Integrating 3D Reconstruction and AR for Enhancing Visitor Experience in Submerged Heritage Sites

Santina Fortuna[1], Antonio Lagudi[1], Luigi Scarfone[1], Barbara Davidde[2], Fabio Bruno[1], Loris Barbieri[1]

[1] Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria, P. Bucci, 46C, 87036 Rende, CS, Italy – santina.fortuna@unical.it
[2] National Superintendency for Underwater Cultural Heritage, Ministry of Culture, Via Cugini 7, 74123 Taranto, TA, Italy

Keywords: Underwater 3D Reconstruction, Underwater Augmented Reality (UWAR), Smart Buoy, Underwater Navigation, Underwater Cultural Heritage (UCH).

Abstract

Underwater Cultural Heritage (UCH) sites offer unique opportunities for archaeological exploration and cultural tourism but remain difficult to interpret due to the environmental constraints of the underwater setting. This paper introduces an integrated Underwater Augmented Reality (UWAR) system designed to support real-time, site-specific interpretation for recreational divers. The approach combines opto-acoustic 3D reconstruction with thematic annotation and portable AR delivery. A high-resolution, georeferenced 3D model of the site is generated by fusing multibeam sonar and underwater photogrammetry data. This model provides the spatial framework for distributing interpretive content through georeferenced Points of Interest (POIs), including descriptive texts, images, and 3D reconstructions. The system architecture includes a smart buoy equipped with USBL and GNSS positioning systems and an underwater mobile device for AR visualization. This setup enables real-time localization and contextual content delivery without the need for permanent infrastructure. The presented UWAR system aims to improve site readability, promote active learning and support sustainable cultural engagement, offering a scalable model for heritage interpretation in underwater environments.

1. Introduction

Preserved beneath the water surface, Underwater Cultural Heritage (UCH) sites offer exceptionally well-conserved material evidence of ancient human activity, often protected by environmental conditions that limit degradation over time. Submerged shipwrecks, ports, and coastal settlements hold significant archaeological and historical value, while also offering compelling experiences for divers interested in cultural tourism. In fact, over the past decades, an increasing number of these sites have become accessible to recreational divers, reflecting a growing demand for underwater experiences that merge a sense of adventure and discovery with meaningful engagement with submerged cultural and natural heritage (Sumanapala et al., 2023).

Despite this growing interest, the ability to effectively understand and interpret UCH during a dive remains limited. The underwater environment poses numerous perceptual and cognitive challenges. Visibility is frequently compromised by turbidity and suspended particles; light attenuation reduces contrast and color perception with depth (Diamanti and Ødegård, 2024); marine growth alters surface morphology, and sedimentation can obscure key features of the archeological artifacts (Meyer-Kaiser and Mires, 2022). These conditions complicate the recognition of archaeological elements and obscure the spatial logic of sites, making it difficult for divers to form a coherent understanding of what they are observing. Additionally, many UCH sites are characterized by structural collapse, fragmented remains, and partial burial, which amplify the sense of disorientation. For non-specialist divers, who typically rely on immediate visual cues, these factors severely constrain the interpretive experience (Dimmock and Wilson, 2011).

To assist interpretation, recreational divers typically rely on pre-dive briefings and static underwater panels (Cooper and Knott, 2016). While these tools offer useful introductory information and help orient visitors, the content they provide is often general and lacks the depth or adaptability needed to support meaningful on-site engagement. As a result, key archaeological features may go unnoticed, and the overall historical narrative of the site remains only partially understood.

This disconnection between access and understanding reduces the educational and cultural value of the experience. It also risks transforming complex archaeological landscapes into ambiguous or generic underwater scenes, depriving them of narrative depth and weakening the connection between visitors and the historical significance of the site (Pérez-Reverte Mañas et al., 2021).

Addressing these issues requires new solutions that actively support underwater interpretation in real time. Recent developments in underwater documentation and immersive technologies offer promising opportunities to enrich the diver's experience directly on site. This paper presents an Underwater Augmented Reality (UWAR) system specifically developed for use by recreational divers. The proposed approach addresses the interpretive challenges of UCH by combining a modular pipeline for the creation and distribution of contextual content with a custom hardware setup tailored to the needs and constraints of non-professional users. This approach enables an immersive and informed experience of submerged sites, enhancing both accessibility and interpretability while supporting site preservation through non-invasive engagement.

