

「水中可視光通信」

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日時: 平成28年11月30日

Published by Visible Light Communications Association at "Visible Light Communications Work shop 2016" on November 30, 2016 in Yokohama, Japan.

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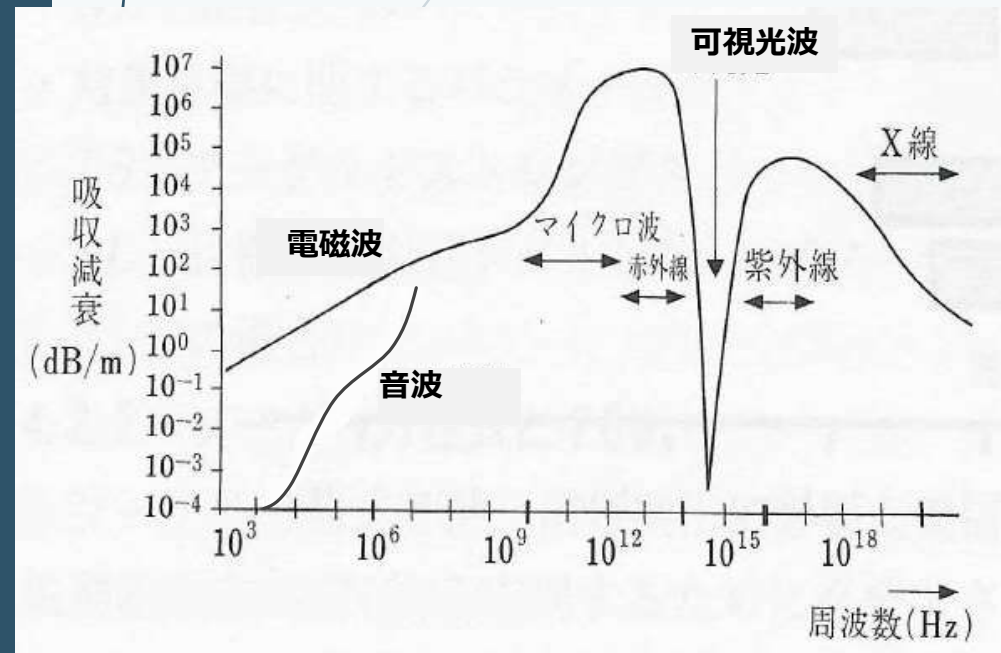


