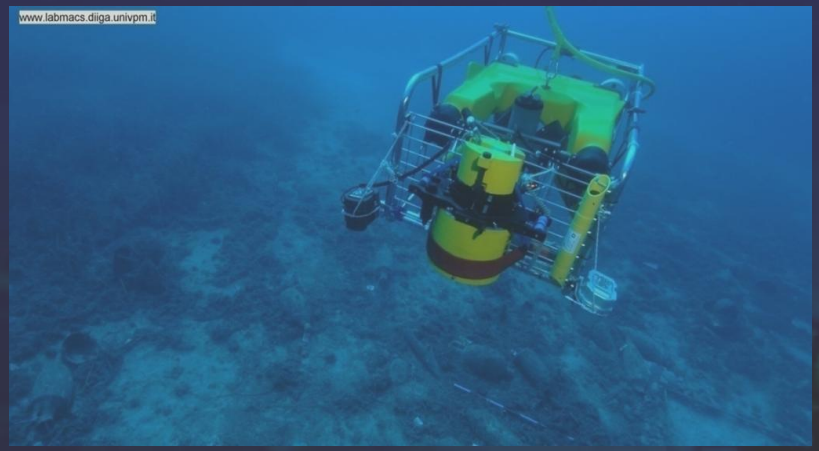


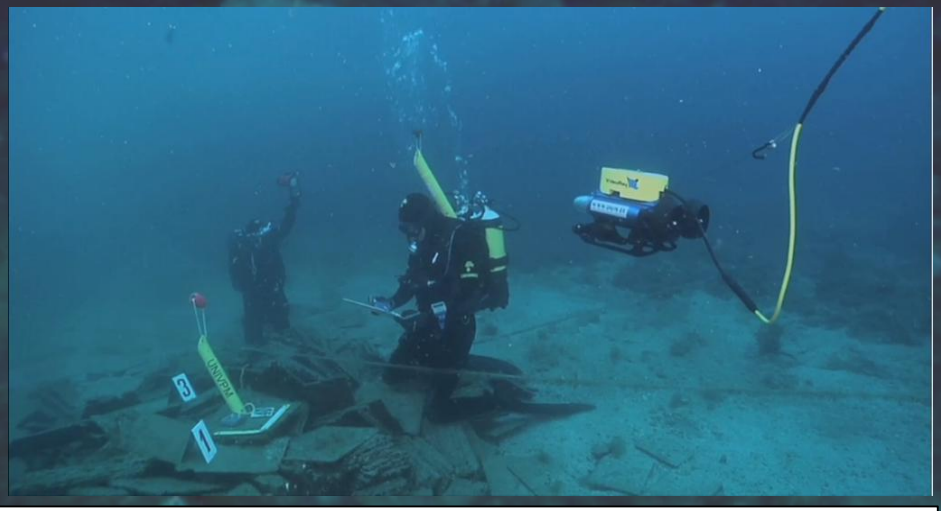
VIPS 2012 ROV Conference

Tools and Techniques for 3D documentation of Underwater Sites

David Scaradozzi, Laura Sorbi

Università Politecnica delle Marche

LabMACS
Laboratory of Modeling, Analysis and Control of dynamical Systems



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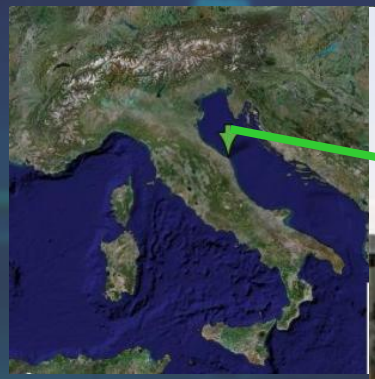
Who we are

Research infrastructure

LabMACS participates in the research infrastructure of ISME - Interuniversity Centre of Integrated Systems for the Marine Environment (6 University, 40 researchers)



Equipments for underwater activities

- ROVs: Deep Ocean PhantomS2, Prometeo Reloaded, VideoRay Pro4
- High definition 3D cameras, FullHD DV videocamera
- USBL positioning system
- Imaging sonars
- Multiparametric probe for water analysis

Competences, skills

- Development of NGC, hardware and software for robotics
- Data acquisition and processing
- 3D documentation and reconstruction

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Tools and Techniques for 3D documentation of Underwater Sites

Outline

1. Introduction and motivations
2. Methodology used in the archaeological survey
3. Methodology and technology applied to the *dolia* case study
4. Results
5. Conclusions

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- The topic:

Conservation of marine habitats and of archaeological heritage is a binding priority in the modern world and this also applies to deep-sea environments, which are inevitably difficult to access, and pose considerable difficulties for their inspection.

