

PRELIMINARY REPORT: UNDERWATER ACTIVITIES OF THE UNIVERSITÀ DEGLI STUDI DI NAPOLI  
“L’ORIENTALE” TEAM AT CASTEL DELL’OVO

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Introduction (C. Zazzaro)

In January 2020, a team of researchers and students from the Università degli Studi di Napoli “L’Orientale” started an underwater survey on the western side of Castel dell’Ovo, the oldest castle in the city of Naples and one of the most representative landmarks of the Gulf of Napoli (Fig. 1). Castel dell’Ovo also carries an important historical significance for the city of Napoli, as it is believed to have been the location of the Roman villa of L. Licinius Lucullus (Maglio 2015).

The underwater archaeological activities were possible thanks to the authorization of the Soprintendenza Archeologia, Belle Arti e Paesaggio per il Comune di Napoli, with which the Università “L’Orientale” signed an archaeological cooperation agreement in 2019.

The purpose of the survey was to verify the characteristics of a now-submerged tuff outcrop, positioned parallel to the western side of the islet of *Megaritis* on which Castel dell’Ovo stands. The outcrop is elongated in shape and contains anthropically excavated channels (Fig. 2). The structure had already been identified and recorded by previous topographical surveys, but these surveys were never conducted with an archaeological approach.

The anthropic modifications are certainly attributable to antiquity, considering the tuff’s current submerged position. Previous scholars have suggested such modifications may be connected to the Roman villa of L. Licinius Lucullus (Beloch 1890, 81-82; Napoli 1869, 768-770 *contra* Jolivet 1987). However, this interpretation is somewhat unfounded, given the absence of dating material and the objective difficulty in accurately distinguishing the anthropic changes from the natural ones that occurred. It was therefore necessary to carry out a new topographic survey that could effectively ascertain the area’s archaeological and geological attributes.

In the first phase of this survey, the team intended to test archaeological, topographical and geomorphological methodologies of investigation and data management. In the future, these methodologies could also be applied to the numerous other submerged ancient structures of the Gulf of Napoli, which remain poorly investigated

and understood by archaeologists<sup>1</sup>. This fieldwork was also an opportunity to train students.

THE PROMONTORY OF PIZZOFALCONE AND THE ISLET OF *MEGARIS* IN ROMAN TIMES: THE STATE OF STUDIES (S. Iavarone)

During the Roman period, a luxurious *villa maritima* probably stood on the Pizzofalcone promontory and the on *Megaritis* islet. Similar buildings were undoubtedly located along the adjacent coastal plain of Chiaia (nowadays widely urbanized), and their existence has been evidenced along the hill of Posillipo and on the Nisida islet. While ruins of some of these villas are still visible along the Posillipo coast, only a few remains can be associated with the Pizzofalcone complex. At the beginning of the 20<sup>th</sup> century, remains of roman thermal baths - in particular, a large tub understood to be a *frigidarium* - were discovered during the construction of the Santa Lucia road, at -0.5m from the present-day sea level (Dall’Osso 1906).

Another Roman structure came to light in the 1960s on the hilltop of Pizzofalcone (Monte Echia) during the demolition of modern buildings (Pane 1964-1965). Here, an outcrop of tuff, preserved despite the significant transformation of the area, showed traces of conduits and tubs partially excavated in the bedrock. These findings are challenging to interpret. Facing the sea, the outcrop’s face has four regular niches engraved in the rock refined with *opus caementicium*, while another smaller niche is located immediately West of the larger ones. These ruins were dated and interpreted in various ways, but a Roman chronology is most convincing due to their characteristics, position and building techniques. Nothing currently links the Monte Echia ruins to the bath complex on the slopes of Pizzofalcone but the assumption of an unitary complex arranged on several terraces is consistent with the model of Roman maritime villas. On the basis of this theoretical model, the areas now occupied by the Castel dell’Ovo should have been the locations of the villa *pars maritima*. The columns and the architectural remains that were reused in the so-called “Sala delle Colonne”, even if

<sup>1</sup> At the time of writing, the publication by Gunther (1913) remains the most comprehensive source on this subject.

of uncertain provenance, testify to the existence in the Roman period of a monumental complex on the islet. Remains of ancient buildings ("avanzi di antichi edifici") are also traced in the Duke of Noja topographic map into the sea East of Castel dell'Ovo (Fig. 3). However, these remains are no longer traceable, especially after the creation of the harbour and Borgo Marinari in the early 20<sup>th</sup> century.