背景：水中無線通信（Underwater Free-space Optical Communication）の利点

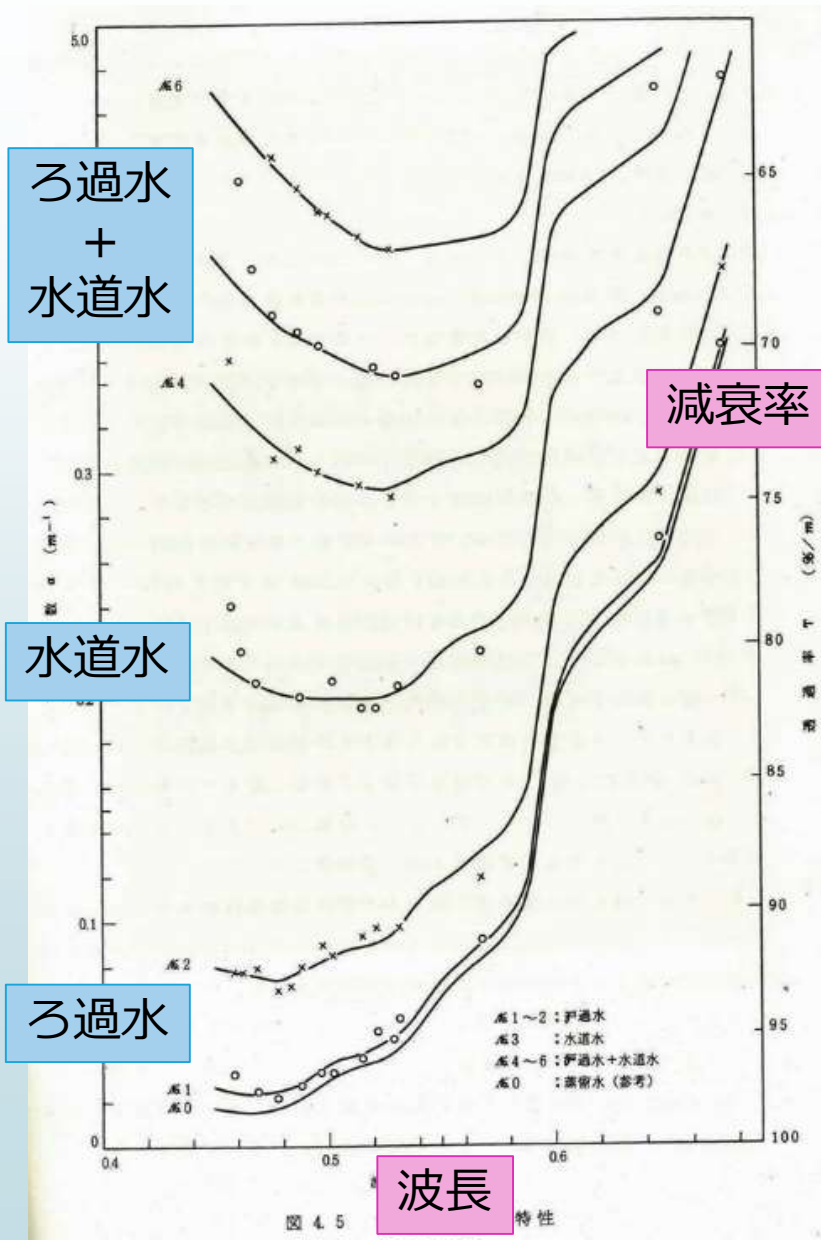
- 水中では音波を使った通信が一般的で、位置測位や状態監視に広く用いられるが、データ送受信にはあまり用いられない
 - 通信速度が遅いから（せいぜい10kbps)
- コンピューターの発達により、扱うデータは膨大に
 - 例えば64Mbのデータを音響通信でやりとりしようとすると、1時間以上かかる
 - 水中高速無線通信の確立が望まれている
- 光無線通信は本質的に高速
 - 小型，強力，高速応答で青や緑の光を放射する高性能なLEDやLDが普及
 - 水中利用の環境が整った

