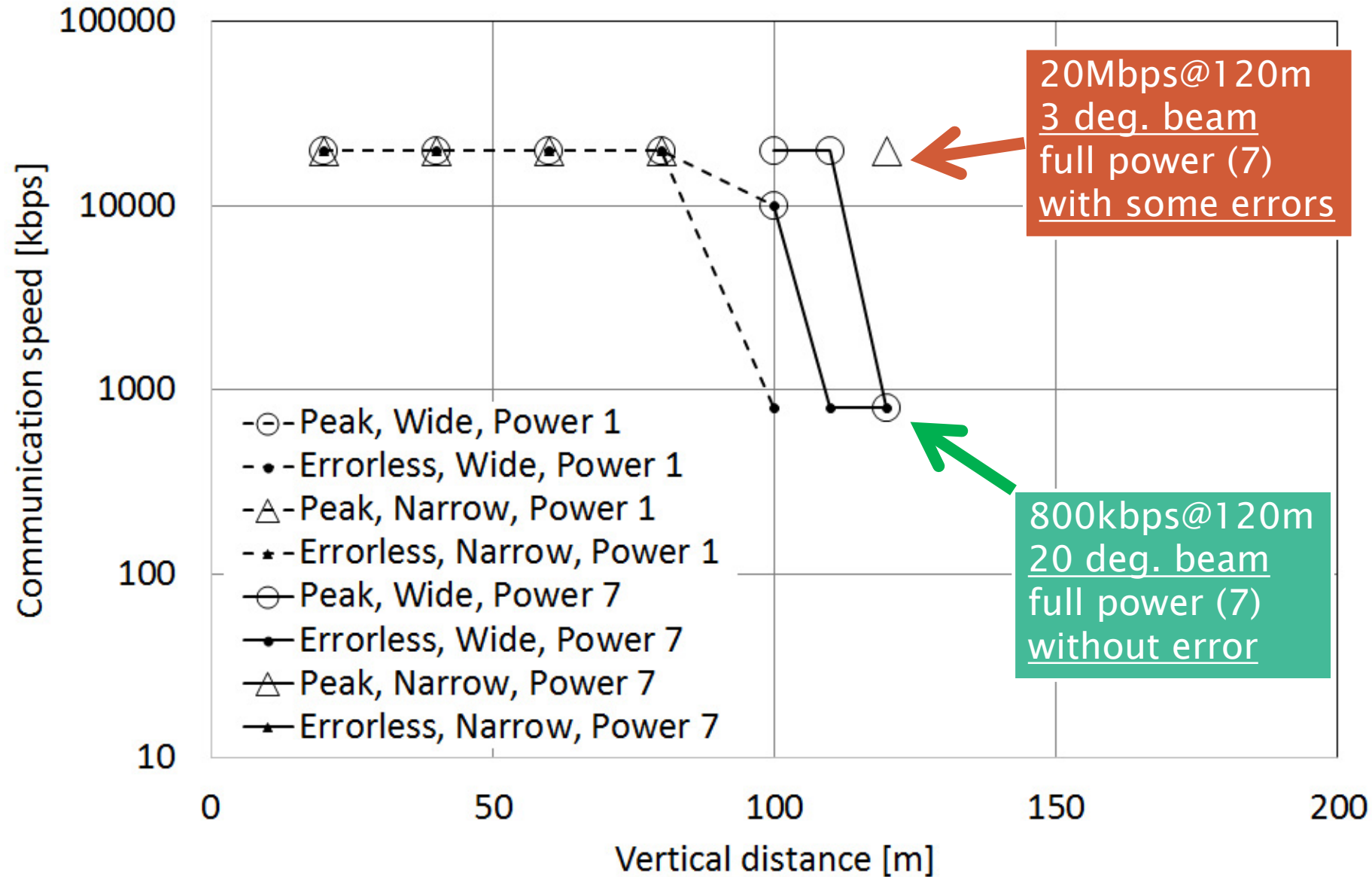


JAMSTEC

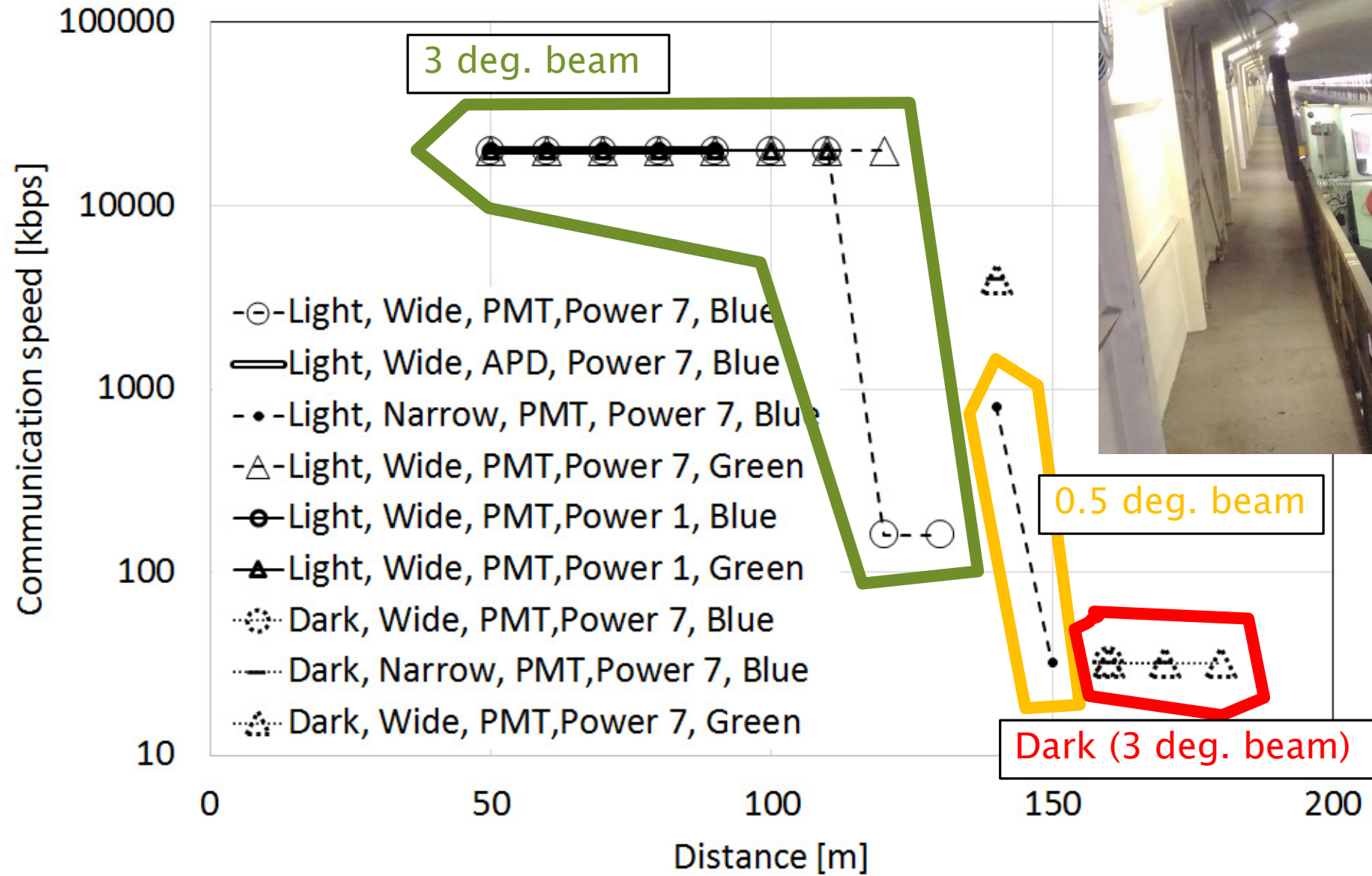
国立研究開発法人
海洋研究開発機構

Japan Agency for Marine-Earth Science and Technology

COMMUNICATIONS BETWEEN ROV 「KAIKO」 MODULES