2. Related works

In the last decades, digital technologies have increasingly been recognized as valuable tools for the enhancement, interpretation, and dissemination of submerged archaeological sites. In particular, geospatial survey techniques, high-resolution 3D reconstruction, and immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) have been widely explored for their potential to improve both research outcomes and public engagement. These methods offer new ways to document complex submerged environments with high spatial accuracy, while also enabling novel forms of interaction that enhance the intelligibility and experiential quality of underwater archaeological sites (Korniejenko and Kontny, 2024).

This growing interest has led to the development of several European research initiatives that have demonstrated the practical application of these technologies in real underwater contexts. Among these, the VISAS project stands out for its development of a network of acoustic transducers, positioned in geo-referenced points around the site, that communicate with an underwater tablet via an integrated acoustic modem. This technological setup allows divers to determine their underwater position with precision and access interactive digital content contextualized to their location (Bruno et al., 2016). Building on this foundation, the iMARECULTURE project developed AR applications that integrated 3D models, metadata, images, and videos into the live video feed of the tablet. Tests conducted in real underwater archaeological sites showed that such systems improved divers' spatial awareness and focus, supported memory retention, and were positively received even by non-expert users, who described the experience as intuitive, engaging, and informative (Čejka et al., 2021).

3. Materials and Methods

Building on the promising results of previous research, the UWAR system presented in this paper offers a fully integrated solution specifically tailored to recreational divers. It combines 3D reconstruction, real-time positioning, and contextual content delivery to enhance underwater exploration. As illustrated in Figure 1, the system follows a complete pipeline, from the acquisition and processing of survey data to the delivery of AR content.

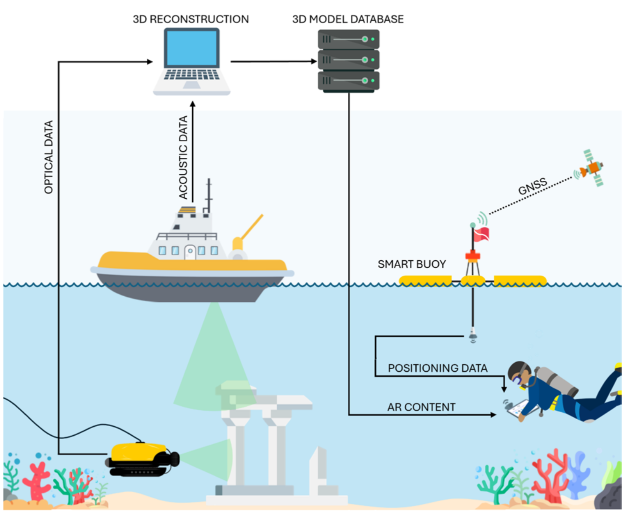


Figure 1. Data processing and content delivering pipeline.

Specifically, high-resolution optical data and large-scale acoustic data are fused to generate a comprehensive and georeferenced 3D model of the archaeological site. This model serves as the spatial backbone for an interactive experience, enabling divers to explore the site while accessing AR content anchored to their real-time position. The system architecture includes a smart surface buoy equipped with Ultra-Short BaseLine (USBL) system and GNSS modules for underwater localization, and an underwater mobile device that displays the AR content. As the diver moves through the environment, contextual information related to nearby archaeological features is dynamically activated. This supports a spatially guided, narrative-based experience that enhances both orientation and interpretive depth.

3.1 Geomorphological Survey and 3D Reconstruction

The development of accurate, high-resolution and georeferenced 3D models is a fundamental step in the UWAR content pipeline, serving as the spatial foundation for immersive visualization and interpretive content delivery. The challenges inherent in documenting submerged archaeological sites, such as water turbidity, inconsistent illumination, complex bathymetry and depth-related constraints, have led to the adoption of multimodal survey approaches that combine acoustic and optical techniques. The integration of these data sources enables the creation of models that are both metrically reliable and visually detailed, suitable for scientific analysis, conservation, and public dissemination activities.