背景：水による光の吸収

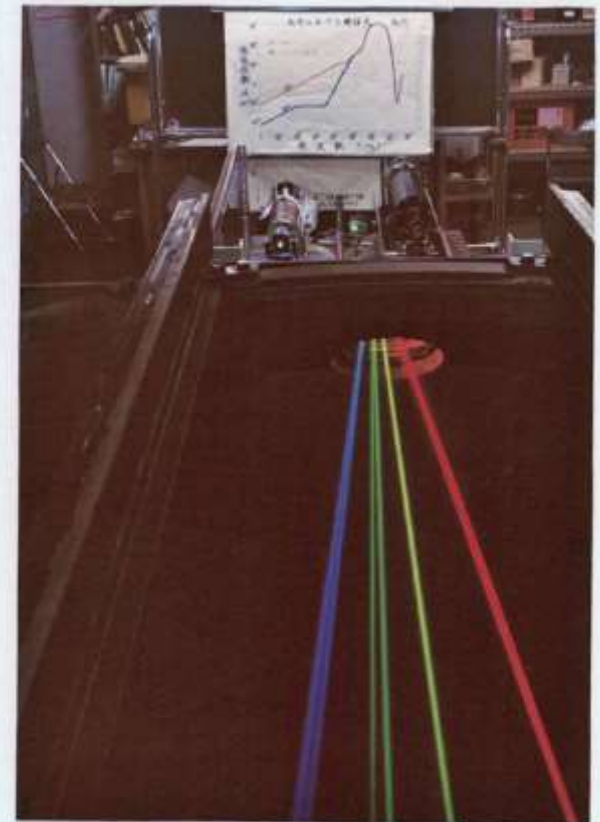
3



海中での音波と電磁波（電波・光）の減衰
※「水中音響の原理」 R.J.ユーリック著、土屋明訳 共立出版カピ式会社



中尾定彦
慶應義塾大学
理工学研究科
1979年度博士論文



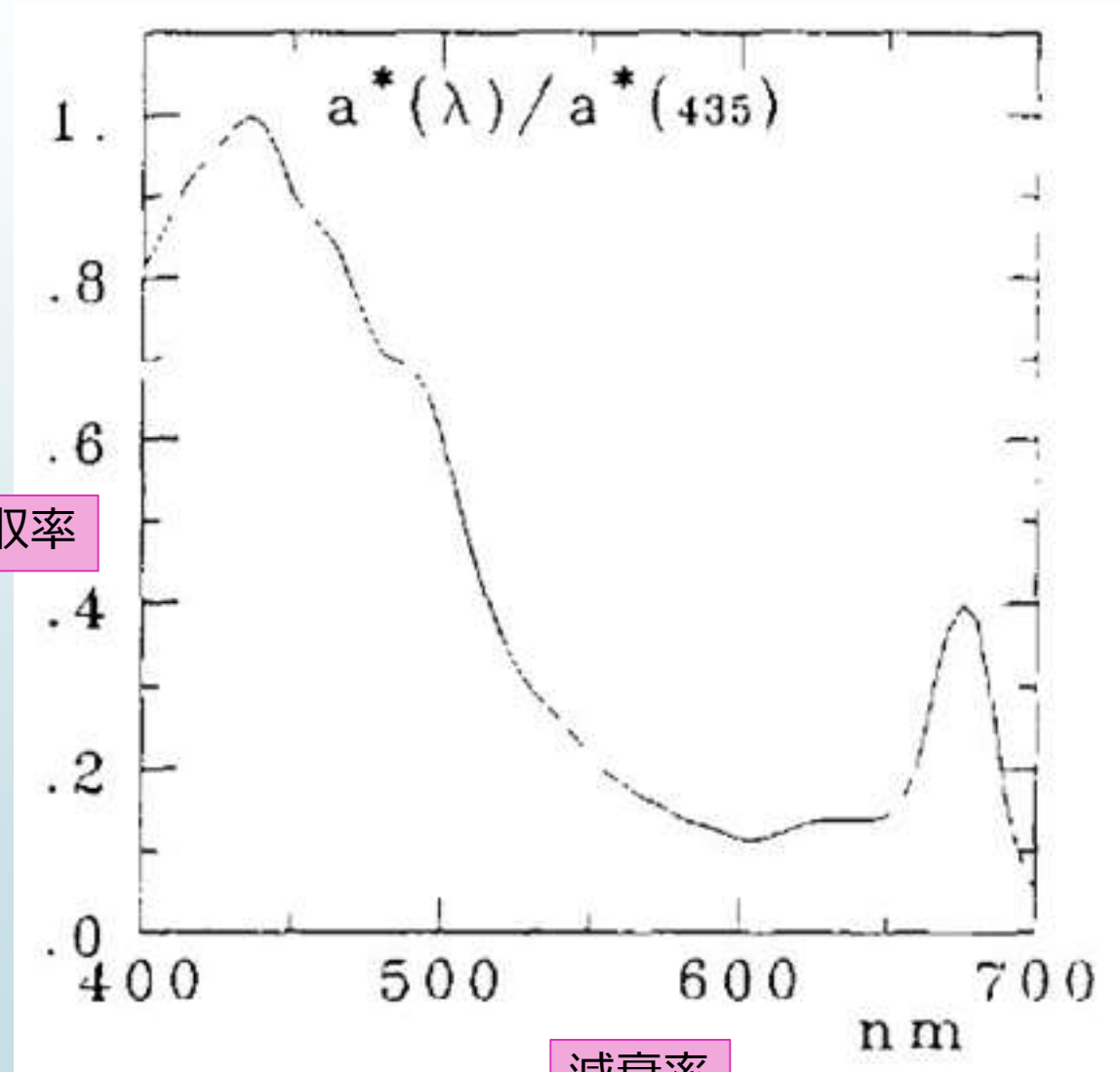
(5.4.9.11撮影)