COMMUNICATIONS IN TEST POOL

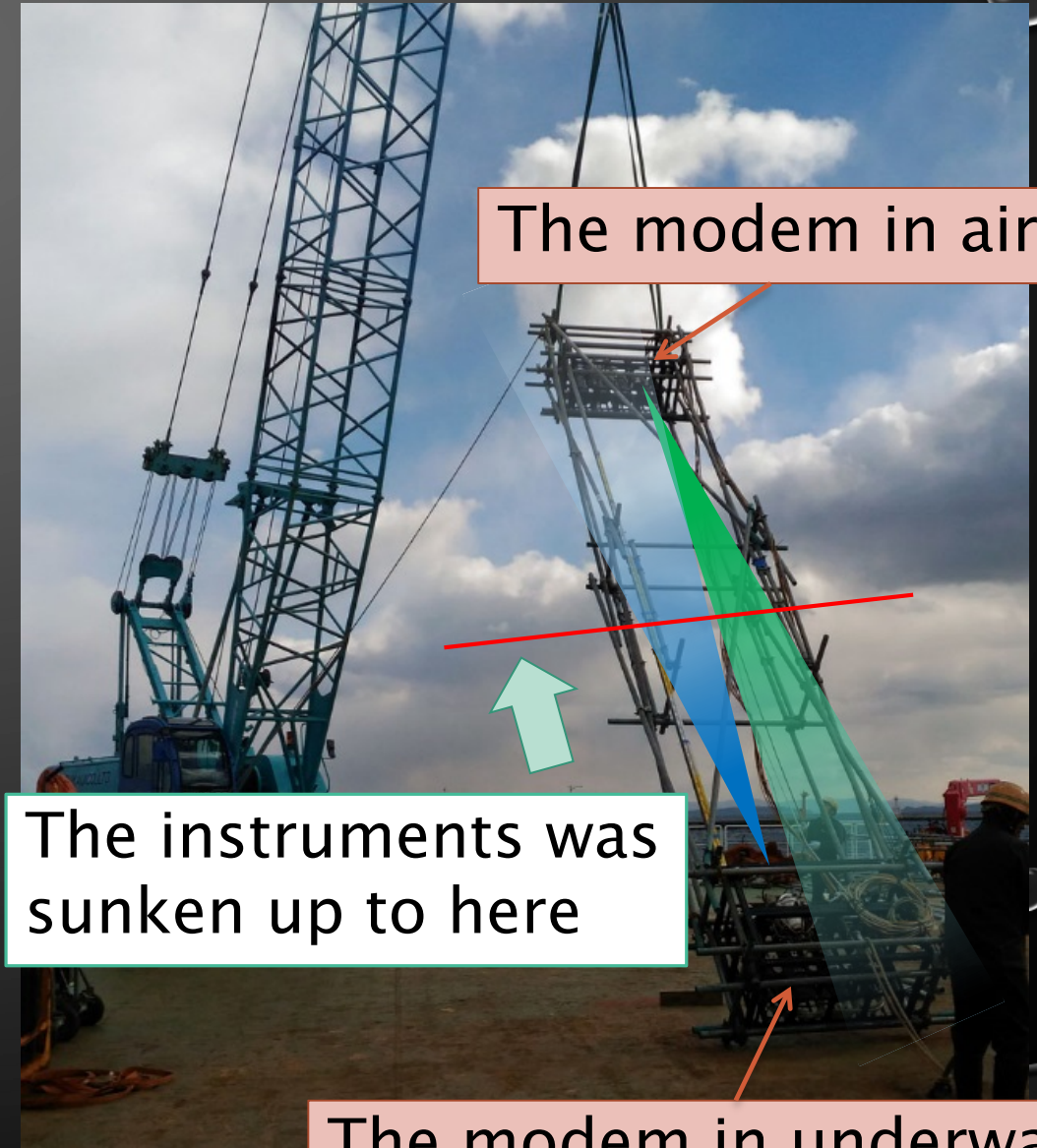


UOWC ACROSS THE SEA SURFACE

- 5m path in air and 5m path in underwater
- UOWC keep the communication until the end of the test



Down looking camera at air side



The modem in air

The instruments was sunken up to here

The modem in underwater

ESTIMATIONS OF COMMUNICATION PERFORMANCE

Turbidity = 0.01 [FTU]
Chlorophyll = 0.01 [ppb]
Light color = 460 [nm]

