Underwater archaeological surveys in Salento waters: results and methods

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Preface

We are happy to present the proceedings from the 6th European Conference on Scientific Diving (ECSD), which took place in April 2021 as virtual meeting. The first ECSD took place in Stuttgart, Germany, in 2015. The following conferences were hosted in Kristineberg, Sweden (2016), Funchal, Madeira/Portugal (2017), Orkney, Scotland/UK (2018), and Sopot, Poland (2019), respectively. The 6th ECSD was scheduled for April 2020 but has been postponed due to the Corona pandemic by one year. In total 80 people registered and about 60 participants were online on average during the two days of the meeting (April 21 and 22, 2021). 36 talks and 15 posters were presen-ted and discussed. Some authors and co-authors took advantage of the opportunity to hand in a total of 25 extended abstracts for the proceedings published in the open access journal FOG (Freiberg Online Geoscience).
The contributions are categorized into:

- Device development
- Scientific case studies
- Aspects of training scientists to work under water

The order of the contributions within these three categories is more or less arbitrary.

Please enjoy browsing through the proceedings and do not hesitate to follow up ideas and questions that have been raised and triggered during the meeting. Hopefully, we will meet again in person during the 7th ECSD in France.

The team of the Scientific Diving Center of TUBAF, Freiberg, Germany

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Underwater archaeological surveys in Salento waters: results and methods

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Abstract. This paper is related to the survey carried out in several coastal sites of Puglia in 2020, within the project UnderwaterMuse. The core of the activities took place at the Torre S. Sabina site, on the Adriatic Sea, where an integrated topographic and photogrammetric survey has been conducted on the late-imperial Roman shipwreck. Another activity, always on the Adriatic Sea, are been conducted in the "Le Cesine" Natural Reserve how led to the identification of a big pier from the Augustan period. On the Ionian Sea, furthermore, in Porto Cesareo Marine Protected Area, new evidence has been added to the numerous ones already known, such as some spectacular formations composed uniquely by cemented sherds of Tripolitanian amphorae (2nd cent. AD). This evidence seems to be significant markers of sea-level changes and the evolution of the seascape.

Introduction

This contribution concerns the archaeological survey carried out in September - October 2020 as part of the UnderwaterMuse Project (Italy-Croatia 2014-2020 Cooperation Programme)[1].

The activities were conducted at different levels of detail in various Apulian sites in the Adriatic and Ionian seas. The core of the activities took place at the Torre Santa Sabina site (Carovigno, Brindisi, Italy), in particular on the late-imperial era roman shipwreck, located in "Baia dei Camerini" on the Adriatic Sea (Fig. 1).

In the "Le Cesine" Nature Reserve, also on the Adriatic coast, and in the Marine Protected Area of Porto Cesareo, in the Ionian Sea, discoveries are reported, also obtained thanks to the use of new detection technologies (Fig. 1).

All these sites have shared characteristics that make it possible to highlight a series of aspects that are of interest for the reconstruction of the ancient environment and above all the variations in sea level since antiquity.

In methodological terms, the research conducted in the three areas followed a holistic, contextual, diachronic and transdisciplinary approach to the archaeology of landscapes, or rather seascapes, in this case, coastal and underwater. The primary objective of this systemic vision is to tell the story of social groups in changing landscapes, recording their discontinuities, formative processes and identity.

[1] www.italy-croatia.eu/web/underwatermuse.

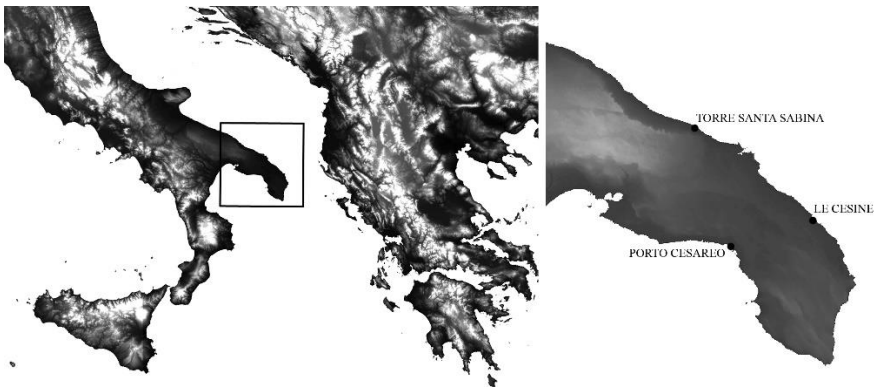

Fig. 1. Archaeological research areas of the UnderwaterMuse Project in Puglia.