- Motivations:

Several kind of applications aim at obtaining enriched maps of the underwater environment in an efficient, economic and non-invasive way.

Examples:

- monitoring of underwater building status
- biological marine environment monitoring and analysis
- survey of archaeological sites

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- During last years…

ISME (Interuniversity Ctr. Integrated Systems for the Marine Environment) and SBAT (Italian Ministry of Culture, Superintendence of Archaeological Goods of Tuscany - Soprintendenza per i Beni Archeologici di Toscana) have been working toward automation of the survey process in order to build augmented map of underwater environments.

We propose:

an innovative methodology and an integrated system based on low-cost, easy-to-use and non-invasive optical and acoustical tools useful to obtain a geo-referenced augmented 3D map of an underwater site

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Methodology used in the archaeological survey

Tools and Techniques for 3D documentation of Underwater Sites

Archaeologist activities requires a systematic recording and mapping necessary, and an accurate documentation has to be provided at each stage of the methodology.

In the following we are going to see the underwater archeology methodology for studying sites based on traditional techniques and augmented with the surplus value of technological innovation.

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Tools and Techniques for 3D documentation of Underwater Sites

Methodology used in the archaeological survey

1. Area Choice	•Distributed computing platforms that can manage web-scale datasets
2. Site Localization	•Differential GPS, Radio Buoys
3. Site Cleaning	•Dredges or Crane with force feedback and positioning system
4. Site positioning	•USBL: Underwater positioning systems and Diver tracker system
5. Artifact Cataloging	•General viewer of the site: Artifacts positioning system; Automatic tools for archiving and GIS connection
6. Sea-Bottom referencing system adding	•USBL transponder with mooring and filtering system
7. Site Surveying	•Camera with positioning and attitude measurement system
8. Site Restitution	•2D augmented map viewer
9. Site Exploration	•3D virtual environment and documentation

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Methodology used in the archaeological survey

Tools and Techniques for 3D documentation of Underwater Sites

1. Choice of an interesting area

identifying an area where an interesting archaeological site is potentially present; the choice is performed by comparing several information coming from different sources.

2. Site localization

archaeologist delimits a sub-area to explore, where the concentration of artifact materials is relevant: this sub-area becomes a site, precisely 2D geo-referenced to the surface by GPS.

3. Cleaning the archaeological site

Dredges and/or crane are used for removing organic materials like algae, dead "posidonia", sand and a thick layer of sediment in general, in order to improve the recognition of artifacts within the site.

4. Site outline

preliminary observation of the site is performed by the archaeologist divers

A central position is chosen, where a buoy is placed and tentatively geo-referenced from the surface.

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Methodology used in the archaeological survey

5. Cataloging

the objects are numbered and labeled.

6. Positioning a referencing system on the sea-bottom

An USBL transponder is leaved for a certain measurement time in the central point identified during the second stage thanks to previous campaign information. At the end of the chosen period,

latitude, longitude and depth at the referenced point are obtained

7. Surveying the site

The technological contribution can significantly make the survey stage more efficient, with custom electronics improving the way photos and videos are acquired.

8. Restitution: mapping

software suites can integrate and fuse acoustical, optical and platform navigation data.

9. Exploration

Further explorations, investigations and interpretations can significantly take advantage from the previous stage output.

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Methodology used in the archaeological survey

