Deployment of Biosensors in Aquatic Bio-Optical Communication System& its Applications in Gulf of Mannar

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Abstract:
The Gulf of Mannar Marine National Park is popular destination for the marine tourists and environment lovers. Diversity of aquatic plants and animals makes it attractive among the Indians and foreigners. Coral Reef and Shallow water of this park preserve the marine life for global significance.Conventionally, electronic equipment and devices are setup for communication and gaining the valuable insights into the behavior, health, and conservation status of fishes and aquatic species in their natural habitats. This equipmentproduces the lot of disturbance and water pollution in the natural environment.
AnAquaticBio-Optical Communication System is more reliable system for visible light communication inside the ocean. It uses the natural resources like bioluminescence, sediments, biosensors and physical behavior of the light. In this paper, procedure for deployment of Aquatic Bio-Optical Communication System in the shallow water of ocean is explained with minimum cost of expenditure.
The procedure includes the location, depth; connectivity and data rate of the system for provide the required link for communication. By integrating the natural elements into the comprehensive approach, the system works towards the preserving of marine life environment.

Keywords: Underwater Optical Communication,Biosensors, Visible Light Communication Device, Gulf of Mannar Marine National Park
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1. INTRODUCTION

The Gulf of Mannar Marine National Park is situated on the Tamil Nadu state of southern part of India. It is famous tourism destination located in the Coromandel Coast region. Marine Park is surrounded with coral reefs and shallow water of the Indian Ocean. It starts from Pumban bridge of Rameshwaramtill Kanyakumari in Tamil Nadu.Also stretches between 8° 47' to 9° 15' N latitude and 78° 12' to 79° 14' E longitude and covers the total area of 10,500 Km^2 with the average depth of around 5.8 meters (19 Ft.) [1].

The park has a protected area of560 km^2 or 220 sq mi which is called "Gulf of Mannar Marine Biosphere Reserve" and was established as a National Park in 1989. Gulf of Mannar Marine Biosphere Reserve has 21 islands along with costal line. These islands are made by calcareous substratum and encircle by dense coral reef habitat.Average depth of water surrounded with the islands is ranges between 3.5 to 15 meters. Complete Park is divided into two zones – core zone and

its surrounding area Buffer zone.Some part of the park is open for tourist, fisherman and other living hood activities[1,2].

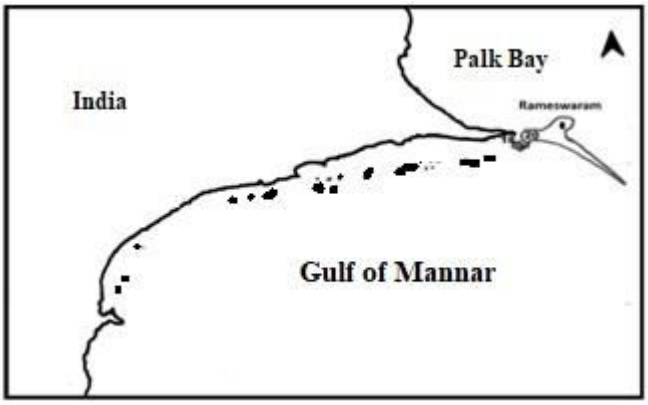


Figure.1: Gulf of Mannar Marine Biosphere Reserve

2. Existing Methods of Communication in Underwater scenarios –

Underwater communication is a challenging task due to the physical properties of the water, such as high attenuation, multipath propagation, and limited bandwidth. However, several methods have been developed to facilitate communication in underwater environments:

Table 1: Existing methods of underwater communication [4]

Methods	Challenges
Acoustic wave	• Sea bottom topology, • Doppler shift, • Transducer efficiency, Different Noise
Optical Communication	• Light scattered and absorbed in seawater due to marine plankton
Electromagnetic Wave	• High attenuation • low data rates • Losses due to the high conductivity of water
Magnetic Induction Communication	• effectively over short distances

Each method used for underwater communication has its some disadvantages and limitations. The choice of method depends on factors such as the required data rate, coverage range, level of attenuation, and availability of resources & technology. Also, it depends on the geographic locations and environmental conditions of the water body.

Every method of communication in the Underwater environment haslimitations that hinder their effectiveness and present the gap to fulfill the present requirement related to environment friendly mechanism. However, a new underwater communication system is needed to reduce the effective radiation, noise and aquatic disturbance. A natural type system is required which may enhance securitymechanism, enable the real-time monitoring, improve the data transmission rates, increase reliability, extend range and reduce the power supply issues in the ocean. Also, could support the various applications like ocean exploration, environmental monitoring, offshore oil and gas operations, underwater robotics and defense activities, and scientific research.