Torre Santa Sabina

The choice of Torre S. Sabina as the setting for a pilot intervention within the UnderwaterMuse Project stems from the quality and variety of the archaeological sites in the bay (Fig. 2). The exceptional potential of this millenary landing place is an ideal scenario for a holistic approach to research, that is, that of the global archeology of landscapes, in this case coastal and maritime, or seascapes. It is a "super-site", with stratifications of events that are also significant indicators of the evolution of the coastal landscape: cargos and hulls, but also remains of quarries and settlements (Auriemma 2014).

The combination of data obtained through traditional and interdisciplinary survey methods and the use of new technologies, such as drones, remote sensing systems, underwater photogrammetry and the creation of a DEM of the seabed of Baia dei Camerini, obtained after the multi-beam survey (Fig. 3), allow us to argue our hypotheses of historical reconstruction on a solid documentary basis.

A general multiscale UAS survey of the Torre Santa Sabina settlement was carried out with the help of several drones, exploiting the possibility offered by the on-board GNSS that allows the direct georeferencing approach: using RTK (Real-Time Kinematik) or PPK (Post-Processing Kinematic) solutions (Fig. 2). Furthermore, a second activity was carried out concerning the underwater survey of the aft area of the Roman wreck using close-range photogrammetry (Fig. 4).

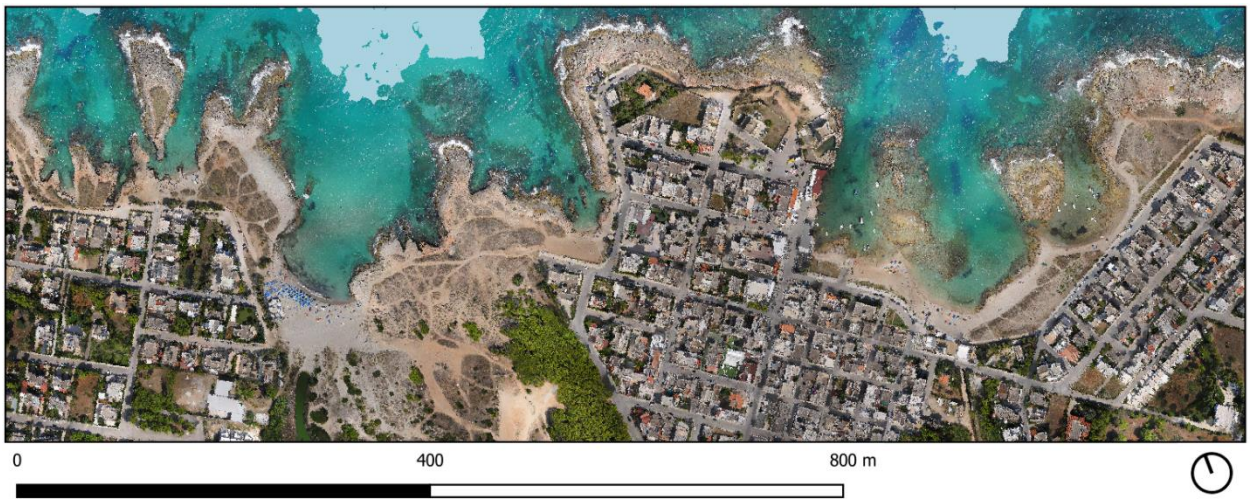

Fig. 2. UAS orthoimage of the shore of Torre Santa Sabina (eBee X).

The well-preserved shipwreck site found in the 1970s is related to a Roman ship dating from the late 3rd and early 4th centuries AD. The hull of the ship, which is still on the seabed, was over 20 meters long and of relatively heavy tonnage. There is no doubt that this wreck is one of the most interesting in the Mediterranean, due to its exceptional state of conservation which allows us to understand the details of the construction technique (Auriemma 2012).