写真4.1 レーザ光の水中伝播

背景：クロロフィル（葉緑素）による光の吸収



相対吸収率



減衰率

André Morel
Progress in Oceanography
Volume 26, Issue 3, 1991, Pages 263-306

既存装置の紹介： 東洋電機



東洋電機株式会社

日本放送協会・太陽誘電株式会社と共同開発

高速水中可視光通信装置

High-Speed Underwater Visible-Light Communications

—水中でのワイヤレス伝送(IP通信)を実現—
映像など大量のデータ伝送が可能に！



試験風景(沖縄の慶良間諸島の海)

特徴

- 高速
 - ・水中で動画の伝送が可能な最大50Mbpsの通信速度を実現(※)
- 長距離
 - ・50Mbpsで最長20mの通信距離(海水)を実現(※)
- 双方向
 - ・水中で双方向の無線LAN環境を実現
- 多色・多波長対応
 - ・水質等に応じて濃青(447nm)から緑(530nm)の各色を選択可能
- 外形寸法
 - ・Φ250mm×L450mm(突起物を除く)

(※) 記載の通信速度、通信距離を保証するものではありません。水中の透過率に依存します。

◆お問合せ先：

東洋電機株式会社 経営企画本部

TEL : 0568-34-3008

E-mail : info@toyo-elec.co.jp

Daitron**Underwater Optical Communication System****DUOC-100**

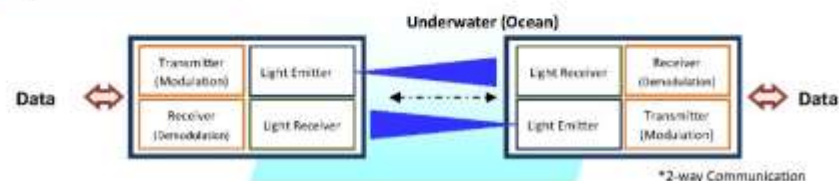
The DUOC-100 is an underwater optical uni/bi-directional wireless communication system.

With the use of blue light source having low light attenuation rate in water, this system provides high-speed, large-capacity data communication, compared to existing sound transmission systems.

Ethernet (LAN) and digital/analog communications are available.

Key features

- ▶ High-speed wireless data communication (10Mbps or more, Max. 100Mbps)
- ▶ Bi-directional(Ethernet)/Uni-directional, digital/analog communication
- ▶ Long-distance data transfer
- ▶ Appropriate light source forms (Gaussian: Wide-angle/Collimated: Long-distance)

System Block**Applications**

- ▶ Real time transfer of image data captured by an observation unit
- ▶ Underwater Ethernet network
- ▶ Ground⇄Underwater seamless communication system
- ▶ Controlled communication among free-running units

Specification

- ▶ Transfer speed ... Digital: 10Mbps or more, analog: 18MHz
- ▶ Transfer distance ... 25m *Unidirectional, 10m * Bi-directional

既存装置の紹介： ダイトロンテクノロジー

Details

Specifications	
▶ Particulars	
- Utilities	100V AC/ 24V DC
- Temperature	-5 to 50°C
- Weight	Up to 15kg (including the water-resistant case)
- Case	Water pressure resistant
- Unit Interface	Water pressure resistant connector
▶ System Specifications	
- Out port diameter	φ100mm
- Communication	Ethernet (TCP/UDP)/Digital/Analog

Appearance**Underwater Test**

*Wide-angle communication (2-way)

Contact:

Daitron Technology, Kameoka Plant Sales & Technology Division
 3-13-1, Oi-cho Namikawa, Kameoka, Kyoto 621-0013
 TEL +81(771)24-1011 <http://www.dtc-daitron.com/>

既存装置の紹介： Sonardyne



Sonardyne
SOUND IN DEPTH
SUBSEA TECHNOLOGY

BlueComm is a through-water wireless optical communication system, developed to transmit subsea data, stream video and perform tetherless vehicle control at very high speeds. The BlueComm modem family is currently made up of three variants. BlueComm 100 is optimised for shallow water 'high ambient light' operating environments and offers a good balance between data rate and range. BlueComm 200 sends data at up to 12.5 Mbps and is suitable for deep or night time operations. The dual laser configuration of BlueComm 5000 supports data transfer rates of up to 500 Mbps.

TECHNOLOGY OVERVIEW

BlueComm uses the electromagnetic spectrum rather than acoustic pressure waves to transmit high volumes of data. Typically operating in the 450nm Blue light region of the spectrum, BlueComm can achieve data rates of greater than 500 Mbps. Optical data transmission is highly efficient, enabling 1 Gb of data to be transmitted with the energy contained within a single lithium D-sized cell over distances greater than 150 metres.

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SONARDYNE BLUECOMM UNDERWATER WIRELESS OPTICAL COMMUNICATION SYSTEM

WHAT YOU NEED TO KNOW

- 1-500 Mbps rate achievable
- Up to 150metre operating range
- Depth ratings to 4,000 metres
- Enables fast and efficient data recovery via AUV, ROV or surface deployed 'docking' system
- Integrated long range acoustic communications and positioning
- Highly energy efficient communications providing long battery life
- Compatible with standard subsea Ethernet networks
- Can be integrated with long range acoustic communications and positioning systems

BlueComm 200 also uses an array of rapidly modulated LEDs but has a separate photomultiplier tube as its receiving element. The photomultiplier tube allows a much more sensitive receiver capability allowing communication ranges of up to 150 metres. Due to the sensitivity of the photomultiplier receiver, the emitter is packaged separately to prevent interference. BlueComm 200 is excellent as a long range remote to ROVs.

BlueComm 5000 uses two rapidly modulated off frequency lasers to produce simultaneous bi-directional communications. The equipment is optimised for peak data transfer performance with transfer speeds of 500 Mbps being achievable. BlueComm 5000 is excellent for large data offloads from deployed sea bed nodes or fast 'fly-by' data collections by fluid resident AUVs.

BLUECOMM SUMMARY SPECIFICATIONS

BlueComm 100	
Light Source:	LED, integrated Transmitter and Receiver
Range:	10 metres maximum
Bandwidth:	1.5 Mbps data transfer rates
Operating Scenario:	Optimised for all lighting conditions
Optics:	Custom beam patterns and wave lengths
Communications:	Ethernet connected

BlueComm 200	
Light Source:	LED, separate Transmitter and Receiver
Range:	150 metres maximum
Bandwidth:	1-12.5 Mbps data transfer rates
Operating Scenario:	Optimised for maximum range
Optics:	Custom beam patterns and wave lengths White light emitters to prevent ROV lights from interfering with transmission
Communications:	Ethernet connected

BlueComm 5000	
Light Source:	Dual laser based
Range:	7 metres maximum
Bandwidth:	Up to 500 Mbps data transfer rates
Operating Scenario:	Optimised for fastest data transfer
Optics:	Focused beam pattern
Communications:	Ethernet connected

Options and Accessories

Subsea network cabling
Inert gas light sources
Subsea network switches
External battery packs
Integrated acoustic positioning and telemetry
Data loggers



BlueComm modems

BlueComm is a wireless, high speed optical communication technology that can transfer data underwater at substantial speeds. Data rates of 500 Mbps can be achieved.



BlueComm 200

BlueComm 200 uses modulated LEDs and a separate photomultiplier tube as its receiving element.