The existence of ancient underwater ruins is frequently reported in the scholars works of 17<sup>th</sup> and 18<sup>th</sup> century. In the 17<sup>th</sup> century, Carlo Celano mentioned the remains of the Lucullus fishponds "[...] in dove si conservavano le decantate murene, ed oggi, allorché le acque sono tranquille, si vedono tre bellissimi avanzi di esse, una delle quali di forma ellittica" (Celano 1692). Two centuries later, Camillo N. Sasso located the fishponds on the West of the islet "dalla parte di occidente, che guarda Posillipo, vi sono le famose peschiere delle murene del detto Lucullo" (Sasso 1856).

The identification of the famous Neapolitan villa of L. Lucullus in the Castel dell'Ovo ruins originates from Late-Roman and medieval sources, which located the villa on the Pizzofalcone hill. On this basis, when the promontory was fortified and surrounded by walls - possibly during the extension of the fortification, as ordered by Valentiniano II in 440 AD - the stronghold was referred to as *Castrum Lucullanum*. Romolo Augustolo, the last Roman emperor in the West, was imprisoned and died in this stronghold in 476 AD (Amm. Marc. Chron. A. 476).

Ancient sources tell us that L. Licinius Lucullus, consul in 74 BC, had a villa around *Neapolis* where he dug a channel through a mountain (*perfordisset montem*) to enable water to move into and between the villa's ponds. For that reason, he was compared to Neptune for the abundance of fish at his villa, and was called "Xerxes in a toga" as a reference to the channel cut through the isthmus at Mount Athos (Varro, *De re rustica*, III, 17, 9; Pliny IX, 171).

However, classical sources placed Lucullus's villa on the Nisida islet (Jolivet 1987)<sup>2</sup>. Thus, the location of *Lucullanum* on Pizzofalcone is uncertain, unless it is assumed that Lucullus owned two villas around *Neapolis*, in addition to a third one at *Misenum* (Bacoli).

During the 1990s, a team coordinated by Antonio Di Stefano conducted underwater surveys around Castel dell'Ovo on behalf of the Soprintendenza Archeologica delle Province di Napoli e Caserta. The team investigated some anthropic cuts made in a semi-submerged tuff ridge

located West of Castel dell'Ovo. The tuff outcrop is already recognizable in the Duke of Noja map and is consistent with the fishpond area identified by Sasso (1856) (Fig. 3). It consists of a shelf connected with the islet of *Megaritis* that descends -3 / -4m below present sea level. Towards the sea, it is bordered by a vertical ridge, whose upper part is approximately -1 metres below sea level, running parallel to the islet with a NW-SE orientation. Some artificial channels ranging from 2.2 to 3.8m of height and about 1.5m width pass through the ridge perpendicularly: three of them, quite near to each other, were discovered in the 1990s, while other channels in worse condition have been identified more recently.

The channels have been interpreted as fishponds, but this is speculation based on current - and inadequate - knowledge. In our opinion, later underwater surveys did not advance any understanding of the channels: thus, the chronology and the function of this structure still remain unclear (Pappone et alii 2019).

#### GEOLOGICAL AND GEOMORPHOLOGICAL BACKGROUND (C. Donadio)

Castel dell'Ovo is located between the districts of San Ferdinando and Chiaia, in front of the Via Partenope seafront. The castle is based on the tuff islet of *Megaritis* and is NW-SE oriented, overlooking the Monte Echia promontory and a thin isthmus that previously connected it to the mainland.

The area is characterized by outcrops of thickly layered yellow-brown tuff (Monti et alii 2011; Scarpati et alii 2013; Scarpati et alii 2015), which reaches around 8m of depth. These outcrops are attributable to the products of the Yellow Neapolitan Tuff, with an age of about 15 ka BP, and of the Tuffs of Castel dell'Ovo, dated around 78 ka BP. The morphology of the substrate indicates it is a strip of a relict volcano, of which other small strips are present at Monte Echia (near the coast to the NW, at a depth of about 2-4m bsl) and at a few tens of meters off to the SW of the castle (about 16-20m bsl).