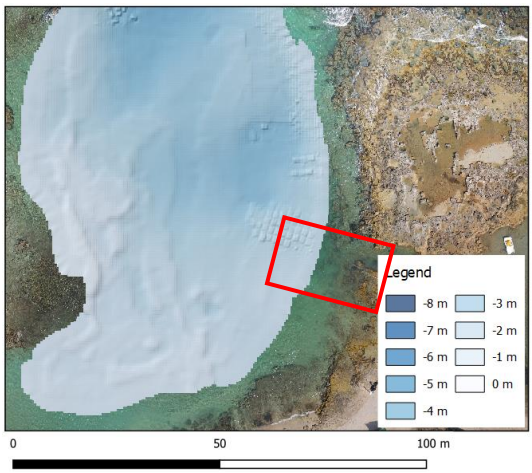

Fig. 3. DEM of the seabed of Baia dei Camerini obtained after the multi-beam survey; in red, the concrete blocks that protect the roman shipwreck's archaeological site area.

Fig. 4. Orthoimage of the aft part of the shipwreck.

The underwater photogrammetric acquisition of the aft part of the wreck was performed using an Olympus Tough TG-6 digital camera according to different acquisition schemes (nadir and oblique) useful for obtaining complete 3D and 2D documentation. The camera used can operate without underwater housing at a maximum depth of 15 m, reducing the residual systematic patterns of the image that are usually detected when the dome doors are used (Menna et al. 2020). The camera also integrates an underwater mode that performs radiometric adjustment on the fly. Also given the shallow depth over which the survey took place, this option was used without any further colour correction adjustments in pre-processing.

The measurement of the topographic points was carried out using TS (total station), with side shot acquisitions from the shore. Two divers manipulated the prism mounted on a 4 m rod to take the TS measurement points.

A previous survey campaign carried out in 2007 (Alfonso 2014) had produced a series of images acquired using a Nikon D50 (3008 x 2000 pixels) with underwater housing.

Since the images had suffered severe chromatic aberration (Agrafiotis et al. 2017), radiometric pre-processing was required, using the C-code adaptation of the ACE (Automatic Color Enhancement) image colour enhancement filter (Getreurer 2012), integrated into the image enhancement process tool of the i-MARECULTURE project.

The two sets of images of 2007 and 2020 made it possible to produce a complete orthomosaic and a DEM (Fig. 5) to facilitate the shape of the shipwreck and the understanding of the extension and plan future investigations and any recovery operations.

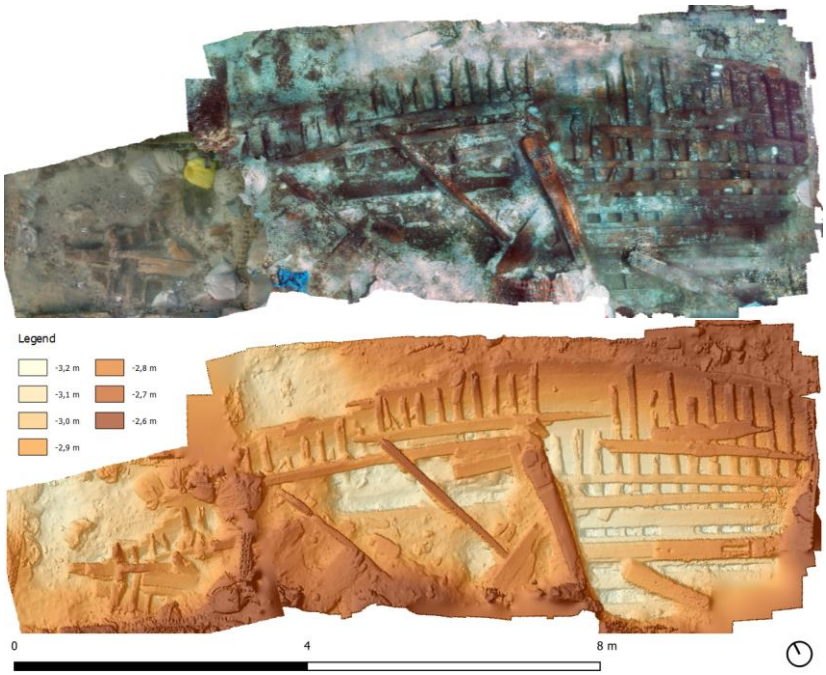

Fig. 5. On the top, RGB orthoimages of the two parts of the wreck surveyed in 2007 (right) and 2020 (left); on the bottom, DEMs of the same orthoimages of the two surveys.