- Technology added value -

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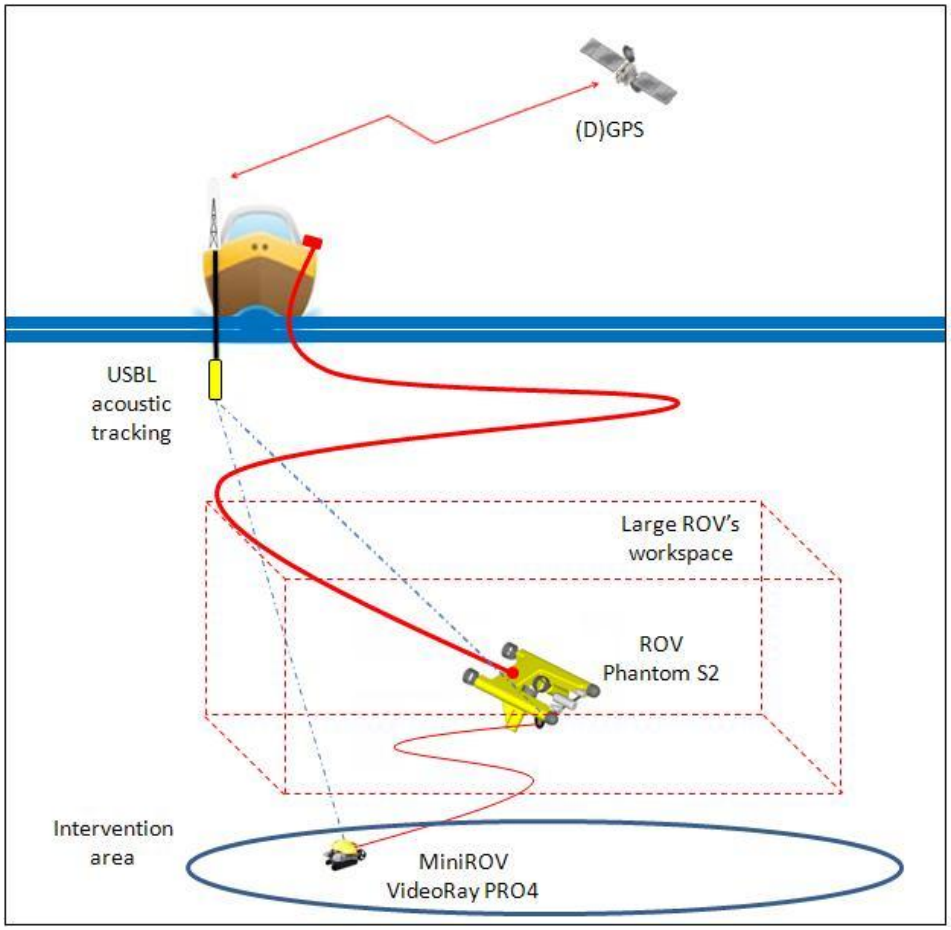

Integrated system composed by:
- a surface vessel
- a bigger ROV for monitoring
- a Micro ROV for deeper intervention
- USBL acoustic system
- GPS surface positioning

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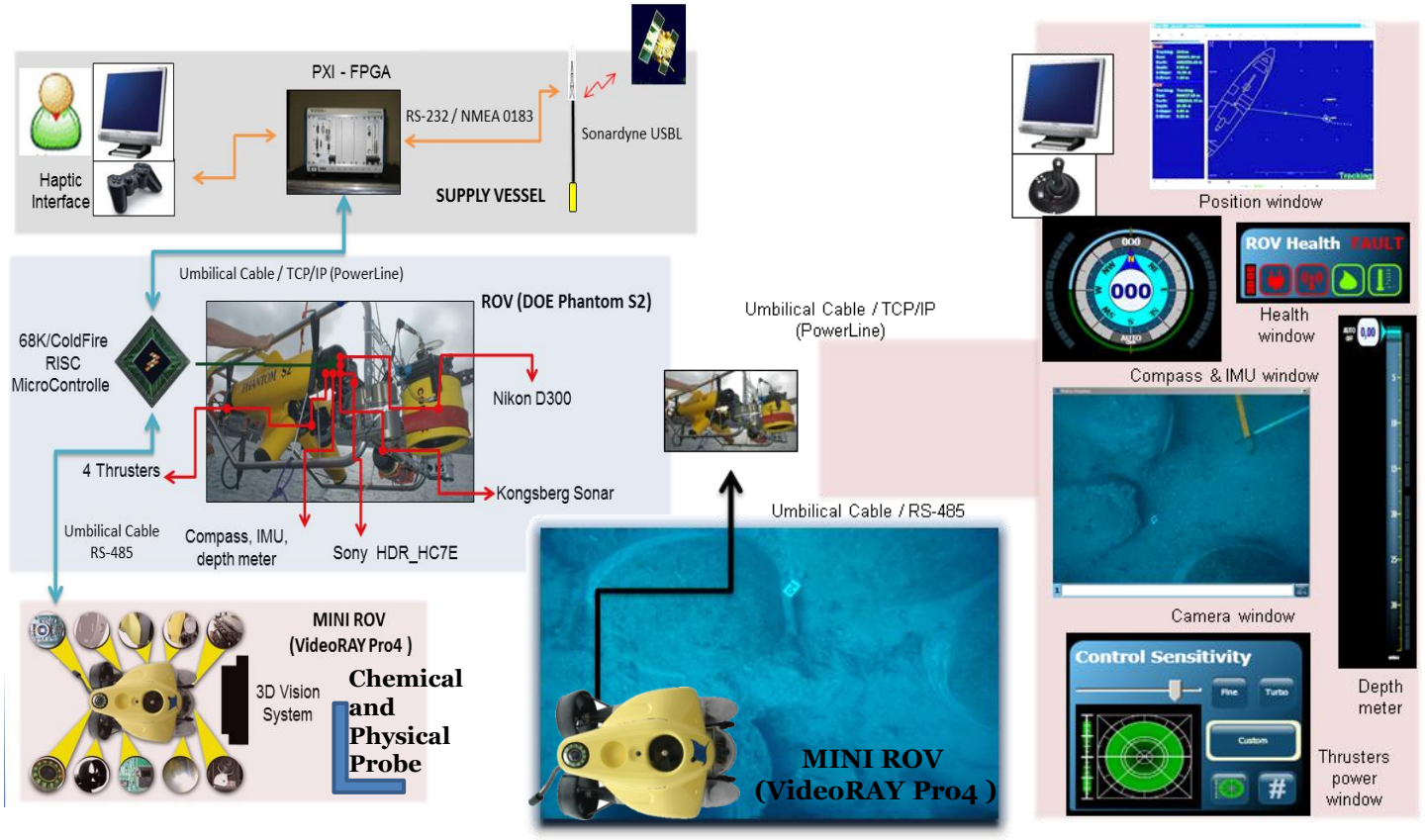

