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Enhancing Marine Ecosystem Monitoring through the Integration of Pop-up Buoys with Wireless Communication and Satellite Connectivity

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***Abstract* – Upgrading underwater communication capabilities for seafloor monitoring: The PLOME project's innovative pop-up buoy concept for near-real-time data collection and transmission.**

Keywords *- Stand-Alone Oceanographic Platform, Seafloor Ecosystem Monitoring and Pop-Up Buoys.*

I. INTRODUCTION

The rise in the ocean temperature caused by industrial and transport pollution has forced marine species to migrate to other habitats in search of suitable environmental conditions [1]. Additionally, overfishing has severely depleted the stock of some species, such as tuna [2]. Policymakers have implemented marine protection policies to mitigate these effects in response to global awareness. However, there is an urgent need to improve our understanding of marine ecosystem to quantify the effectiveness of such policies. This improvement relies on adequate spatiotemporal multiparametric monitoring procedures that require technology to play a central role.

Underwater-cabled observatories with video capabilities, such as those presented in [3], are essential for acquiring multidisciplinary oceanographic and biogeochemical data for monitoring marine ecosystems and their species. These observatories provide knowledge on different ecological indicators such as species richness and biodiversity. However, their high deployment and maintenance costs, as reported in [4], have led to the increased use of standalone platforms for ecosystem monitoring in temporary deployments. Articles [5] and [6] reported other stand-alone seafloor ecosystem monitoring platforms, including video acquisition. However, access to data in these examples is only possible after the recovery of the platform, making new real-time and in-situ communication strategies necessary to monitor the data acquisition status.

II. METHODOLOGY, RESULTS and DISCUSSION

The PLOME (Platform for Long-lasting Observation of Marine Ecosystems) project, funded by the Spanish Ministry of Science and Innovation, aims to improve the communication capabilities of standalone seafloor platforms. By integrating several remote stations with Autonomous Underwater Vehicles (AUVs) and Unmanned Surface Vehicles (USVs), data can be collected and transmitted in near real-time. This project included the use of pop-up buoys to expand communication capabilities. These buoys, upgraded with sensing, processing, and communication capabilities, are released periodically to transmit stored data and positions through a satellite link, providing scientists with access to data before the station is recovered, and ensuring proper experimental functioning.

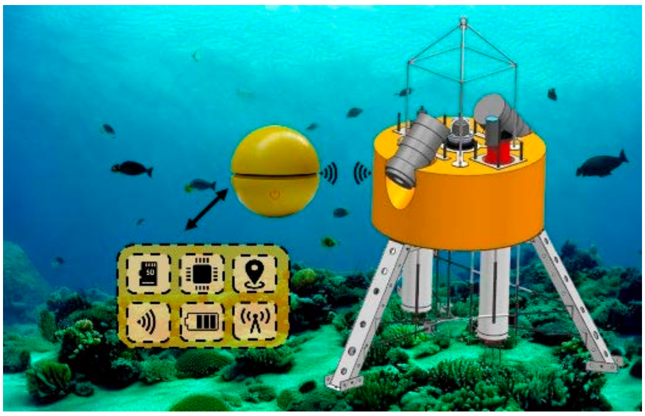

Fig. 1. Seafloor ecosystem monitoring platform from PLOME, with the under design pop-up buoy and its main functionalities.

As shown in the schematic (Fig. 1) the pop-up buoy must have a microcontroller, Wi-Fi, logging, communication, GNSS modules, and an autonomous power system. However, the development of pop-up buoys poses technological challenges. One challenge is to include a wireless link to transmit oceanographic data to the internal storage of the buoy [7]. Wi-Fi is the selected technology due to its low-power capabilities [8].

Another challenge is to develop an automated release mechanism that can maintain the positive buoyancy of a buoy. As a preliminary mechanism, Nd magnets driven by a motor equipped with an endless screw were tested [9].

The pop-up buoy must have a reliable satellite communication unit to transmit data during the drift phase. The Kinéis system, which uses Argos-4 network nanosatellites, is a cost-effective and low-power solution to achieve global coverage. This technology has already been used for drifters as stated in [10]. A test proved its effectiveness in pop-up buoys [11]. Additionally, the buoy must have a battery pack to power all modules before and during release, which requires low power consumption and a well-designed sleep-wake cycle.

III. CONCLUSION

This work aims to address the challenges faced in marine ecosystem monitoring by developing an innovative solution that integrates seafloor stand-alone remote stations with pop-up buoys to transmit data in near-real time through a satellite link. The use of pop-up buoys with sensing, processing, and communication capabilities enables the collection of scientific and engineering data, without the need to recover the station. Although there are technological challenges related to the development of pop-up buoys, including wireless communication, automated release mechanisms, reliable satellite communication, and battery power, our work aims to develop a proof-of-concept design to demonstrate the feasibility of transmitting data from stand-alone platforms in near-real time to validate its correct operation without the need to recover it.

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REFERENCES

[1] P. Petsas, A. Doxa, V. Almpanidou, and A. D. Mazaris, “Global patterns of sea surface climate connectivity for marine species,” Commun. Earth Environ., vol. 3, no. 1, 2022, doi: 10.1038/s43247-022-00569-5.
[2] J. M. Fromentin and J. E. Powers, “Atlantic bluefin tuna: Population dynamics, ecology, fisheries and management,” Fish Fish., vol. 6, no. 4, pp. 281–306, 2005, doi: 10.1111/j.1467-2979.2005.00197.x.
[3] J. Del-Rio et al., “Obsea : A Decadal Balance for a Cabled Observatory Deployment,” IEEE Access, vol. 8, pp. 33163–33177, 2020.
[4] A. Witze, “Oceanography’s billion-dollar baby,” Nature, vol. 501, no. 7468, pp. 480–483, 2013.
[5] D. Pelletier et al., “Kosmos: An open source underwater video lander for monitoring coastal fishes and habitats,” Sensors, vol. 21, no. 22, 2021, doi: 10.3390/s21227724.
[6] J. K. Choi, T. Fukuba, H. Yamamoto, Y. Furushima, T. Miwa, and K. Kawaguchi, “Pinpoint and safe installation of a standalone seafloor observatory,” 2018 Ocean. - MTS/IEEE Kobe Techno-Oceans, Ocean. - Kobe 2018, pp. 1–4, 2018, doi: 10.1109/OCEANSKOBE.2018.8559472.
[7] M. Y. I. Zia, J. Poncela, and P. Otero, State-of-the-Art Underwater Acoustic Communication Modems: Classifications, Analyses and Design Challenges, vol. 116, no. 2. Springer US, 2021.
[8] A. Arias, “Caracterización de sistemas de comunicación RF y ópticos en aplicaciones submarinas,” Bachelor Thesis. Univ. Politècnica Catalunya, 2022.
[9] C. Lobelles, “Sistema de liberación de ‘pop-up bouy’ en estación submarina,” Bachelor Thesis. Univ. Politècnica Catalunya, 2022.
[10] D. M. Toma, M. Carandell, and J. Del Rio, “Performance of WAVY Ocean Lagrangian Drifters for Surface Characterization of Ocean Dynamic Structures,” in *2022 IEEE International Workshop on Metrology for the Sea - Naples*, 2022, pp. 133–137, doi:10.1109/metrosea55331.2022.9950995.
[11] M. Ledesma, “Dispositiu de seguiment i transmissió de dades amb tecnologia Satèl·lital Argos Kineis i LPWAN Sigfox,” Bachelor Thesis. Univ. Politècnica Catalunya, 2021.