The proposed reconstruction workflow was applied on the archaeological site of Capo Bianco B, a shipwreck located within the Marine Protected Area of Capo Rizzuto, along the Ionian coast of Calabria, approximately 10 kilometres from the city of Crotone in southern Italy (Figure 2).

Figure 2. Geographical location of the Capo Bianco B shipwreck site.

https://doi.org/10.5194/isprs-archives-XLVIII-2-W10-2025-63-2025

The site lies on a flat, sandy seabed at a depth of approximately 10 meters and is characterized by the presence of nine cast-iron cannons, as well as several large ferrous concretions. These accretions are believed to contain additional metal components, possibly related to fastening and structural elements of the original hull. The distribution of the artillery, shown in Figure 3, follows an overall northwest–southeast (315° N) alignment. However, the barrels of the cannons point in various, uncoordinated directions, without any clear pattern or functional logic (Medaglia et al., 2021).

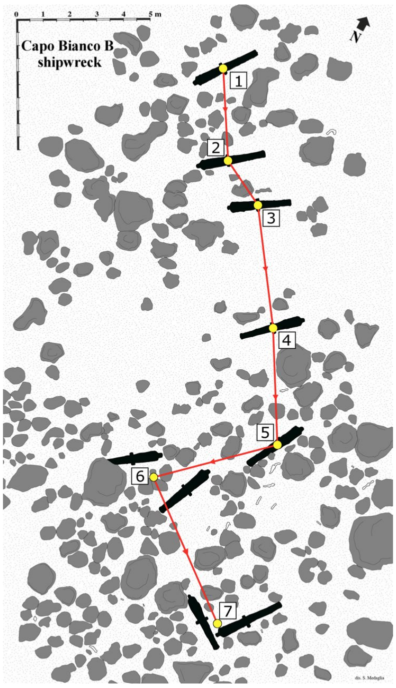


Figure 3. Site plan illustrating the spatial distribution of the cast-iron cannons (adapted from Medaglia et al., 2021).

The reconstruction process begins with the acquisition of acoustic data using a high frequency multibeam echosounder (MBES), a technology that enables continuous and high-resolution mapping of the seafloor morphology. This method remains effective regardless of water turbidity or ambient light, two factors that often limit the reliability of optical documentation techniques. At the Capo Bianco B site, the acquisition strategy followed a systematic grid of equidistant, orthogonal transects, designed after an initial site reconnaissance. The lines were spaced to ensure at least 50 percent overlap between adjacent sonar swaths, using a beam aperture of 120 degrees. This method provided complete and redundant coverage of the survey area, while optimizing acquisition time and ensuring high spatial consistency.

This acoustic dataset served several essential functions. It established a precise spatial framework for subsequent 3D model alignment, offered a complete overview of the geomorphology of the site, and informed the planning of photogrammetric acquisition by highlighting key zones and potential occlusions. Furthermore, acoustic sensing provided reliable documentation in environmental conditions where optical methods may fail due to limited visibility or sediment cover, ensuring the completeness and continuity of the reconstruction workflow.

The acoustic dataset was acquired using the QPS Qinsy software suite and subsequently processed with QPS Qimera (QPS, 2025). The total surveyed area covered approximately 0.43 hectares (4,300 square meters), and the final bathymetric model achieved a spatial resolution of 0.25 meters by 0.25 meters. This level of detail allowed for the precise delineation of archaeological features and the characterization of the site's geomorphological context. Figure 3 presents the resulting bathymetric map of the Capo Bianco B site, illustrating the main morphological variations across the seabed and the extent of the surveyed zone.

