

# ClepsYdra: translating submerged archaeological remains from shallow water to digital environment with geoinformatics

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## Abstract

Coastal and shallow submerged archaeological sites face risks due to sea level rise and erosion. The documentation of visible remains will be completed through satellite and aerial remote sensing methods. Geophysical prospection methods will map the continuation of the structures below the sea bed. Multi criteria decision support algorithms will assess the risk threatening the shallow submerged archaeological sites.

## Keywords

applied geophysics; assessment cultural heritage; photogrammetry; satellite remote sensing; underwater archaeology

## — Introduction

The study and documentation of Cultural Heritage (CH) is rapidly developing, at times favoring or even pushing the progress of technologies and equipment in place for the digitalization of items and landscapes. At the same time, the survival of CH is constantly threatened by factors related to the accessibility of the artefact, its location and context as well as the chronology. Nowadays it is possible to document in high detail the surroundings, making a step further to “look” beneath the soil and produce images of buried (Sarris 2015) and submerged (Galaniidou et al. 2020) structures to assist and complement archaeological research in a timely and costly efficient manner.

Although the availability of mapping methods for the documentation of CH in deep-water is nowadays well established, significant developments have also been made to reconstruct the archaeoenvironment in the coastal and shallow aquatic environment transition zone with geophysical and geoarchaeological methods (e.g. Pydyn et al. 2021; Wilken et al. 2019; Cvikel et al. 2017). However, there is still space for methodological improvements to document archaeological sites in shallow water environ-

ment which are at risk of being excluded from the archaeological discourse on coastal area exploitation.

To this direction, the research project ClepsYdra: “Translating Submerged Archaeological Remains from Shallow Water to Digital Environment with Geoinformatics” has the ambition to maximize the accessibility to information regarding the current-state of now-submerged sites by minimizing the lack of protocols, procedures and equipment for shallow-water CH investigations, developing ways to explore and promote these under-studied submerged contexts. ClepsYdra is funded by the Hellenic Foundation of Research and Innovation and it will run for a period of two years. It is joining the efforts of two international research centers (Foundation for Research and Technology Hellas and Italian National Research Council) with the Greek Ephorate of Underwater Antiquities to understand the cultural landscape of shallow submerged archaeological sites in eastern Crete.

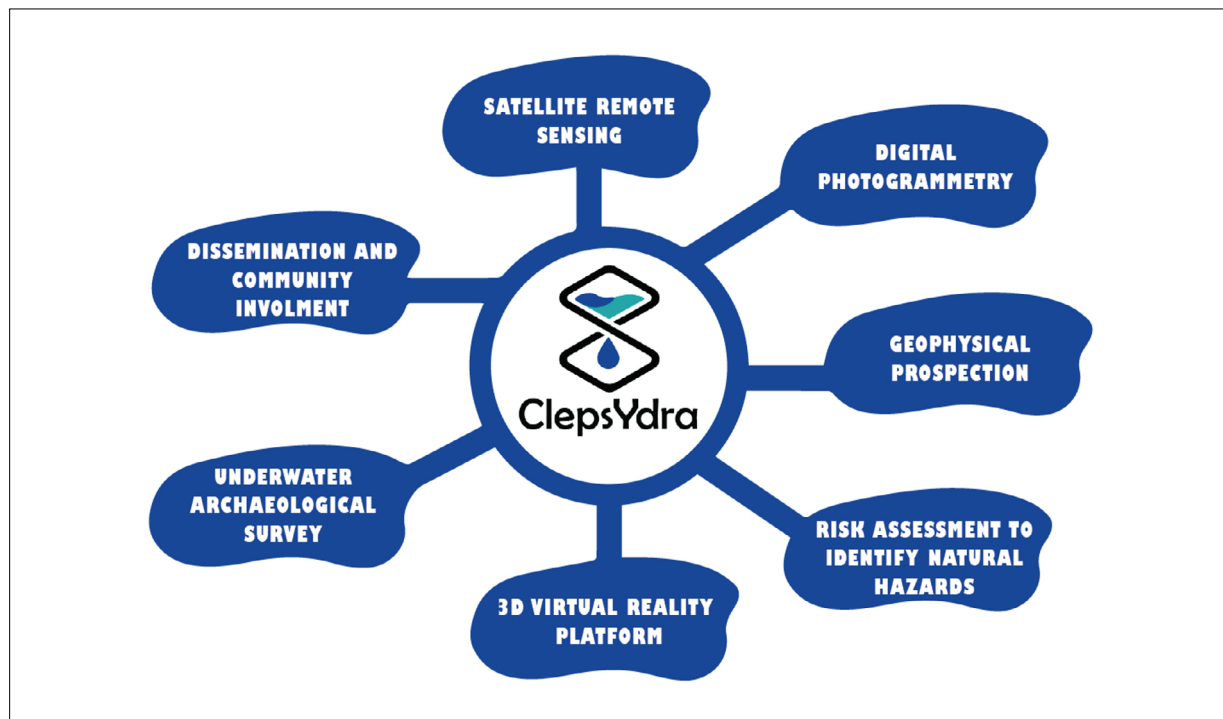


Fig. 1: Integration of the different research modules to fulfil the scientific objectives of ClepsYdra.