System monitoring

Diagnostic software allows the status of a BlueComm communication link to be monitored and optimised in real time.



水中光無線通信の課題

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➤ 海が濁ると通信できない

- ただし，濁った時に透過しやすい波長がある（≡色が変わる）
- 濁りに対応して送信波長を変えたらどうか？
- 海の状態を計測し，キャリア波長，通信符号，速度に対する影響を調べる

➤ 通信距離が短い（減衰が大きい）

- 感度が高い光電子増倍管を用いれば，距離は延長できる
- 太陽光や照明，生物発光など，外乱光の影響を調べる



実海域でこれらを確認するため，光の伝搬を計測する装置「海域基礎データ取得装置」を製作

光電子増倍管を用いた適応型水中光無線通信の研究



国立研究開発法人 海洋研究開発機構 海洋工学センター 澤 隆雄

水中で高速無線通信を行うため、海の濁りに応じた光の伝搬特性を計測し、その濁りに対応して青緑色光や光電子増倍管を使った水中光無線通信の研究を行う。

濁りに対応する光無線通信装置

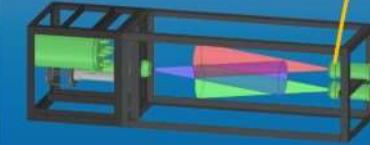


指令信号により、発光色、通信用符号、受信素子を変更して水中通信が可能

海の濁りと光伝搬を計測



海底基礎データ取得装置

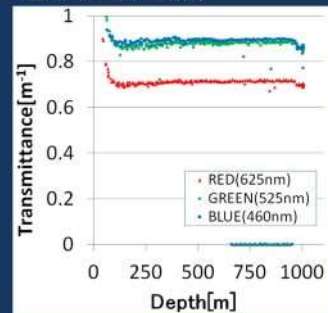


1000m深度まで季節と場所を変えながら計測

《計測項目》

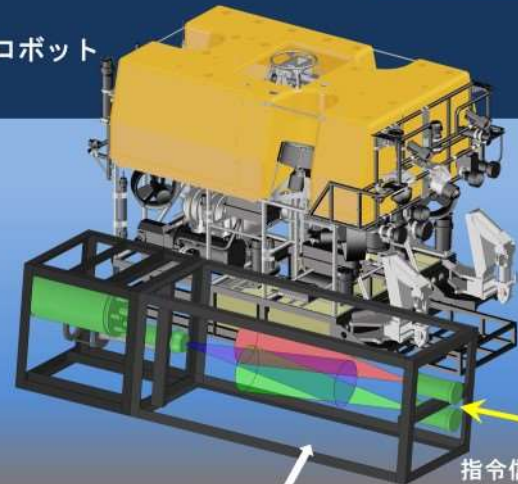
青・緑・赤光の
伝搬減衰・反射・散乱/塩分/
電気伝導/クロ
ロフィル溶存酸
素/温度/深度/
濁度