This research aims to introduce an efficient, reliable, and compatible underwater communication system that is environment-friendly and produces the minimum level of

pollution in the water.This paper outlines the fundamental componentsof the system, deployment conditions, and potential applications of the proposed bioluminescent-based underwater communication system, emphasizing its sustainable attributes and minimal environmental impact.

This Underwater communication is based on visible light communication and following principles of Underwater light propagation are included -

- Absorption: Light is absorbed by water molecules when it travels through the water which attenuates the light signal.
- Scattering: Suspended particles and dissolved substances in the water scatter the light, further contributing to signal attenuation and distortion.
- Water turbidity: The cloudiness or murkiness of the water (turbidity) greatly impacts light propagation, as higher turbidity leads to increased absorption and scattering.
- Wavelength-dependent effects: The attenuation and scattering of light in water vary depending on the wavelength of the light, allowing for optimization of the communication system based on the water conditions

3. Aquatic Bio-Optical Communication System

An aquatic bio-optical communication system utilizes bioluminescent organisms and optical signaling to enable underwater communication. By harnessing the natural light production of bioluminescent species, this system offers a unique approach to transmitting data in the underwater environment. It has the potential to overcome some of the limitations of traditional acoustic and optical communication methods, such as signal attenuation and interference. Additionally, leveraging bio-optical communication can lead to lower power consumption and reduced environmental impact compared to other technologies. This innovative approach holds promise for enhancing underwater communication capabilities for various applications, including ocean exploration, environmental monitoring, and underwater robotics.

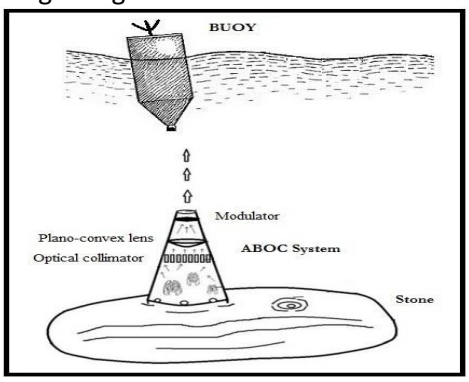


Figure 2. Aquatic Bio-Optical Communication System

Aquatic Bio-Optical Communication System is a conical-shaped device with a transparent cover on the top of the mouth. System is mounted on a hole of the stone which is the habitat of the bioluminescence source (Comb fishes). These comb fishes (Phylum Ctenophora) are hatched in the holes in sufficient numbers so that they can produce light as a source. The device includes an optical collimator to convert the multidirectional light into a parallel beam of light. A Plano-convex lens is equipped in the device to convert the parallel beams into a single beam at a focal point. A modulator is used to convert the single beam of light into pulses of light (digital signal) and to send the pulses of light in a controlled amount to the top of the device, from where it propagates in the seawater towards the Buoy.

A buoyant is a floating body, equipped with solar panels and radio communication devices, which is deployed at the sea skin and above the ABOC system. Buoyant has an optical receiver, deployed underneath to

receive the light signal from the ABOC device and transform it into a form that can be consumed for further communication.

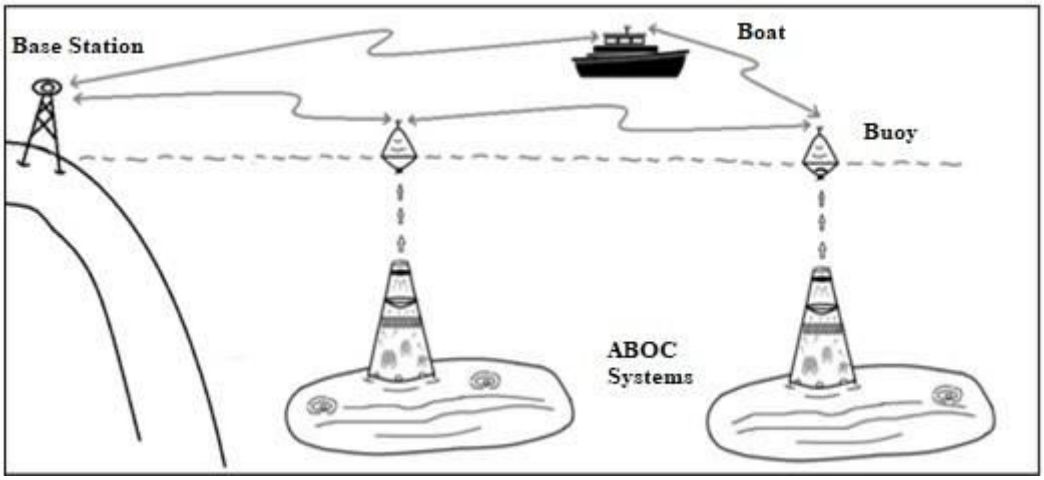


Figure 3. Application of ABOC System

Scenario express the communication network involves understanding its components, connections, and how data flows within it. Aquatic Bio-Optical Communication Systems are deployed on the bottom of the ocean and generate the optical light and transfer it towards the core station through various nodes like Buoys, boats and others.