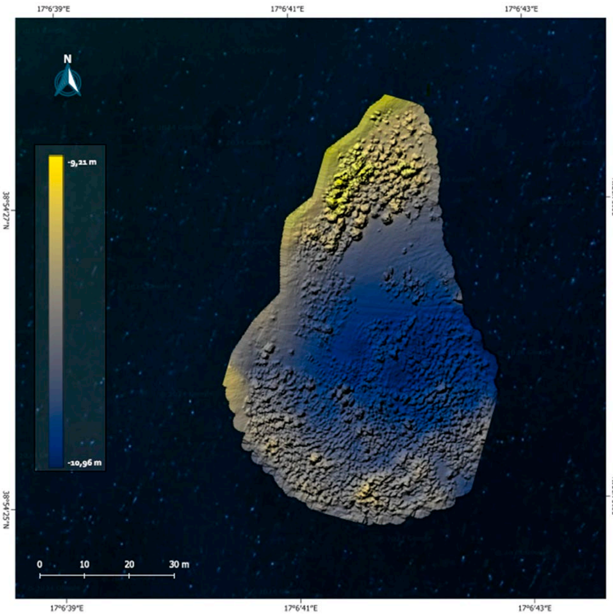


Figure 4. Bathymetric map of Capo Bianco B shipwreck site obtained from MBES data.

Following the acoustic mapping phase, high-resolution visual data were acquired through underwater photogrammetry to support the generation of detailed, metrically accurate, and visually realistic 3D reconstructions. Depending on site conditions, image acquisition can be performed by professional divers or by Remotely Operated vehicles (ROVs) carrying stabilized optical payloads.

At the Capo Bianco B site, the shallow depth and favorable underwater conditions allowed for diver-operated photogrammetry. To ensure comprehensive coverage and structured navigation during data acquisition, the site was first delimited with perimeter tapes to provide a stable visual reference. This setup enabled systematic image collection along planned transects and improved spatial control during diving operations. Seventeen 12-bit coded optical markers were then distributed across key locations on the site. Their spatial positions and inter-marker distances were carefully measured using calibrated tools, creating a geodetic control network to be used for metric scaling and accurate referencing in post-processing. These Ground Control Points (GCPs) served as fixed reference targets, ensuring internal model consistency and enhancing the accuracy of the 3D reconstruction.

Image acquisition followed an aerial-style layout, wherein the diver navigated a grid of orthogonal transects, capturing overlapping images with approximately 70 to 80% frontal and 50 to 60% lateral overlap. This overlap is critical for enabling successful alignment and 3D reconstruction through Structure from Motion (SfM) and Multi-View Stereo (MVS) techniques. In geometrically complex areas such as undercuts, isolated boulders, or recessed seafloor features, supplementary imagery was captured using a spin-around technique. This involved circling the object while ascending or descending, acquiring images at multiple angles to ensure full coverage of occluded surfaces and topographic recesses.

The complete image dataset was processed in Agisoft Metashape Professional (Agisoft LLC, 2025). The pipeline included image alignment, marker detection and referencing, camera optimization, and dense point cloud generation. The resulting model highly detailed and metrically scaled (Figure 5), formed the visual dataset to be aligned with the bathymetric model obtained through multibeam sonar.

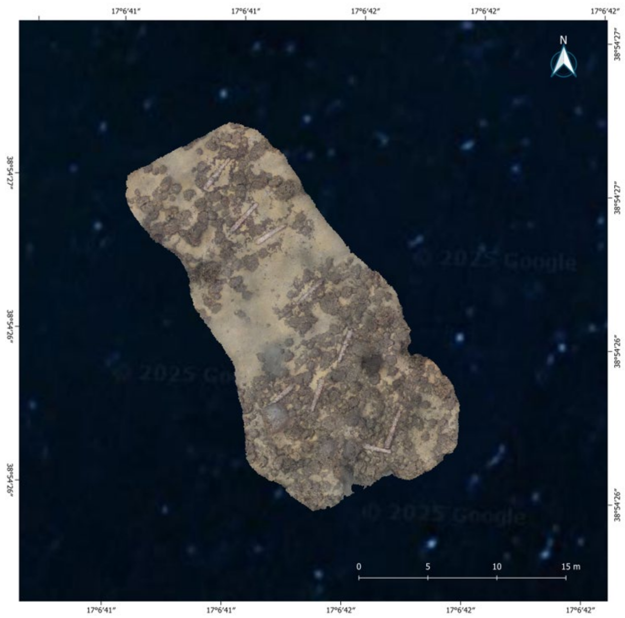


Figure 5. Capo Bianco B shipwreck site orthophoto generated from underwater photogrammetry