各深度における
透過率の計測結果



実海域における水中光無線通信試験展望

水中ロボット

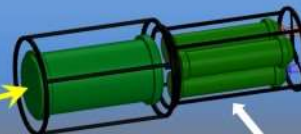


リアルタイム濁り計測情報
水中光伝搬に関するデータベース

水中ロボットと海底ステーション間
距離5~200m、速度0.1~10Mbps程度で試験

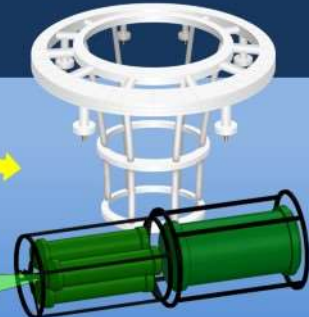
連結

指令信号・通信エラー情報



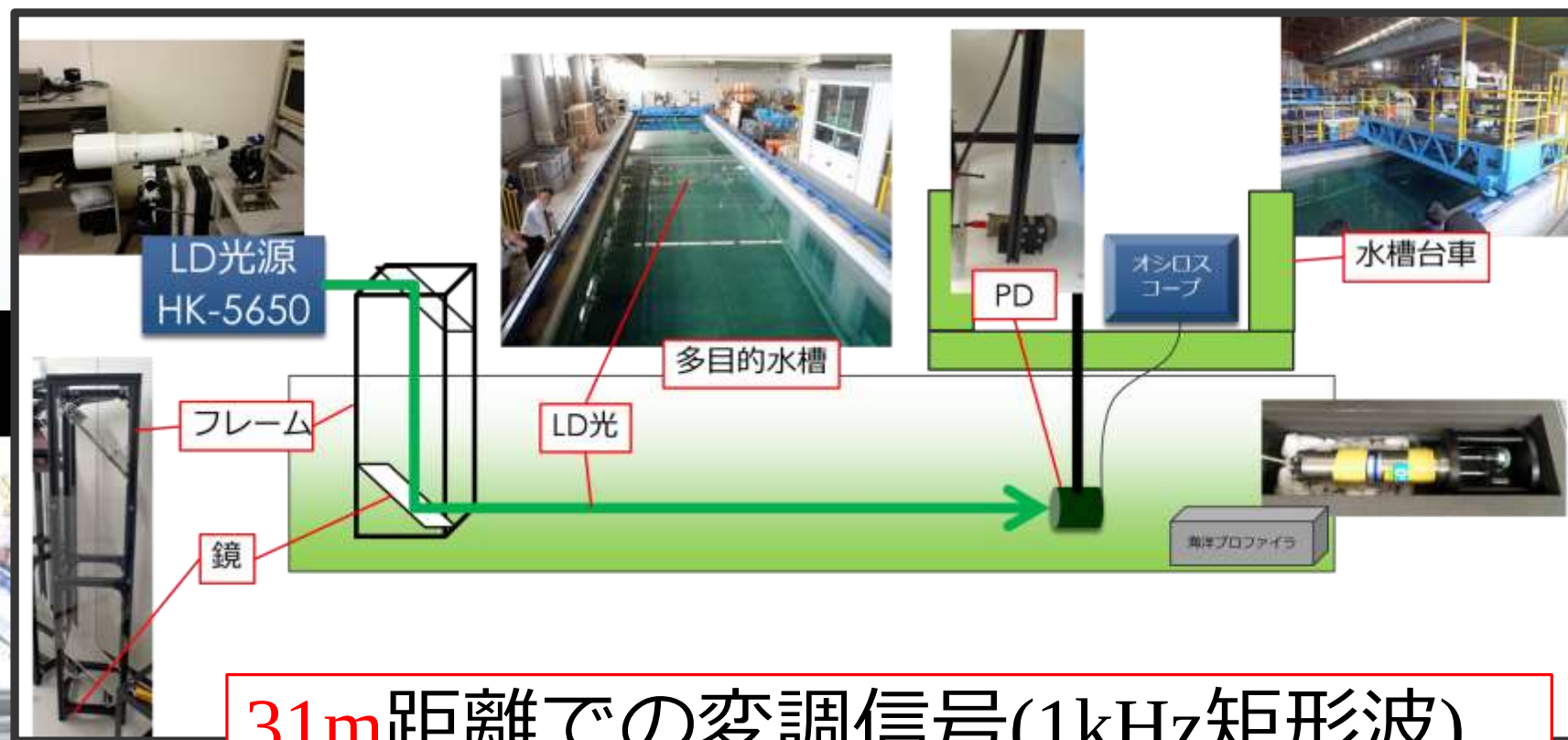
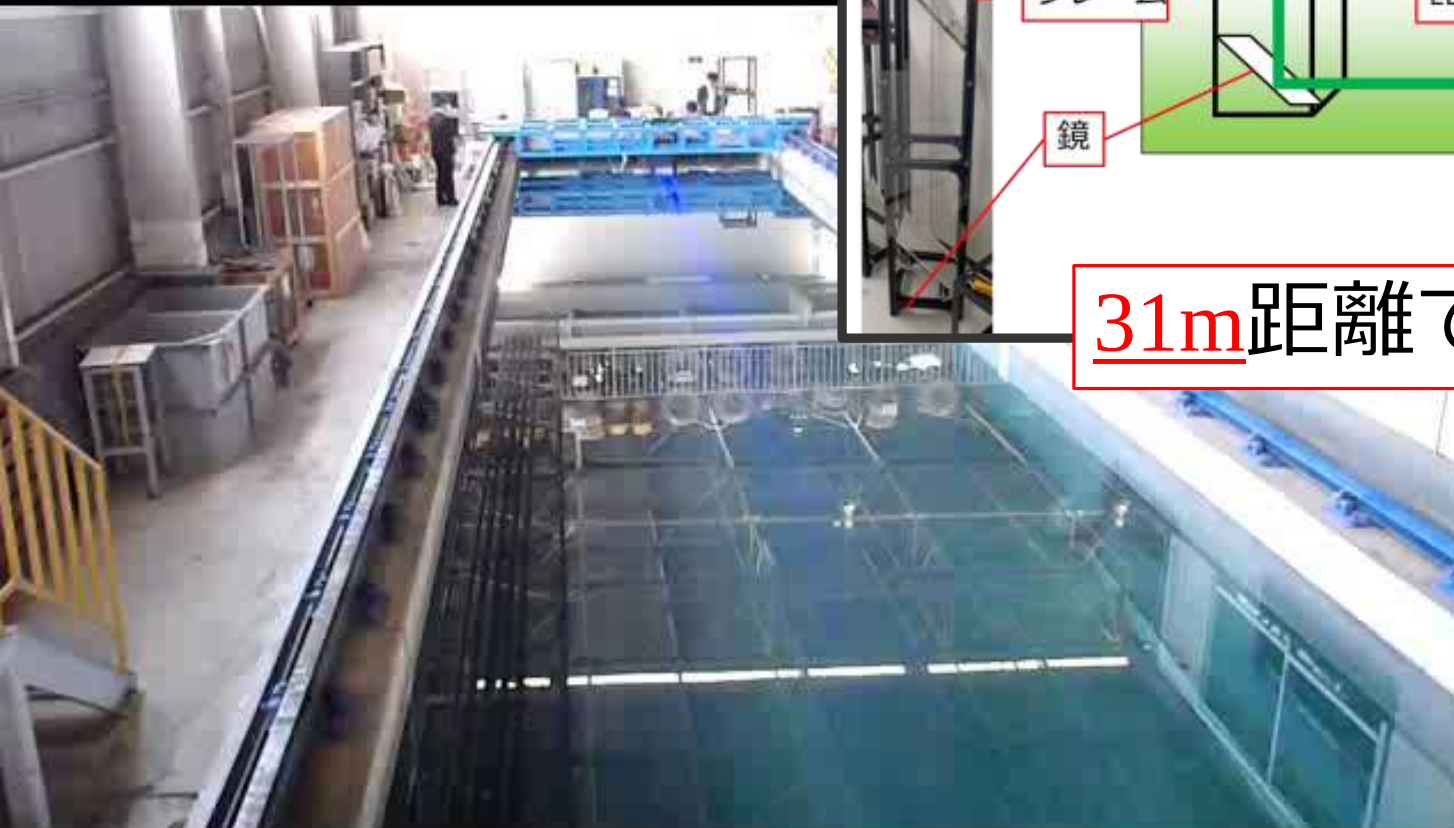
実際に通信し
通信エラーを算出

海底ステーション



蓄積した海の濁りと光伝搬に関するデータを用い、発光色や受信素子をリアルタイムに選択する革新的な水中光無線通信装置を試作、濁りと通信品質の関係を明らかにする。

水槽試験 (予備試験)



31m距離での変調信号(1kHz矩形波)