The area is affected by the bradyseism of the Phlegraean Fields: this is a slow vertical pseudoelastic deformation of the soil due to gas and water vapour in the subsoil of this volcanic area, which involves lowering or lifting the soil (Parascandola 1947; Dvorak, Mastrolorenzo 1991). The bradyseismic activity of the Phlegraean Fields covers a large area extending as far as Quarto and Cuma to the North/West, and the coast of Napoli up to the Castel dell'Ovo to the East. This activity is recorded at its maximum in the historic center of Pozzuoli (Rione Terra), while its minimum is at the extremities of the area (Castel dell'Ovo).

<sup>2</sup> For a discussion of archaeological evidence on the islet, see Severino (2005)

The volcanic rim, parallel to the bigger emerged rim of a submerged crater constituting the islet of *Megaritis*, shows evident modifications of anthropic origins. These have been frequently interpreted as the fishponds of the L. Licinius Lucullus Villa (1<sup>st</sup> century BC). Considering recent literature (Russo Ermolli *et alii* 2014; Di Donato *et alii*, 2018; Pappone *et alii* 2019; Brandolini *et alii* 2019; Donadio 2019), if the now-submerged structure was used as fishponds, the lowering of the soil in the area of Castel dell’Ovo at that time could be estimated between -2.7 and -3.2m, with the average rate of soil lowering probably resulting in ca. -1.3mm/yr (Lambeck *et alii* 2004, 2011; Stanislao 2017). However, these considerations cannot be confirmed until archaeological structures are clearly dated.

It is worth noting that the coast and coastal archaeological evidence along the Gulf of Napoli were affected by different phenomena originating from distinct entities. Each case must be considered individually: the sites of Pozzuoli, Posillipo, Castel dell’Ovo, and Piazza Municipio, for example, have recorded different variations, decreasing from about -4.7 to -1m eastward (Simeone, Masucci 2009; Aucelli *et alii*, 2017a, b; Stanislao 2017; Stefanile *et alii* 2018; Pappone *et alii* 2019; Aucelli *et alii* 2020 and literature therein). Roman port structures in Piazza Municipio are located on sediments and the area is characterized by subsidence of -2.2/-3.7m in the 1<sup>st</sup> century BCE, while Pozzuoli, including Posillipo and Castel dell’Ovo, is characterized by bradyseism. Furthermore, the latter of these (Castel dell’Ovo) has had a minor bradyseismic lowering compared to Pozzuoli and Posillipo, and stands on a tuff islet.

#### FIELDWORK (C. Zazzaro, R. Valentini)

The underwater survey on the western side of Castel dell’Ovo began on the 8<sup>th</sup> of January and continued until the 1<sup>st</sup> of February 2020, with few interruptions. The activities usually started in the morning, leaving the Circolo R.Y.C.C. Savoia pier with a small eight-metre motorboat.

The team included a maximum of five people on a rotating basis<sup>3</sup>. Over the course of 15 working days, about 17 dives were conducted. The dives were carried out in groups of between two and four people, over one or two diving sessions per day. The weather conditions were favourable for almost the whole period. The water temperature was around

16°C. Following a period of strong winds from the West, the visibility was around 6-7m for the first days, and then reduced to 3-4m in the following days. The current was generally perceived at low depth but, above all, the backwash was perceived for the proximity to the bank of the castle. Nevertheless, the current and the backwash did not constitute an obstacle to the investigation procedures. The dives were conducted at a maximum depth of 5m. During two dives, a depth of 22m was also reached.

The purpose of the survey was to preliminarily investigate and georeference a structure cut into the tuff rock. This structure was about 60m by 1-3m, characterised by canals and tunnels, oriented NW-SE and paralleled to the western side of Castel dell’Ovo, 26 up to 45m away from it (Fig. 2). The structure had previously been reported and documented by architects, archaeologists and geophysicists (Avilia, Santanastasio 2019; Pappone *et alii* 2019).