← Clean ocean

Range[m]	Speed[Mbps] @3deg beamwidth	Speed[Mbps] @20deg.	Speed[Mbps] @90deg.
20	95800	9830	510
50	5680	583	30.2
100	51.3	5.26	0.273
150	0.463	0.047	0.002

Higher frequency response of the modem will be needed to put these performance into practice

PREDICTIONS: USAGE OF THE UOWC MODEM

Data retrieve in short time

UUV keep cruising

ROV keep floating

View from UUV

Controller

UOWC modem

UUV

Camera

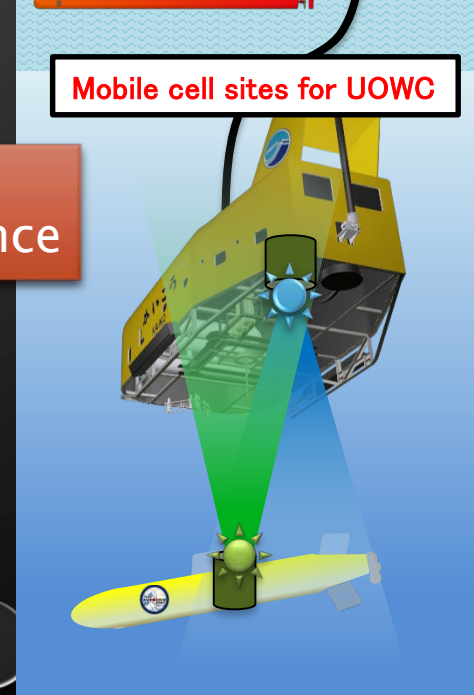
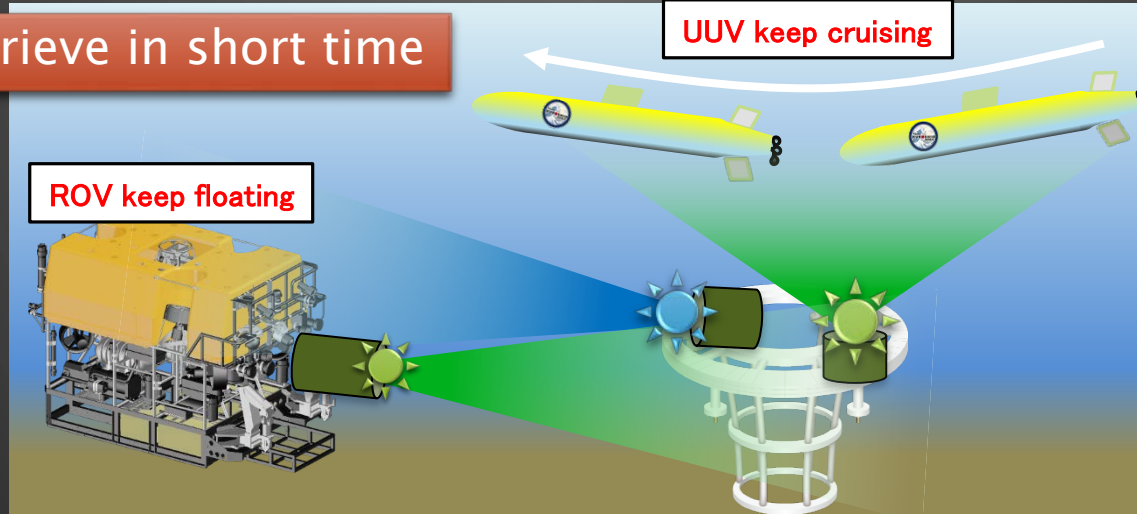
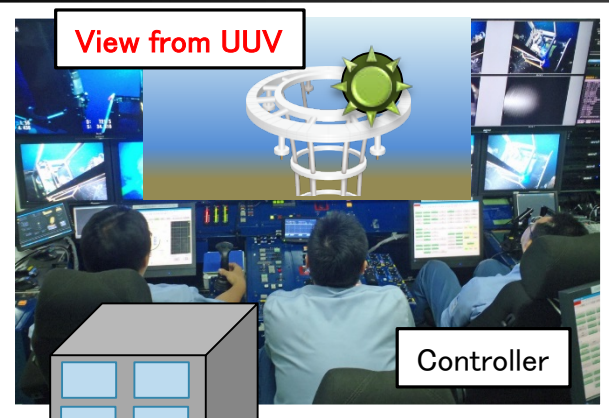
Underwater station