"Le Cesine" Nature Reserve

Let's now pass to presentation of the results that emerged from the investigations in the coastal area coinciding with "Le Cesine" Nature Reserve, which constitutes one of the surviving fragments of the vast marshes that once extended along the coast of Puglia between Brindisi and Otranto. It is a wetland behind the dunes, the residue of an extensive ancient lagoon and marsh system, today greatly reduced due to large-scale reclamation and natural burial processes.

The shallow waters just off the Reserve have yielded much archaeological evidence consisting of particularly interesting submerged items that contribute to a more complete diachronic and contextual reading of the area.

A recent underwater and terrestrial survey has allowed the identification of further archaeological evidence, which enriches the previous knowledge of the area. In addition to the identification of a wall from the Bronze Age in Specchiuddhri, it is worth noting the discovery in 2020 of a submerged port structure of the Roman period, probably a pier, in the locality of San Giovanni, which offers a much more complex view of the ancient port of Lupiae.

Among the evidence already investigated and documented in the 1990s, some was also recognized in the latest photographs and video footage obtained by drone, while other items are no longer visible (Fig. 6).

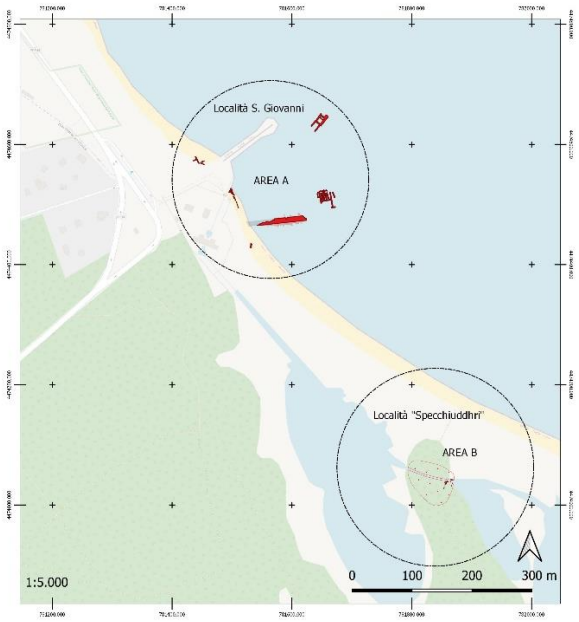

Fig. 6. Archaeological area in San Giovanni.

Also worthy of note here is the structure known as the "submerged church" located in the sea off the channel, 150 m from the shore, at a depth of about 4 m, measuring 33 x 15 m. Carved out of the rocky seabed to a further depth of 1-1.5 m are three large rectangular rooms. Only the layout is preserved, while the walls are believed to have been built of square blocks, judging from the material scattered in the immediate vicinity.

At about 100 m south of the channel and 125 m from the shore, at an average depth of 3 m, there is a rectangular structure composed of blocks of local calcarenite of varying size, arranged parallel and perpendicular to each other, occupying a rectangular area of 24 x 30 m; the complex may be even larger, as some rows of blocks seem to continue under the sand (Fig. 6).

In terms of both position and typological and technical characteristics, this structure seems to be connected to the imposing structure identified during the 2020 surveys. The latter is a pier built using the typical technique of landing stages in the Adriatic and other areas of the Mediterranean, especially eastern, with caissons: two parallel walls built with large parallelepiped blocks of local stone, the space between them filled with irregular stones, sometimes reinforced with internal partitions for the distribution of forces.

This structure begins about 15 m away from the shore (but the initial section may be covered by sand) and 65 m south-east of the outlet channel; it is bordered by two external curtains of large blocks and stretches east/north-east (84 ° N) for about one hundred meters (Fig. 7).

The initial section of the structure measures 43 m on the north side and about 50 m on the southern side. Furthermore, there are two rows of blocks side by side in the center of the pier in its outermost section, corresponding to the last 25 m, with an orientation substantially coinciding with the masonry of the outer walls.