For the management of collected data and those relating to survey activities and dive logs, the Honor Frost Foundation system was applied, as it was to the case of a systematic survey ongoing in Lebanon<sup>4</sup>. In the case of the Gulf of Napoli, the system will have to be modified and adapted in the future according to the specific needs of the project (Fig. 4).

The team firstly decided to conduct an accurate topographical survey of the structure that showed its archaeological characteristics. Digital photogrammetry was adopted for this survey’s methodology, with the aim of obtaining a three-dimensional model that was descriptive of the structure and as precise as possible. Thus, black and white targets were positioned for the purpose of georeferencing, so as to scale and rectify the model. The position of the targets was measured by the nearby Ramaglietto gun battery<sup>5</sup>, using a Trimble M3 DR5” total station. 14 points were measured along the submerged structures using a topographic rod with prisma -30mm mounted on top. In order to georeferencing the topographic points, a GNSS survey has been performed. A i80 CHC Receiver connected in RTK mode to the Regione Campania’s geodetic network gave us the absolute coordinates of the point set up on the Ramaglietto. The open view of the sky gave us strong satellite geometry (Fig. 5)<sup>6</sup>.

<sup>4</sup> The plug-in HFF system survey is accessible at the following webpage: <https://github.com/enzococca/HFF>.

<sup>5</sup> This is the gun battery of Castel dell’Ovo, located just in front of the structure.

<sup>6</sup> The Centro Interdipartimentale di Servizi di Archeologia led the topographic survey.

<sup>3</sup> The team included students (Alissia Cerotto, Giuseppe Ferraioli e Marilena Guadagno), collaborators (Michele Stefanile, Rosario Valentini, Eleonora Minucci, Angela Bosco), and a geologist (Carlo Donadio).

At first, about 10 targets were positioned on top of the structure and about 8 at its structure. Unfortunately, we immediately realised that the shallow depth of the ridge with respect to the sea surface did not allow for satisfactory results. For this reason, we decided to reposition the targets along the sides of the structure, and to proceed with a photographic survey of the structure from the front rather than from the zenith (Fig. 6).

In order to undertake a new photogrammetric acquisition, the team waited for suitable visibility conditions. Once these emerged, around 790 photographs were taken and processed with Photoscan's Agisoft Software. The three-dimensional model of the structure is not completely comprehensive, but it can be used to make some evaluations of the structure's conditions and characteristics (Fig. 7).

The detected positions of the targets were compared with the structure visible in Google Earth (red line), with the topographic survey made by the Mare Terra S.r.l. in 1992 and 1995 (unpublished) (blue line), and with the Side Scan Sonar map mosaic, with the perimeter of the structures interpreted as "archaeological" highlighted in yellow, published by Pappone *et alii* in 2019. The comparison between the images and the relative positioning of the structure reveals an inconsistency; this is probably due to normal georeferencing errors. In particular, the perimeter of the structure traced in blue is rotated with respect to the other alignments. The targets positioned during the last survey in 2019, however, do not differ much from the perimeter of the structure traced by the Google Earth image (red line) (Fig. 8).

Furthermore, it was possible to observe that the survey of the 1990s and the perimeters highlighted on the Side Sonar Scanner (SSS) mosaic map, are somewhat imprecise from an archaeological point of view, evidently because they were carried out by architects and geophysicists respectively. So far, a proper archaeological approach has never been applied in the restitution and characterization of this structure. In particular, the perimeters traced in yellow (the SSS mosaic map) do not correspond to structures that can actually be described as archaeological, or identifiable as specific human made evidence. The distinction between human-made excavation and natural excavation is not so evident. The tunnels are approximately positioned correctly, both on the SSS map, and in the map marked by the blue line (Mare Terra S.r.l.). In this second case, however, the continuation of the structure at the northern end is not clear, and neither is the line tracing to the West

of the structure, towards the south-east half of the structure

The two maps with yellow and blue perimeters are missing two channels excavated West of the structure, which develop perpendicularly North-West of tunnels 1 and 3 (named 2 and 4 in Avilia, Santanastasio 2019), taking a course parallel to the structure. One of the two channels had already been observed and photographed by Avilia, Santanastasio (2019, 21, fig. 11) and interpreted as a "connecting trench" between gallery 1 and 2 (channel 1 and gallery 1 in this report).