Data integration commenced with the spatial alignment of the two point clouds. Initial coarse registration was performed by identifying shared features and manually approximating the transformation between the optical and acoustic datasets. This was followed by a refinement step using the Iterative Closest Point (ICP) algorithm, which iteratively minimizes the distance between the two point sets to compute an optimal alignment. This procedure ensures that the optical model inherits the absolute geospatial reference of the acoustic data, producing a unified point cloud with both geometric fidelity and positional accuracy. The merged dataset was then processed to generate a watertight polygonal mesh. A multiresolution meshing strategy was adopted: high-density areas covered by optical data were meshed with fine granularity to preserve archaeological details, while regions mapped only by sonar were reconstructed at coarser resolution. This balance between resolution and computational efficiency allowed the final model to support both detailed analysis and real-time rendering performance.

The mesh was subsequently textured using the original photographic dataset. High-resolution images were projected onto the 3D surface based on the camera poses computed during the SfM phase, producing a photorealistic representation of the site. This textured model enhances interpretive clarity, enabling the recognition of diagnostic features such as material composition, tool marks, and construction techniques.

To further improve spatial legibility in immersive environments, an ambient occlusion map was computed and applied to the textured model. This shading technique simulates the attenuation of indirect light in concave regions and contact surfaces, increasing the contrast in depth transitions and reinforcing the perception of three-dimensional structure. The result is a visually enhanced representation that supports cognitive mapping and facilitates intuitive understanding of volumetric features, especially in AR or VR applications.

3.2 Multilevel AR Content Design

The 3D model generated through the opto-acoustic reconstruction process functions not only as an accurate spatial representation of the submerged archaeological site, but also as a dynamic platform for delivering interpretive content directly *in situ*. Its geometric precision and photorealistic texture provide a reliable spatial framework upon which digital information can be anchored and displayed via AR during a dive. This enables divers to interact with the cultural landscape in real time, accessing contextual information that enhances both orientation and understanding.

At the core of this interpretive strategy is the spatial annotation of the model with georeferenced Points of Interest (POIs). Each POI corresponds to a feature of archaeological relevance, such as artifacts, structural remains, or environmental markers, and acts as a trigger for the visualization of layered content. POIs are categorized thematically (e.g., armament, hull remains, or natural context) to support narrative organization and allow users to focus on specific aspects of the site. Their placement is designed to reflect both the physical layout of the underwater context and the interpretive priorities defined by the research team.

The following figure (Figure 6) shows the final multiresolution model of the Capo Bianco B site annotated with POIs.

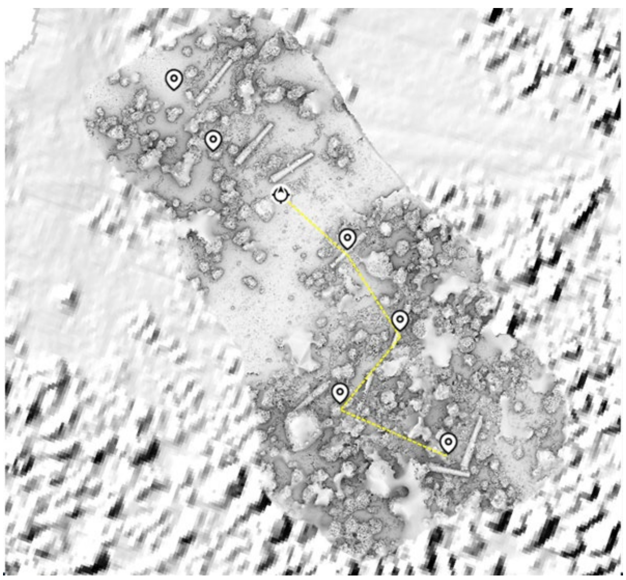


Figure 6. 3D model of the site showing the spatial distribution of POIs.