The pier is about 8 m wide and the overall length, in this preliminary investigation phase, seems to be 100 m (83 m visible); the foundation rows of the two parallel alignments that make up the curtains are composed of large parallelepiped blocks (1.50 x 0.65 cm) which are laid end-to-end along the entire length of the pier (Fig. 8).

In some places, two or more overlapping rows are preserved, but on the outside of both faces, the collapsed blocks are scattered across a wide area.

Fig. 7. Aerial view of the submerged pier in San Giovanni.

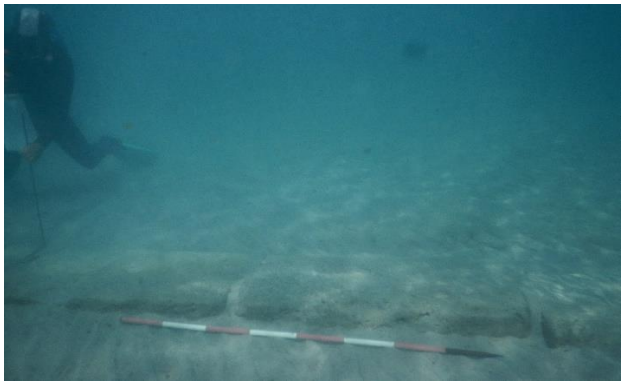

Fig. 8. Northern curtain of the pier seen from the south.

In the terminal stretch, in a secondary position, sections of a channel dug out of long blocks of limestone, sometimes overturned and no longer aligned, probably also removed by the force of the waves, can be seen. The depth of the blocks at the (assumed) start of the pier is less than one meter, while at the head it reaches 4.0 m. It is therefore an important marker of sea-level variation, considering a relative rise since the pier's construction of about 2 m, the draft of ancient ships being compatible with the remaining 2 meters.

This structure shows an affinity of type and construction technique with Hadrian's pier north of the wide bay of San Cataldo and the two structures are of similarly impressive dimensions and monumental character. The caisson technique recurs, as we said, all along the Adriatic coast, with local variations and adaptations. The same technique seems to occur in sections of the "new" pier of S. Giovanni, as well as in the submerged structure just to the north.

Together with the other structures mentioned above, the presence of the large pier of S. Giovanni indicates an important port complex, whose overall geometry has yet to be determined by means of a targeted study.

Certainly, a dating to the Augustan age of these port structures is a very appealing hypothesis. Sources mention Octavian's landing at the port of Lupiae on his journey from Apollonia to Rome[2]. Evidently, in the late republican and early imperial period, some infrastructures already existed in this area. Only later would the port be moved further north, with the construction of the new large pier wanted by the emperor Hadrian.

Porto Cesareo Marine Protected Area

In the waters around Porto Cesareo, submerged and semi-submerged archaeological evidence has recently been uncovered by preliminary surveys carried out in close collaboration with the management of the local Marine Protected Area (Fig. 9). The surveys have added new evidence to the numerous discoveries already made (Alfonso et al. 2012).

[2] Nicolaus Damascenus, fr. 130, XVII-XVIII Jacoby (Life of Caesar); App., Civ., III 2, 10.

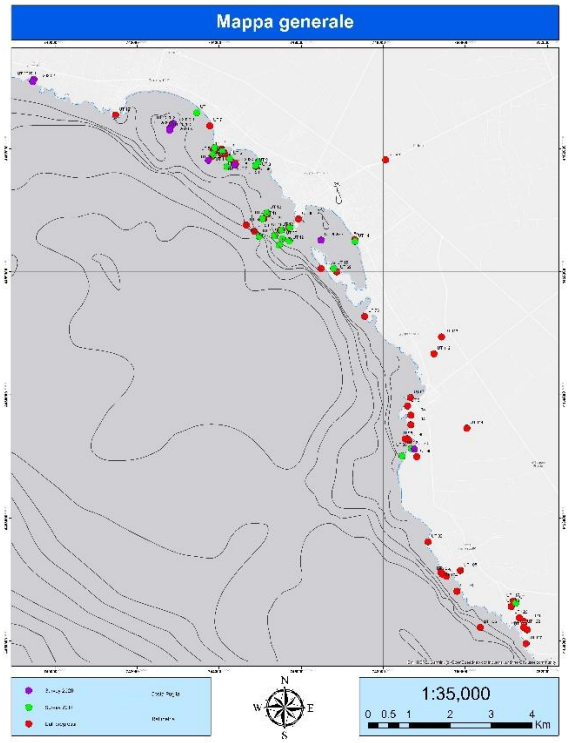

Fig. 9. Archaeological map of the findings. In red the presences already known, in green the data from survey 2014, in purple those of 2020