Remote control with camera view

Remote maintenance

Mobile cell sites for UOWC

Headquarter



IMPORTANT FOR UOWC: PROFILER FOR THE UNDERWATER OPTICS

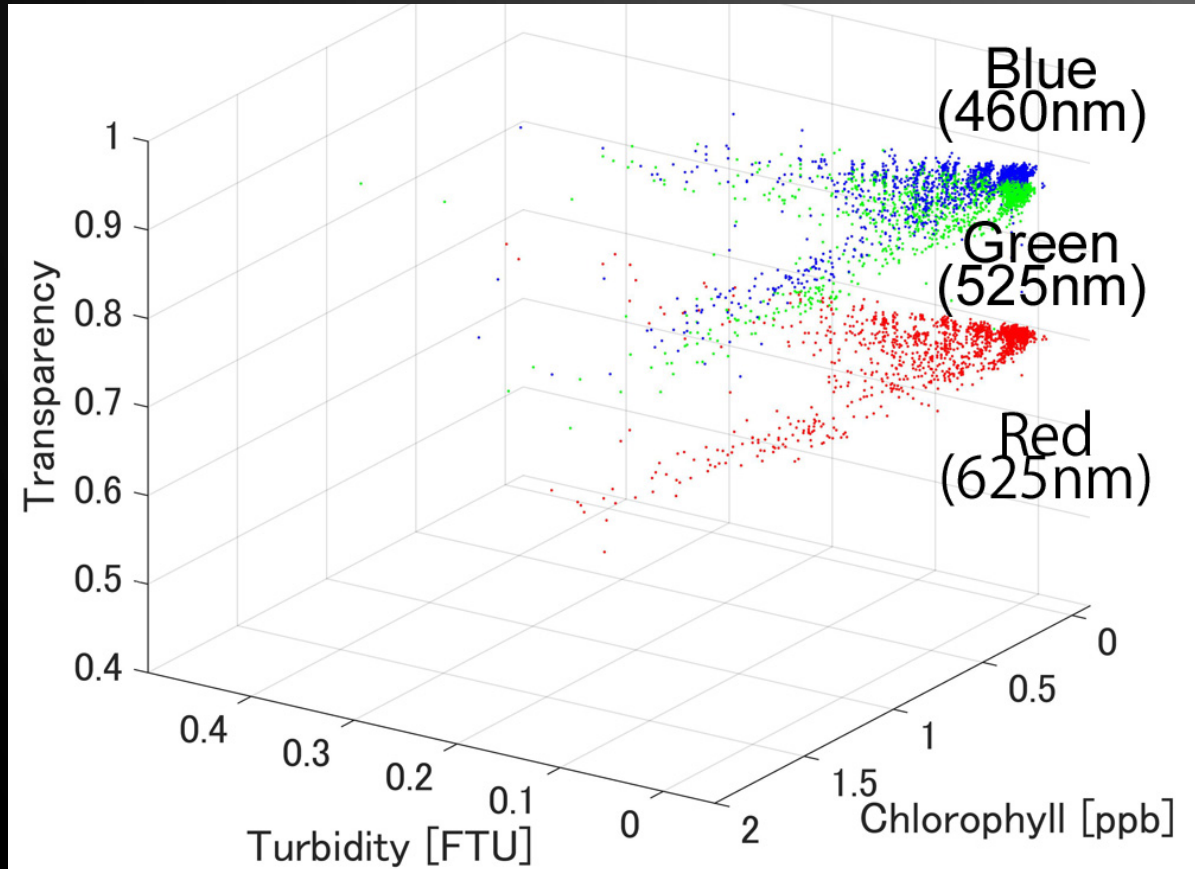
Optical attenuation and backscatter, associated with sea conditions such as salinity, are measured up to 1,000 m depth.