The galleries excavated in the structure are represented in both maps. The Mare Terra S.r.l. map features 3 channels in the north and 3 galleries in the south; in Pappone *et alii* 2019, only 3 "channels" (galleries in this report) are represented and progressively numbered from north to south; Avilia, Santanastasio (2019) report the dimensions and descriptions of 4 galleries, numbered progressively from north to south. In this case, gallery 1 is considered as such and not a channel because the authors believe that the original vault collapsed. In Pappone *et alii* (2019), only the three vaulted galleries are considered.

Our analysis suggests that gallery 1 of Avilia, Santanastasio ought to be considered a channel (channel 1) perpendicular to channel 2 running parallel to the West side of the structure (Fig. 9); it then follows gallery 1 with channel 3 running perpendicular to it and parallel to the structure, connecting the West openings of channel 1 and 3 (Fig. 10). Gallery 2 is characterised by sloping sides on the West opening (Fig. 11), and then follows gallery 3 with a perpendicular channel (channel 4) running parallel to the West side of the structure (Fig. 12). Gallery dimensions vary from ca. 1.9-8.2 m in length to 0.60-1.50m in width, to 2-3.50m in height.

The investigations conducted in the 1980s by the Centro di Studi Subacquei led to speculations of the existence of a fishpond connected to the Roman villa that stood on the ancient islet of *Megaritis*. Pappone *et alii* (2019) note that a step excavation runs along the eastern side of the structure between the "channels" 2 and 3 (galleries 2 and 3 in this report), which they interpret as a "walkway" or as a *crepido* (crackle) for the inspection of the tanks of the ancient Roman fishponds (Fig. 13). Avilia, Santanastasio (2019) do not mention this evidence, or they interpret it differently (Avilia, Santanastasio 2019, 21) in any case, they suggest an interpretation of the structure as being of a military nature and/or a port of Greek construction, rather than Roman (Avilia, Santanastasio 2019, 21).

DISCUSSION (*M. Stefanile*)

As noted above, the recent fieldwork, together with previous research, leaves a considerable amount of unanswered questions about the archaeological interpretation of the underwater structure at the western side of the *Megaris* islet.

Archaeological remains scattered on the island, in the eastern basin of the Borgo Marinari (Fig. 3) and in the nearby Pizzofalcone hill suggest a possible edification of the land pursuant to the model of a late-republican or early imperial Roman *villa maritima*. Nevertheless, definitively clear evidence of this theory is still lacking.

The presence of a now-submerged elongated tuff rim, parallel to the coastline of the *Megaris* islet, evidences a clear architectural effort to modify the natural landscape: this is consistent with the realization of the *pars maritima* in a maritime villa (Lafon 2001). In this sense, the Neapolitan coast offers multiple examples of impressive adaptation works with artificial basins, fishponds, and rock-cut channels and tunnels.

The natural rim parallel to the western side of the islet of *Megaris* seems to have been subject to a series of excavation works, with the opening and regularization of tunnels and channels (Pappone et alii 2019). A long exposure to waves and tides, together with the continuous movement of pebbles and sands on the seabed, widely polished the surfaces of the structure. Such "polishing" has had the effect of erasing some anthropic traces and recreating, with an intense bio-colonization, a natural aspect.

Previous studies have favoured the interpretation of fishponds as part of the Castel dell'Ovo structure. The link with one of the *Lucullus* gigantic villas in Campania (Jolivet 1987; Stefanile et alii 2018), with its huge terraces, hanging gardens with exotic trees and impressive fish farms, is indeed tempting.

The channels for a continuous exchange of water with the sea, and the presence of a possible *crepido*, are good indicators of a *vivarium* or, better, of a *piscina ex petra excisa*, as in the descriptions by *Columella* (VIII, 17, 2) of artificial fishponds created by excavating the coast (i.e. types IA and IB in the classification by X. Lafon [Lafon 2001]) with the aim of the breeding of specific, very valuable fish species typical of a rocky environment (Higgonbotham 1997). The best examples of this category of fish farms can be found in the cave fishponds of Ponza (*Grotte di Pilato*) and Ventotene (*Peschiere romane*), in the remains of the villa owned by *Servilius Vatia* in Torregaveta (NA), in the possible Lucullian site of *Misenum* (*Peschiere*

*della Dragonara* and *Peschiera di Punta Terone*), and in the *Pausilypon* complex.