In the sea area called "La Pierta", which is the broad bay between Torre Chianca (to the south) and Torre Lapillo (to the north), at 600 to 800 m from the coast and at a depth of 3.5 to 4.5 m, on a rocky platform marked to the east – on the landward side – by a steep descent to a depth of 5.5 - 6 m, what was previously assumed to be rock formations have recently been revealed by Mino Buccolieri to be extensive concretions of fragments of amphorae - handles, bottoms, rims and walls. These are cemented both to each other and to rocky outcrops on the seabed, which, due to environmental erosion, in six cases have acquired a distinctive morphology, reminiscent of gigantic mushrooms, with a reduced base and elongated "hats" (Fig. 10).

Fig. 10. Tripolitanian amphoras' cargo remains.

The fragments are all of North African amphorae from the province of Tripolitania, classified as Tripolitan II (Fig. 11). Their homogeneity confirms that they belong to single ship's cargo. The Porto Cesareo specimens do not seem to have been dumped. They include no other types of amphora or vessel, whether common or valuable.

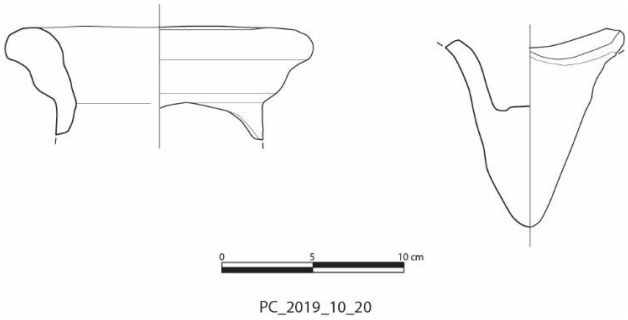

Fig. 11. Tripolitan II amphora fragments.

The remains are therefore attributable to a homogeneous cargo of considerable volume, given the number of fragments and the extent of the seabed affected. It therefore appears to have been a "direct" shipment from the place of production to the place of consumption: a "supertanker" travelling fully loaded with a "wholesale" shipment, probably headed east, towards the ports of the eastern Mediterranean, whose voyage was tragically cut short along the Ionian coastal route between Crotone and Capo Iapigio.

Regarding the dynamics of the formation of this field, the hypotheses are still being debated. The cargo was evidently fragmented by the impact on the bottom, and perhaps by the devastating environmental energy of the waves; the constant hydrodynamic movement subsequently grouped the fragments on the seabed, collecting both near rocky spurs and in depressions; in the sandbanks, the remains were captured and hidden by sediments. However, the erosion of exposed areas has helped to generate the spectacular formations that we see today, dispersed over an area of about 2-300 m².

In the last few years, further investigations have been also conducted at the Bronze Age site of Scalo di Furno, a protohistoric, long-term coastal settlement occupied almost without interruption from the early Middle Bronze Age (16th-17th centuries BC) to the Late Iron Age (5th-6th centuries BC). The underwater archaeological survey of the area between Scalo di Furno and the nearby islet made two important discoveries. First, a submerged wall (about 17 m long, 5 m wide and 1 m high) was found about 100 m southwest of the southern remains of the Bronze Age fortification wall. The second find concerns a large area (about 2000 m²) paved with stone slabs lying on the rocky substrate, which preserves the archaeological soil with hundreds of fragments of local handmade pottery and many fragments of animal bones. Both pieces of evidence lie about 3.5 m beneath the current sea level and demonstrate a substantial change in the coastal geography of this area that probably began during the first half of the 2nd millennium BC: all of the currently submerged area up to the islet was dry land during the Bronze Age and represented the lower terrace of the settlement.