### Objectives and methodology

Time is definitely the most essential and distinctive connotation of CH, which in combination with space and human interventions, are responsible for the conservation of archaeological remains. Its present and future survival is often compromised or threatened by various factors, mostly driven by natural phenomena. This is particularly evident when the space in which these artifacts are hosted today is hostile or it renders the documentation process a complex and expensive task. This is the case of archaeological sites close to the modern coasts, which were once in dry land and are now submerged because of the sea-level change across time.

The objectives of ClepsYdra include: a) Extensive 3D digital documentation of submerged and underwater buried archaeological evidences for five statistically representative case studies. b) Construction of a new low-cost open-hardware device for the digital documentation of shallow water contexts in automated and systematic manner. c) Application of non-destructive research methods (satellite / terrestrial remote sensing, aerial photography, underwater photogrammetry, traditional and digital 3D archaeological documentation) to capture the current

state of selected sites, despite their difficult accessibility and incomplete visibility with naked eye. d) Modification, adaptation and improvement of geophysical methods and protocols to account for the shallow water context. e) Systematic merging and summarization of the above data for the enhancement of the archaeological understanding and interpretation, towards the analysis of the paleoenvironment in coastal and shallow submerged archaeological sites. f) The active and growing involvement of local community in the understanding, promotion and protection of CH (Fig. 1).

The main technological advancements include the: a) development of an algorithm for calibration of drone-aided photographs to account for the two medium problem and the creation of a custom made sailing platform for automated navigation and photo-capturing in single medium, b) development of algorithms for joint inversion of resistivity and seismic data, c) development of algorithms within a Multi-Criteria Decision Analysis (MCDA) model to assess the overall risk assessment of the CH sites that are found on the merged inland and littoral zone.

In order to achieve the project's objectives, statistically relevant sample sites have been identified, including some commonalities, logistics facilities and peculiarities. All the



**Fig. 2:** Location of the ClepsYdra case studies in eastern Crete. The background base satellite map is taken from Google Earth (©2010 DigitalGlobe, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, ©2010 European Space Imaging).

sites have similar chronology dated in the Roman Times and are located in the eastern part of Crete which is gradually sinking based on established geological and tectonic models (Mourtzas et al. 2016). Thus, the sample includes four shallow submerged and (partially) sand-buried sites in the Eastern part of the island of Crete including an important Roman settlement (Koufonisi islet), two pluri-stratified -prehistoric to Roman- sites (Gaidouronisi islet, and Stomion bay) and one ancient harbor (Hierapetra). (Fig. 2).

### Expected results

ClepsYdra aims towards a better understanding of the cultural landscape and the closer contact of the coastal and marine archaeological sites of Crete with the wider public. It will propose an integrated approach for the documentation of the shallow submerged archaeological sites combining: a) underwater archaeological investigation and geophysical imaging, b) satellite, aerial, low-altitude and underwater mapping with digital photogrammetry, c) risk modelling and assessment, all together providing a unique tool to understand the Cretan marine archaeology, especially of the Roman times which were until recently

underexplored. It will also put the bases for a protocol or a sequence of procedures for the successful implementation of integrated methods in similar shallow marine archaeological environments. Underwater archaeology will also gain a new set of tools for approaching coastal sites in a holistic manner that will allow to easily combine results from submerged sites with those of land archaeology. These tools will also give the advantage of a relatively rapid data collection that is crucial for remote sites along the coast where weather conditions (mostly wind) and in situ difficulties (waves, water turbidity and others) are not always ideal for fieldwork activities. The amount of information derived by the integrated application of new and improved methods will be concentrated in a new set of information regarding the risks to which each site is exposed. Indeed, the capability to fuse all these in an all-in-one geoinformatics package arises by offering the opportunity to evaluate the natural hazards and the overall risk assessment of the CH sites found inland, while extending this with submerged structures at the littoral zone as well.

## Acknowledgments

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