However, the absence of perpendicular walls enclosing the basin, the lack of internal separations among different tanks, and the lack - or loss - of the typical closing system with *cataractae* casts doubt upon such an interpretation. Thus, there continues to be a possibility that the original structure underwent subsequent modifications and adaptations for other uses.

Another possible interpretation is that of a harbour, or a defensive structure. Avilia, Santanastasio (2019) recently suggested it was an infrastructure connected with a Greek port, related to the nearby earliest Greek settlement of Parthenope identified on the hilltop of Pizzofalcone (Monte Echia) (Amato et alii 2009). However, this hypothesis is highly flawed based on our knowledge of the relative sea level change for the Greek and Roman ages, and is very problematic in terms of the basin's position, as it is almost totally exposed to the winter winds.

It is nevertheless possible to perceive in the submerged structure of Castel dell'Ovo the remains of a breakwater: tunnels and channels would have been artificially created in order to break the waves and to favour the outflow of water, simultaneously avoiding the silting up of the protected part. The structure would not have been a real port, therefore, but more likely a protected water space suitable for a temporary stopping of boats and for defending the buildings on the island from the waves' impact. Evidently, a breakwater system, creating through holes in a natural rock formation in the imitation of an *opus pilarum* jetty, can work efficiently only if it is totally or at least partially underwater: a condition that we can imagine only in Late Antiquity or later.

All that is certain about this underwater structure at this stage of the research, is that - it is a Roman, or later - maritime anthropic structure; it was created by adapting, excavating and modifying a natural, almost straight soft rock formation (at the time when such activity was possible, taking into consideration the relative sea level change); and it had the aim of enclosing a basin, or protecting some building on the islet of *Megaris*. This particular archaeological evidence proves once again the difficulties in documenting, dating and studying archaeological remains underwater characterized by predominant excavation activity. This also shows the further methodological issues related to coastal shallow-water and intertidal archaeology: an apparently easy operative context for maritime archaeologists (Stefanile 2017).

## CONCLUSION (C. Zazzaro)

In conclusion, this preliminary investigation highlighted the difficulties in interpreting this structure, and enabled the team to identify the following issues:

- The underwater photogrammetric survey was particularly complex due to the location at low depth of the structure, the disturbance caused by the constant passage of fish, and the poor visibility due to backwash and sediment suspensions. Nevertheless, the video recording proved to be rather effective for understanding the topography of the area, the structure and its characteristics.

- The previous surveys cannot be considered sufficient for an archaeological understanding of the structure. It is therefore necessary to proceed with a new topographic archaeological survey, using the

total station, a drone and using the photogrammetry. The aim will be to carry out a detailed survey of the structure, in order to highlight its complexity and suggest better interpretive hypotheses.

It will be essential to analyse this structure in relation to the other structures on land, and to similar or contemporary structures along the coast of Napoli from a geomorphological perspective.

Moreover, from a methodological point of view, these investigations are an interesting starting point for planning further research along the Gulf of Napoli coast. Similarly, it would also be interesting to compare the results of future archaeological topographic surveys with the results of the SSS mapping, in order to better understand this instrument's potential in the archaeological context.