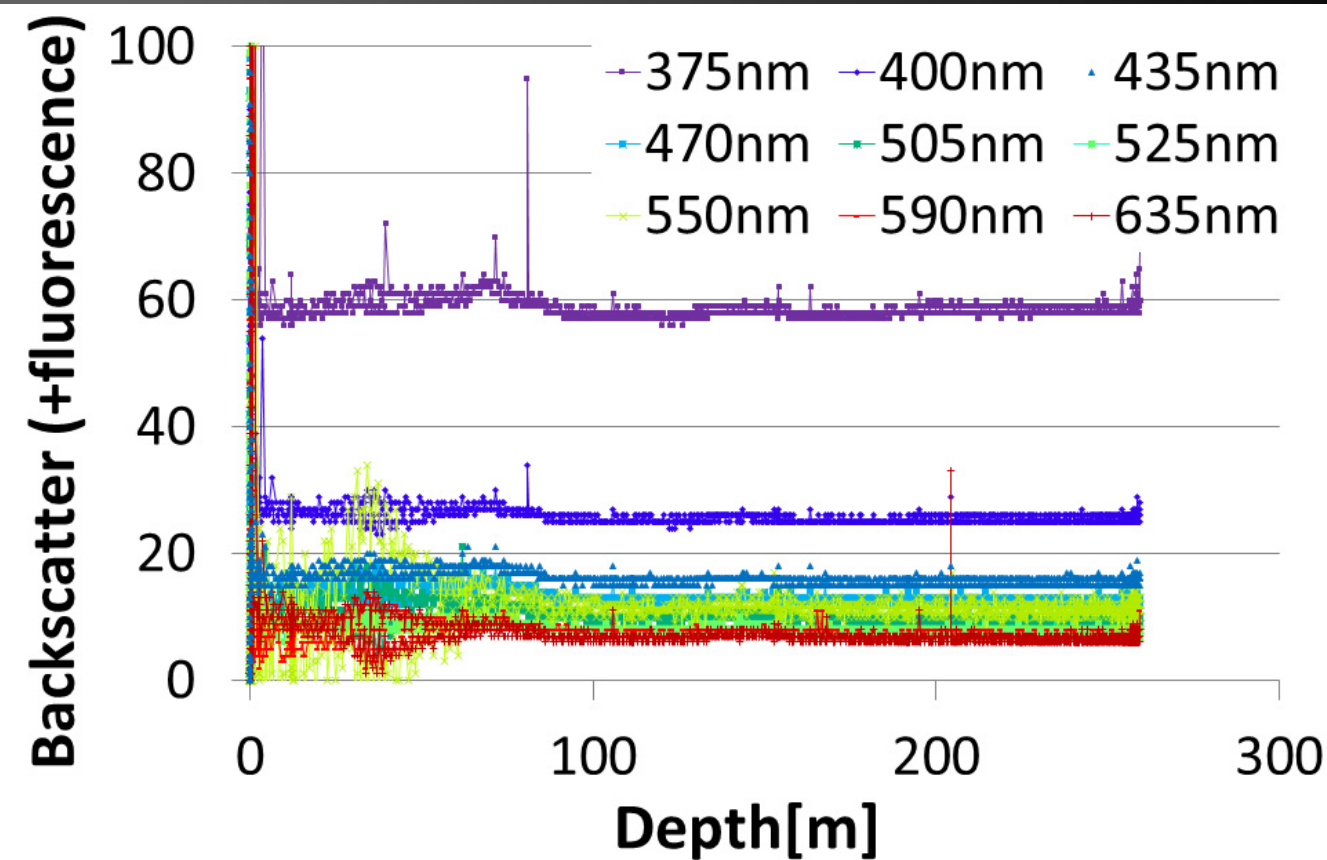
Weight[kg]	60 (in air)
Dimension[m]	1.5 x 0.4 x 0.4
Measurement items	Optical attenuation @460,525 and 625[nm]
	Optical backscatter @370, 400, 435, 470, 505, 525, 550, 590 snf 635[nm]
	Conductivity, Temperature, Depth, Dissolve oxygen, Salinity, Chlorophyll, Turbidity

IMPORTANT FOR UOWC: DATA SAMPLE FROM THE PROFILER

Attenuation vs.
Turbidity and Chlorophyll



Depth vs. Backscatter



These data are used to tune the both of the hardware and software of our UOWC modem

THANK YOU FOR YOUR ATTENTION!



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