The model integrates optical and acoustic data, with a resolution that varies based on the archaeological density of each area. Regions rich in artifacts, such as the cannon cluster, are reconstructed with high detail, while peripheral zones are rendered more coarsely to maintain system performance in real-time applications. This multiresolution approach optimizes both visual fidelity and computational efficiency, making the model well-suited for underwater AR delivery. In addition to the spatial distribution of POIs, the image illustrates a potential trajectory of a diver navigating through the site (in yellow). This sample path demonstrates how users might move between POIs in a logical and narrative-driven sequence, reinforcing the interpretive structure embedded in the AR experience.

The spatial distribution and thematic clustering of POIs reflect a deliberate curatorial logic aimed at guiding users through a coherent interpretive experience. Rather than presenting the site as a uniform assemblage of remains, this organization highlights functional and historical relationships among features, facilitating orientation and deeper engagement.

Content associated with each POI is structured on multiple interpretive levels. Basic materials include concise textual descriptions, photographic documentation, and contextual explanations drawn from archaeological and historical sources. More advanced AR elements include 3D reconstructions that are overlaid directly onto corresponding physical features visible on the seafloor. These reconstructions serve dual purposes. In some cases, they enhance the clarity of existing remains by digitally restoring eroded or partially buried structures. In others, they provide hypothetical visualizations of how the site might have appeared in its original state. Importantly, these hypotheses are not speculative renderings. They are developed through an interdisciplinary process involving archaeologists, historians, architects, and digital modelling experts. Each reconstruction is based on documented evidence such as excavation data, historical records, analogical comparisons, and philological research, and is subjected to peer review to ensure both accuracy and transparency regarding interpretive assumptions.

By anchoring all digital content to specific spatial coordinates, the AR interface fosters an integrated and embodied understanding of the site. Information is no longer delivered passively or externally. Instead, it emerges dynamically in correspondence with the diver's position, orientation, and visual attention. This mode of interaction transforms the 3D model from a static visualization into a responsive interpretive environment, bridging the gap between data acquisition and meaningful engagement. Through this approach, the UWAR system not only improves the legibility of submerged heritage but also promotes active learning and a more immersive form of cultural tourism. The ability to "read" the site in real time, guided by spatially coherent content, represents a significant step toward more accessible, intuitive, and informative underwater heritage experiences.

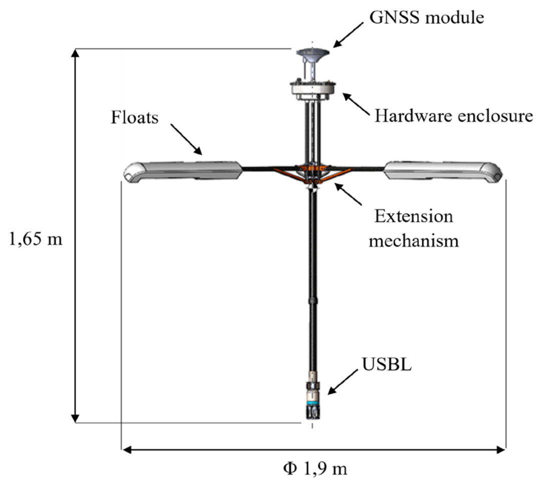
3.3 UWAR Hardware System for Divers

The UWAR system is supported by a purpose-built hardware architecture designed to enable real-time localization and AR content delivery in underwater archaeological environments. It consists of two main components: a mobile device carried by each diver, and a smart buoy that functions as the central localization and communication hub. Together, these elements ensure synchronized tracking, bidirectional communication, and contextual interaction with georeferenced AR content.

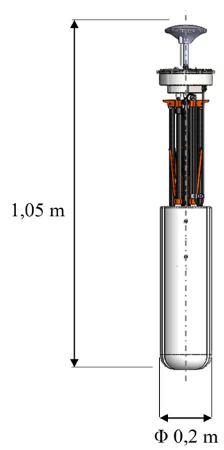
The diver unit consists of a commercial smartphone housed in a professional-grade Leo3 Smart underwater casing manufactured by Easydive (2024). This universal housing is constructed from anodized aluminium to withstand pressure, corrosion, and impact, and features a magnetic wet-contact keypad for interaction with gloved hands. The smartphone runs a dedicated AR application and is equipped with an integrated acoustic modem that communicates continuously with the smart buoy. This setup allows for accurate real-time positioning and automatic activation of location-based AR content.