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## References

- Amato, L., Carsana, V., Cinque, A., Di Donato, V., Febbraro, S., Giampaola, D., Guastaferrò, C., Irollo, G., Morhange, C., Romano, P., Perriello Zampelli, S., Ruello, M.R., Russo Ermolli, E. (2009) Ricostruzioni morfoevolutive nel territorio di Napoli, *Mediterranée* 112, pp. 23-32.
- Aucelli, P.P.C., Cinque, A., Mattei, G., Rizzo, A., (2017a) Studying relative sea level change and correlative adaptation of coastal structures on submerged Roman time ruins nearby Naples (southern Italy), *Quaternary International*, 501, parte B, pp. 328-348.
- Aucelli, P.P.C., Cinque, A., Mattei, G., Pappone, G., Stefanile, M. (2017b) Coastal landscape evolution of Naples (Southern Italy) since the Roman period from archaeological and geomorphological data at Palazzo degli Spiriti site, *Quaternary International*, 483, pp. 23-38.
- Aucelli, P.P.C., Mattei, G., Caporizzo, C., Cinque, A., Troisi, S., Peluso, F., Stefanile, M., Pappone G. (2020) Ancient coastal changes due to ground movements and human interventions in the Roman Portus Julius (Pozzuoli Gulf, Italy): results from photogrammetric and direct surveys, *Water*, 12, 658.
- Avilia, F., Santanastasio, R. (2019) Evidenze Geo-archeologiche nel Golfo di Napoli tra Posillipo e Castel dell'Ovo, *Quadrimestrale dell'Ordine Nazionale dei Geologi*, 1.19, pp. 15-22.
- Beloch, K.J. (1890) [1879] *Campanien: Topographie, Geschichte und Leben der Umgebung Neapels im Alterthum*. Breslavia, Morgenstern.
- Brandolini, P., Cappadonia, C., Luberti, G.M., Donadio, C., Stamatopoulos, L., Di Maggio, C., Faccini, F., Stanislao, C., Vergari, F., Paliaga, G., Agnesi, V., Alevizos, G., Del Monte, M. (2019) Geomorphology of the Anthropocene in Mediterranean urban areas, *Progress in Physical Geography: Earth and Environment*.
- Celano, C. (1692) *Notitie del bello, dell'antico e del curioso della città di Napoli*, Napoli.
- Cinque, A., Irollo, G., Romano, P., Ruello, M.R., Amato, L., Giampaola, D. (2011) Ground movements and sea level changes in urban areas: 5000 years of geological and archaeological record from Naples (Southern Italy), *Quaternary International*, 232, pp. 45-55.
- Dall'Osso, I. (1906) Napoli trogloditica e preellenica, *Napoli Nobilissima*, XV, pp. 33-51.
- Di Donato, V., Ruello, M.R., Liuzza, V., Carsana, V., Giampaola, D., Di Vito, M.A., Morhange, C., Cinque, A., Russo Ermolli, E. (2018) Development and decline of the ancient harbor of Neapolis, *Geoarchaeology*, 33, pp. 542-557.
- Donadio, C. (2019) Urban geomorphology of Naples, southern Italy, C. Fontaine, R. Valente, V. D'Ambrosio (eds.) *Naples Lab: Research and tentative design*, 50-55, Louvain la-Nueve.
- Dvorak, J.J., Mastrolorenzo, G. (1991) The mechanisms of recent vertical crustal movements in Campi Flegrei caldera, southern Italy, *Geological Society of America*, 263, pp. 1-47.
- Galante, G.A. (1872) *Guida sacra della città di Napoli*, Napoli.
- Gunther, R.T. (1913) *Pausilypon. The Imperial Villa Near Naples*, H. Hart (ed.) Oxford.
- Higginbotham, J. (1997) *Piscinae. Artificial Fishponds in Roman Italy*. Chapel Hill, North Carolina.
- Jolivet, V. (1987) Xerxes togatus: Lucullus en Campanie, *MEFRA*, 99, pp. 875-904.
- Lafon, X. (2001) *Villa Maritima: recherches sur les villas littorales de l'Italie romaine: IIIe siècle av. J.C.-IIIe siècle ap. J.-C.* Roma.
- Lambeck, K., Antonioli, F., Anzidei, M., Ferranti, L., Leoni, G., Scicchitano, G., Silenzi, S., (2011) Sea level change along the Italian coast during the Holocene and projections for the future, *Quaternary International*, 232, pp. 250-257.
- Lambeck, K., Anzidei, M., Antonioli, F., Benini, A., Esposito, A. (2004) Sea level in Roman time in the Central Mediterranean and implications for recent change, *Earth and Planetary Science Letters*, 224, pp. 563-575.
- Maglio, L. (2015) *Castel dell'Ovo dalle origini al secolo XX*, Milano.
- Monti, L., Sbrana, A., Isaia, R., Marianelli, P., Aiello, G., Barra, D., Marsella, E., D'Argenio, B., Putignano, M.L., Donadio, C., de Alteriis, G., Conforti, A., Di Martino, G., D'Isanto, C., Giordano, F., Innangi, S., Passaro, S., Pelosi, N., Sammartino, S., Scotto di Vettimo, P., Tonielli, R., Ferraro, L., Iannuzzi, E., Perrotta, A., Scarpati, C., Toccaceli, R.M., Vietina, M., Minopoli, C., Tarallo, F., Sgrosso, A., Terlizzi, F. (2011) Carta Geologica D'Italia alla Scala 1:50.000 - Foglio 446-447 Napoli. Progetto Car. G, Regione