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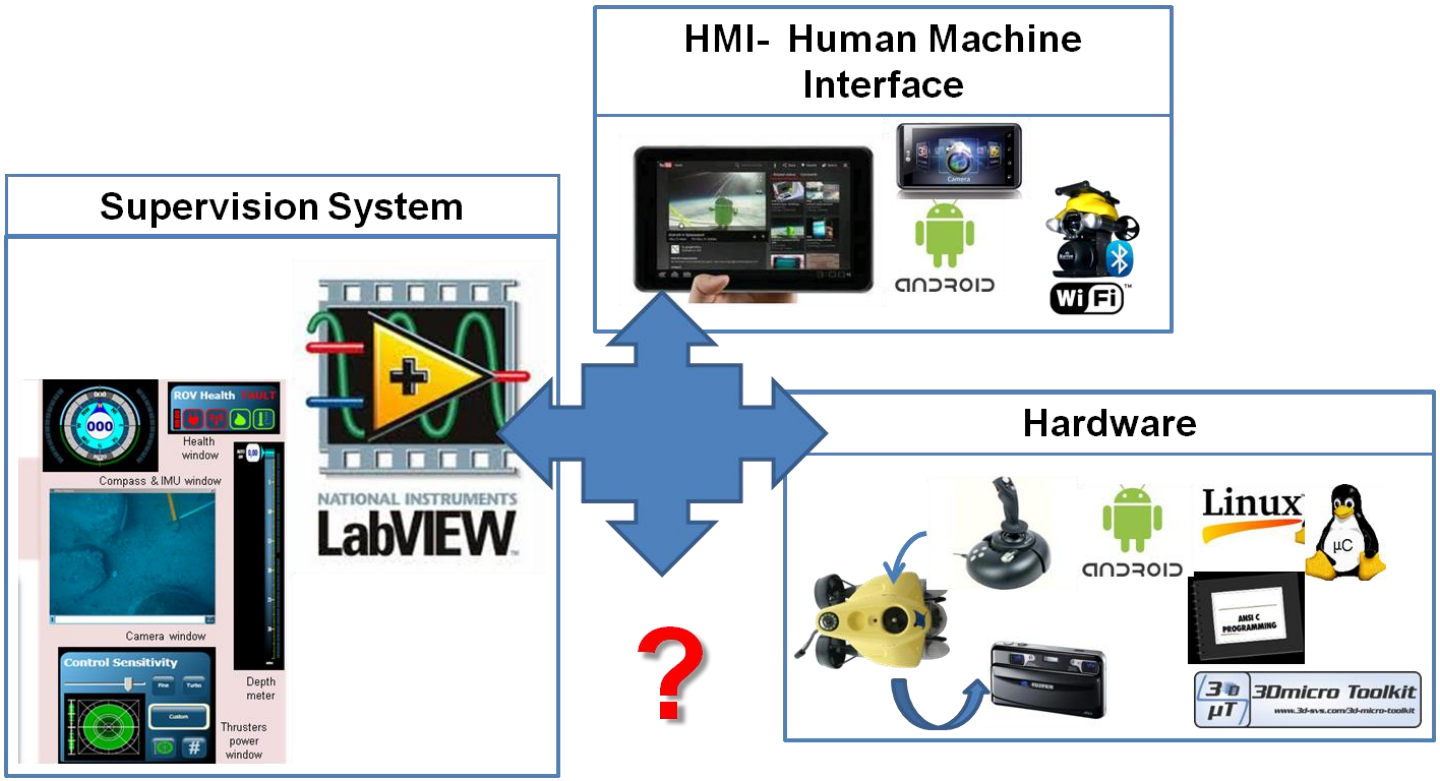