4. Role of Underwater Biosensors

Highly sensitive and selective Biosensors deployed with the ABOC system at the benthic of ocean and usedfor monitoring the aquatic environments, providing real-time dataof marine lifeand enabling researchersto make informed decisions. Biological sensor is devicethat detects biological or chemical substances and made up of a transducer and a biological element that may be an enzyme, an antibody or a nucleic acid.

Silicon, Microbial and Fiberoptic based biosensors [3, 4] are attached with the system which are used in energy production, environmental sensing, bioimaging and biosensing applications to detect the scenarios of the water body. Fiber opticbiosensor works on the principle of total internal reflection [5]. Typically, it consists of a light source, a fiber optic cable, a sensor, and a detection system. It correlates the light intensity with the previous values at the detector. When light is transmitted through a fiber optic cable, it passes through a sensor designed to communicate with the target. The sensor can be made of a variety of materials, including polymers, metals, and enzymes. Light passing through the sensor is then detected and measured by the detection system, providing information about the concentration or presence of the target substance. These are highly sensitive,robust, reliable and used in real time monitoring.

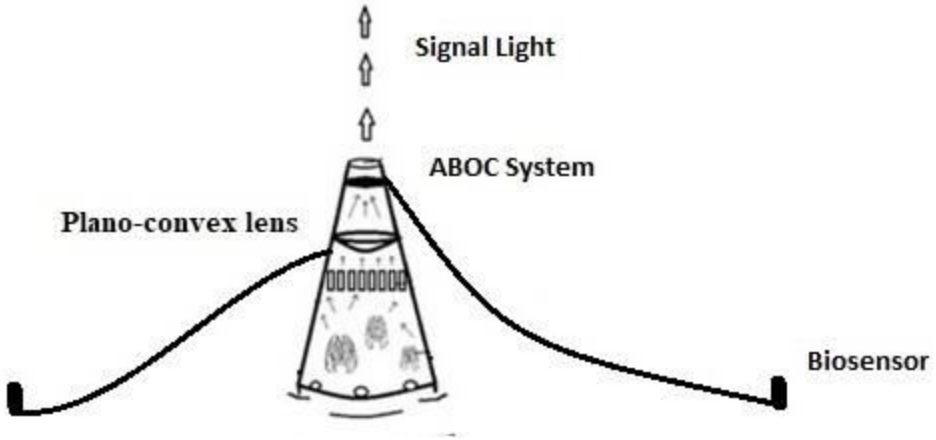
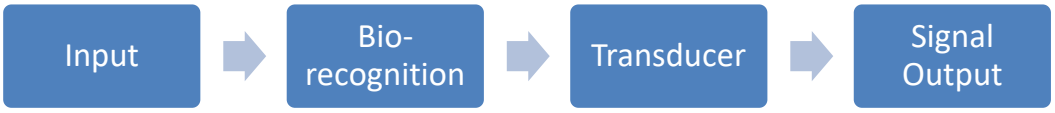


Figure 4. Deployment of Biosensors with ABOC System

Opticalbiosensor combines a biological recognition element with opticaltransducer, which converts the biological signal into an electrical signal.



5. Applications and Future Directions

- Potential applications in underwater research, exploration, and monitoring
- Integration with marine biology studies and environmental monitoring
- Future advancements and research directions

Toxic algaeand single-cellular planktonic organisms are very relevant target for organism analysis by the biosensors. Sensors based on nucleic acid hybridization detection have been developed with the ABOC System. With it heavy metals are hazardous in marine environment andRecombinant Luminescent Bacterial Sensors are used for the detection of zinc and chromate. [6]

The marine environment is a challenging area for biosensors due to the presence of various factors such as physical effects, corrosion, biofouling, and many more. Biosensor should be able to collect and analyze data without human intervention. It should have robustness, drift-free, with minimal power consumption. [7]

6. Conclusion

This paper emphasizes the need for continued research and development efforts to improve the suitable underwater communication, reliability, and its sustainability in harsh underwater conditions by using the Biosensors. Also provides the comprehensive methods, fundamental principles, impact of environmental factors and emerging applications of the ABOC system. A System, based on natural resources of the ocean and does not use electric and radiation-based equipment, which directly impacts of the conservation of natural resources and pollution fee environment in the water bodies.

Furthermore, the paper explores the diverse applications of underwater communication. It also Significance of sustainability and environmental considerations

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