In the same area the wreck of a Roman navis lapidaria, with a cargo of five monumental cipollino marble columns and 1 block from the quarries of Karystos in Evia, Greece, 8.5-8.8 metres long, with a total weight of 78 tons, lies 4.5 meters deep (Fig. 12).

Fig. 12. The wreck of a *navis lapidaria* during the survey phases

The latest investigations allowed us to complete the photogrammetric survey and the 3D model of the integrated ship (Balletti et al. 2016). Furthermore, the modelling and animation enabled us to understand the dynamics of the shipwreck; the ship ran aground due to its draft (3 metres) being greater than the depth at the site, considering that sea level was then approximatively 3 metres lower than today.

New discoveries, measurements and reports concern isolated or decontextualised finds, such as anchors, amphorae, lamps, table and kitchen ware, fishing equipment and ship components.

All these remains attest to the intense occupation of this area in ancient times, which was both a fishery and on a coastal trade route.

Finally, we must point out the presence of two beached wrecks. One is particularly relevant (Fig. 13), due to its chronology: it is dated by radiocarbon to 9th century AD, and seems to be a medium-sized cargo vessel, suitable for long-distance coastal navigation and similar to examples from the Levant or the Aegean (Alfonso et al. 2012; Auriemma 2012).

Particularly interesting is its vicinity to the place where was found a golden ring-seal of Basilios, the protospatharius and eparch of Byzantium, who took part to the legation sent by the emperor Basilios I to the Pope Nicola I in 867 AD, showing an intriguing coincidence.

Fig. 13. The medieval wreck of the "Bacino Grande".

Significant coastal seascapes' changes are testified also by the presence of archaeological material and anthropic deposits on the islets of the Porto Cesareo archipelago, dated from the Archaic to the Roman Age, and the structures partially under the sea level on the peninsula near Torre Chianca (Roman age) and on the "La Strea" peninsula (medieval age), the latter probably identifiable with the enigmatic settlement of Caesarea Augusta, founded by Federico II (Martin 1995); in the shallow water of "La Strea" a second beached wreck has been recently found, probably coeval to the settlement.

Also the quarry of Torre Castiglione, brought to the light by the powerful storms of 2019, is a precious testimony of a different ancient coastal landscape: in addition to the large deposit on the shore, squared blocks, of various dimensions, are currently under the sea level up to 2.10 m deep.

Discussion and conclusions

The main result of the activities presented in this article lies in the definition of a wide-ranging survey methodology that integrates and updates the previous documentation with the help of new documentation tools and technologies.
An essential part of the activities carried out in the underwater environment was the photogrammetric acquisition of the aft part of the Roman wreck of Torre Santa Sabina, which allowed the experimentation of survey techniques to be used in the future campaign. It was also possible to integrate the new data with those of the survey conducted 14 years before this study.

The results presented show that modern photogrammetric algorithms can provide a valid alternative to direct investigations in the documentation of the excavation phases of archaeological sites.

The use of digital photogrammetry techniques applied to the archaeological survey of underwater sites can constantly speed up survey operations without neglecting the quality and reliability of the data collected. The implementation of these procedures also provides better conditions for the operators' involved thanks to the reduction of the total immersion time.

For some years now, marine photogrammetry has been an essential documentation tool and we have seen significant growth in applications. This methodology, in fact, allows to document, reconstruct and virtually restore the detected submarine assets (Bandiera et al. 2015) and make them accessible remotely (both to the public, but also specialists and scholars of the sector).

At the same time, the adoption of low-cost sensors offers the possibility of rapidly processing and obtaining photogrammetric point clouds, but often at the expense of adequate metric accuracy (Capra et al. 2015). Fortunately, geomatics allows us to overcome these problems by providing the tools to obtain reliable documentation suitable for the study, conservation and enhancement of cultural heritage (Capra et al. 2017).

The amount of data collected in the three sites will constitute the documentary basis on which to set future lines of research, allowing an organic vision of the problems and interpretative criticalities inherent in the historical reconstruction of this territory. It is an approach to documentation that wants to be global and contextually dynamic, that is, open to the revision and integration of data and the re-elaboration of the same.

The investigations in the coming months will further enrich our knowledge and contribute to the historical reconstruction of this region, but in general will provide fundamental data to understand the long process of interaction between man and the natural environment, in a landscape, i.e. the coastal landscape, constantly evolving.

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