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Methodology and technology applied to the *dolia* case study

Tools and Techniques for 3D documentation of Underwater Sites

The shipwreck of Dolia of Punta del Nasuto (Marciana Marina, Elba Island) is collocated within the Tuscany Archipelago and presents a load of **ten** big dolia.

Photo: Adriano Penco, 2010

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Methodology and technology applied to the *dolia* case study

First underwater campaigns (2007-2008)

Scuba divers technicians have performed first divings:

✓the ten visible *dolia* count

✓the single objects geolocalization using *transponders*

triangulation among the acoustic reference *transponder*, and the transponder carried by the diver or placed on a finding and a transceiver located below the keel of the supply boat, allowed to know the GPS position of all the points of interest.

Only four of the ten *dolia* resulted visible during this first stage.

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Methodology and technology applied to the *dolia* case study

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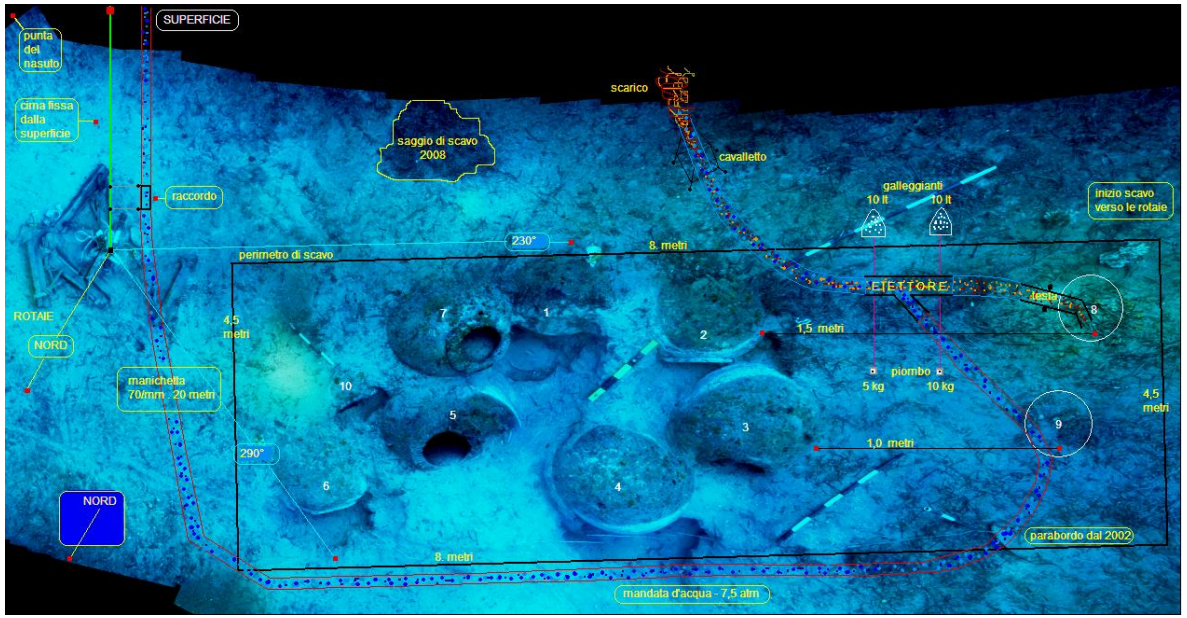
2009 campaign

✓site exploration with a *transponder* field carried by the divers for measurements, individual *dolia* geolocalization, and delimitation of the wreck's perimeter;

✓ first dolia intensive surface cleaning;

✓elaboration of a photo mosaic to document in a high-definition and georeferenced way the surface layer.