The smart buoy is a compact and deployable platform designed for stability and portability during offshore operations. It can be launched quickly from a small support vessel and stabilized in the water using a tripod expansion mechanism: three arms unfold to ensure buoyancy and balance in dynamic sea conditions. A telescopic central tube supports a USBL transducer, which enables underwater localization and communication with the diver's device (Fortuna et al., 2024).

The following figures show the 3D model of the buoy in both its open (Figure 7(a)) and closed (Figure 7(b)) configurations, illustrating the transformation from a compact form factor to an operational state ready for in-field use.



(a)



(b)

Figure 7. Smart buoy in it (a) open and (b) closed configurations.

https://doi.org/10.5194/isprs-archives-XLVIII-2-W10-2025-63-2025

Located at the top of the telescopic tube, a sealed electronics enclosure houses the core processing unit of the system, GNSS receiver, and wireless communication modules, allowing real-time transmission of positioning data and synchronization signals to a remote control station. The entire buoy system is powered by rechargeable lithium batteries, offering an operational autonomy of approximately 4 hours. Its construction combines corrosion-resistant metal alloys, marine-grade polymers, and closed-cell polyurethane foam for flotation and mechanical resilience.

In transport configuration, the buoy measures approximately 1 meter in length and 0.2 meters in diameter, weighing around 5 kg, making it manageable even from small boats. Once deployed, it extends to a total length of 1.65 meters and a maximum diameter of 1.9 meters with stabilizing arms fully opened.

This integrated hardware configuration supports seamless interaction between the diver and the virtual environment. As the diver navigates the site, their position is tracked with high precision relative to the 3D model. The coordination of localization, visualization, and communication ensures a fluid and immersive experience tailored to the needs of recreational divers, while preserving the integrity and accessibility of the archaeological context.

4. Conclusions

This paper presents an integrated UWAR system designed to enhance the interpretation and experiential quality of submerged archaeological sites during recreational dives. By addressing the inherent perceptual and cognitive challenges of the underwater environment, the proposed system offers an innovative and scalable solution for cultural engagement among recreational divers.

The 3D reconstruction methodology, validated at the Capo Bianco B site, combines high-resolution optical photogrammetry with multibeam acoustic bathymetry to produce accurate and georeferenced models of the archaeological landscape. The resulting model enables detailed documentation while also providing the spatial structure necessary for the delivery of contextual AR content. By annotating the 3D environment with thematically categorized POIs, each linked to interpretive material, the system transforms a static dataset into an interactive and narrative-driven experience.

A key innovation lies in the highly portable and easily deployable hardware architecture, which includes a smart buoy equipped with USBL and GNSS systems for real-time positioning, and a mobile underwater device for AR content delivery. This configuration eliminates the need for permanent infrastructure, allowing flexible and rapid deployment even in remote or protected marine areas. The immersive AR experience is grounded in spatial logic and user movement, promoting an active learning mode that encourages personal discovery rather than passive consumption of information.

Future development will focus on system optimization and the integration of collaborative features to support guided or multi-user experiences. Additionally, planned user studies will evaluate learning outcomes, emotional engagement, and the long-term impact on cultural heritage appreciation.

In conclusion, the UWAR framework helps redefine the boundaries of underwater exploration. It offers a vision of diving that is not only adventurous, but also intellectually enriching and culturally meaningful.

Acknowledgements

This work has been partially funded by the European Union – Next Generation EU - Italian NRRP, Mission 4, Component 2, Investment 1.1 "Fund for the National Research Program and Projects of Significant National Interest (PRIN)" (Directorial Decree n. 1409/2022) "PRIN 2022 PNRR" - title of the project: smart low-impact buoys for monitoring marine environments (SUMMER), project code P2022M9CFC, CUP: H53D23008640001. This work reflects only the authors' views and opinions, neither the Ministry for University and Research nor the European Commission can be considered responsible for them.