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Methodology and technology applied to the *dolia* case study

2010 campaign

✓work on the site has been organized thanks to the photomosaic seen.

✓site deeper investigated and studied

✓technologies applied to the data gathering have allowed the 3D reconstruction of the site.

2011 campaign

✓methodologies and technologies validate further developed

✓better 3D reconstruction of the ***dolia*** wreck site

✓definition of **operational requirements**.

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Methodology and technology applied to the *dolia* case study

operational requirements

Instrument calibration (sensors and camera)

Sensors: useful to remove any system noise and other specific errors coming from the studied environment)

Camera: in order to eliminate lens, underwater housing and water effects.

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Geoposition data aided 3D documentation of archaeological and biological sites

operational requirements

Georeferenced Data Acquisition

✓ acquisition of optical and acoustic data with an underwater
✓ position and orientation of the underwater recovery device are registered, referring them to a known origin

The photographer position is monitored and stored for data post-processing thanks to an acoustic system USBL Sonardyne Scout (operating at the acoustic frequency of 35-55KHz, with repetition frequency of 1 Hz). The DGPS information were compared and filtered with the average value of the fixed point in the reference position.

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operational requirements

Virtual reconstruction

Building build 2D and 3D models the explored area in a virtual environment. Thanks to data acquired by the USBL system, the diving path has been outlined; then, a partial reconstruction of the area has been produced thanks to data coming from the developed tools, useful to evaluate the documentation coverage.

All information and data coming from the photographic survey can be merged with the documentation of previous campaigns, in order to obtain a 3D virtual reconstruction of the scene and of material removal temporal layers.

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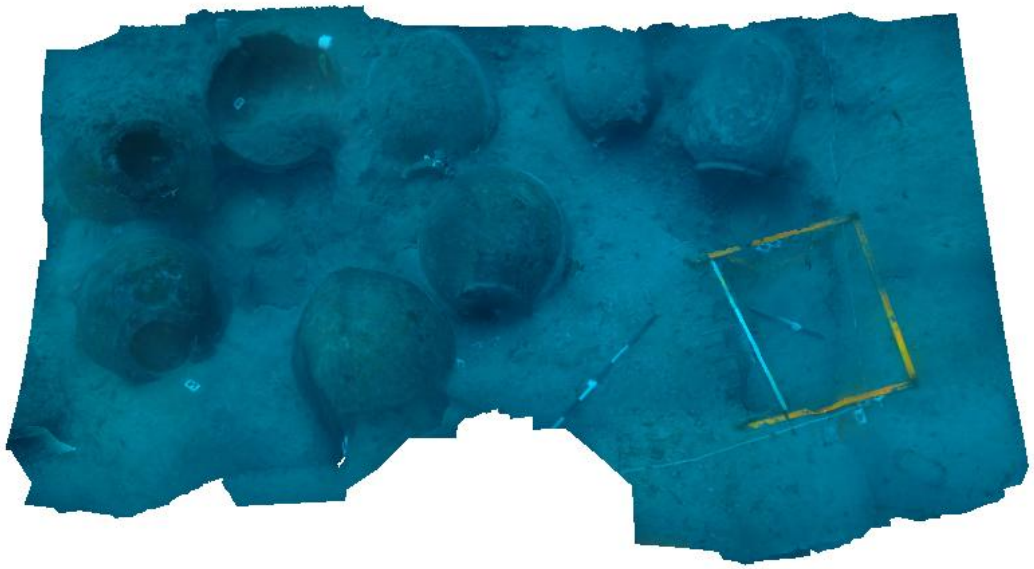
Results

3D virtual representation of the dolia wrecksite obtained thanks to Neri's photos



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Results

3D virtual representation of the dolia wrecksite obtained thanks frames coming from 3D videos

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Conclusions

✓ This work presents the great potential of USBL and underwater robotics in the field of underwater archeology, providing tools and innovative methodologies useful in order to explore sites.

✓ Results obtained will help archaeologists to get new information and to obtain more accurate reconstruction of the archaeological site, which could be presented to the general public.

✓ Future works will include new field experiments for validating and tuning the developed methods, as well as the study and development of advanced intervention techniques.

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