References

Agisoft LLC, 2025. Agisoft Metashape software suite. https://www.agisoft.com/ (20 May 2025).

Bruno, F., Lagudi, A., Barbieri, L., Muzzupappa, M., Ritacco, G., Cozza, A., Cario, G., 2016: Virtual and augmented reality tools to improve the exploitation of underwater archaeological sites by diver and non-diver tourists. In: Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection. 6th Int. Conf., EuroMed 2016, Nicosia, Cyprus, 31 October–5 November 2016, Proc., Part I, Springer Int. Publishing, 269–280. doi.org/10.1007/978-3-319-48496-9_22.

Bruno, F., Ricca, M., Lagudi, A., Kalamara, P., Manglis, A., Fourkiotou, A., Veneti, A., 2020: Digital technologies for the sustainable development of accessible underwater cultural heritage sites. J. Mar. Sci. Eng., 8(11), 955. doi.org/10.3390/jmse8110955.

Čejka, J., Mangeruga, M., Bruno, F., Skarlatos, D., Liarokapis, F., 2021: Evaluating the potential of augmented reality interfaces for exploring underwater historical sites. IEEE Access, 9, 45017–45031. doi.org/10.1109/ACCESS.2021.3059978.

Cooper, V., Knott, P., 2016: The Iona II Dive Trail, building relationships through the protection and management of marine heritage. J. Community Archaeol. Herit., 3(1), 5–21. doi.org/10.1080/20518196.2015.1123882.

Diamanti, E., Ødegård, Ø., 2024: Visual sensing on marine robotics for the 3D documentation of Underwater Cultural Heritage: A review. J. Archaeol. Sci., 166, 105985. doi.org/10.1016/j.jas.2024.105985.

Dimmock, K., Wilson, E., 2011: “Take a deep breath”: how recreational scuba divers negotiate in-water constraints. Leisure/Loisir, 35(3), 283–297. doi.org/10.1080/14927713.2011.614839

Easydive, 2024: Custodia universale subacquea Leo3 Smart. Easydive. www.easydive.it/custodie-subacquee/smartphone/custodia-universale-subacquea-leo3-smart.255.html (20 May 2025).

Fortuna, S., Sollazzo, C., Scarfone, L., Muzzupappa, M., Cucinotta, F., Barbieri, L., 2024: Design Concept of an

Innovative Smart Buoy for Marine Environment Monitoring. In: International Joint Conference on Mechanics, Design Engineering & Advanced Manufacturing, Cham, Springer Nature Switzerland, 455–463. doi.org/10.1007/978-3-031-72829-7_36.

Korniejenko, K., Kontny, B., 2024: The usage of virtual and augmented reality in underwater archeology. Appl. Sci., 14(18). doi.org/10.3390/app14188188.

Medaglia, S., D'Agostino, M., Ghelli, A., Caruso, P., Stefanile, M., 2021: Osservazioni preliminari sulle artiglierie in ferro del relitto "Capo Bianco B" (Crotone). Archaeol. Marit. Mediterr., 18, 129–153. https://dx.doi.org/10.19272/202104501006

Meyer-Kaiser, K.S., Mires, C.H., 2022: Underwater cultural heritage is integral to marine ecosystems. Trends Ecol. Evol., 37(10), 815–818. doi.org/10.1016/j.tree.2022.06.014.

Pérez-Reverte Mañas, C., Cerezo Andreo, F., López Osorio, P., González Gallero, R., Mariscal Rico, L., Arévalo González, A., 2021: Underwater Cultural Heritage as an Engine for Social, Economic and Cultural Development. State of Research at the University of Cadiz (Andalusia, Spain). Heritage, 4(4), 2676–2690. https://doi.org/10.3390/heritage4040151

QPS, 2025. QPS software suite. https://qps.nl/ (20 May 2025).

Sumanapala, D., Dimmock, K., Wolf, I.D., 2023: A review of ecological impacts from recreational SCUBA diving: Current evidence and future practice. Tourism Hosp. Res., 23(4), 564–577. doi.org/10.1177/14673584221112602.