Campania - Settore Difesa Suolo, Ispra, Servizio Geologico D'Italia, Litografia Artistica Cartografica, Firenze, [http://www.isprambiente.gov.it/Media/carg/447\\_NAPOLI/Foglio.html](http://www.isprambiente.gov.it/Media/carg/447_NAPOLI/Foglio.html)

Napoli, M. (1969) Il Porto, *Storia di Napoli*, II, pp. 770-772.

Pane, G. (1964-1965) La villa Carafa e la storia urbanistica di Pizzofalcone, *Napoli Nobilissima*, (I), 1964, IV, pp. 133-148; (II), 1965, IV, pp. 204-215.

Pappone, G., Aucelli, P.P.C., Mattei, G., Peluso, F., Stefanile, M., Carola, A. (2019) A Detailed Reconstruction of the Roman Landscape and the Submerged Archaeological Structure at "Castel dell'Ovo islet" (Naples, Southern Italy), *Geosciences*, 9, pp. 1-24.

Parascandola, A. (1947) I fenomeni bradisismici del Serapeo di Pozzuoli, Napoli

Romano, P., Di Vito, M.A., Giampaola, D., Cinque, A., Bartoli, C., Boenzi, G., Detta, F., Di Marco, M., Giglio, M., Iodice, S. (2013) Intersection of exogenous, endogenous and anthropogenic factors in the Holocene landscape: A study of the Naples coastline during the last 6000 years, *Quaternary International*, 303, pp. 107-119.

Russo Ermolli, E., Romano, P., Ruello, M.R., Barone Lumaga, M.R. (2014) The natural and cultural landscape of Naples (southern Italy) during the Graeco-Roman and Late Antique periods, *Journal of Archaeological Science*, 42, pp. 399-411.

Sasso, N. C. (1856) *Storia de' monumenti di Napoli*, Vol. I. tip. F. Vitale, Napoli.

Scarpati, C., Perrotta, A., Lepore, S., Calvert, A. (2013) Eruptive history of Neapolitan volcanoes: constraints from  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  dating, *Geological Magazine*, 150 (3), pp. 412-425.

Scarpati, C., Perrotta, A., Sparice, D. (2015) Volcanism in the city of Naples, *Rendiconti Online Società Geologica Italiana*, 33, pp. 88-91.

Severino, N. (2005) Recenti ricerche archeologiche sull'isola di Nisida", *Orizzonti. Rassegna di archeologia*, VI, pp. 119-133.

Simeone, M., Masucci, P. (2009) Analisi geoarcheologiche nell'Area Marina Protetta Parco Sommerso di Gaiola (Golfo di Napoli), *Il Quaternario*, 22(1), pp. 25-32.

Stanislao, C. (2017) *Elementi geomorfologici e geoarcheologici per la valutazione dei moti verticali recenti del paesaggio costiero della Campania*. Tesi di Dottorato di Ricerca, XXX Ciclo, Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli Federico II, tutor prof. C. Donadio, co-tutors prof. M. Pennetta, prof. J.P. Oleson.

Stefanile, M. (2017) Tra terra e mare: Appunti per una riflessione sull'archeologia delle coste, *Archaeologia Maritima Mediterranea*, 14, pp. 169-176.

Stefanile, M., Mattei, G., Troisi, S., Aucelli, P., Pappone, G., Peluso, F. (2018) *Le pilae* di Nisida. Alcune osservazioni geologiche e archeologiche, *Archaeologia Maritima Mediterranea*, 15, pp. 81-100.



Fig - 1 - Castel dell'Ovo in the Gulf of Napoli landscape

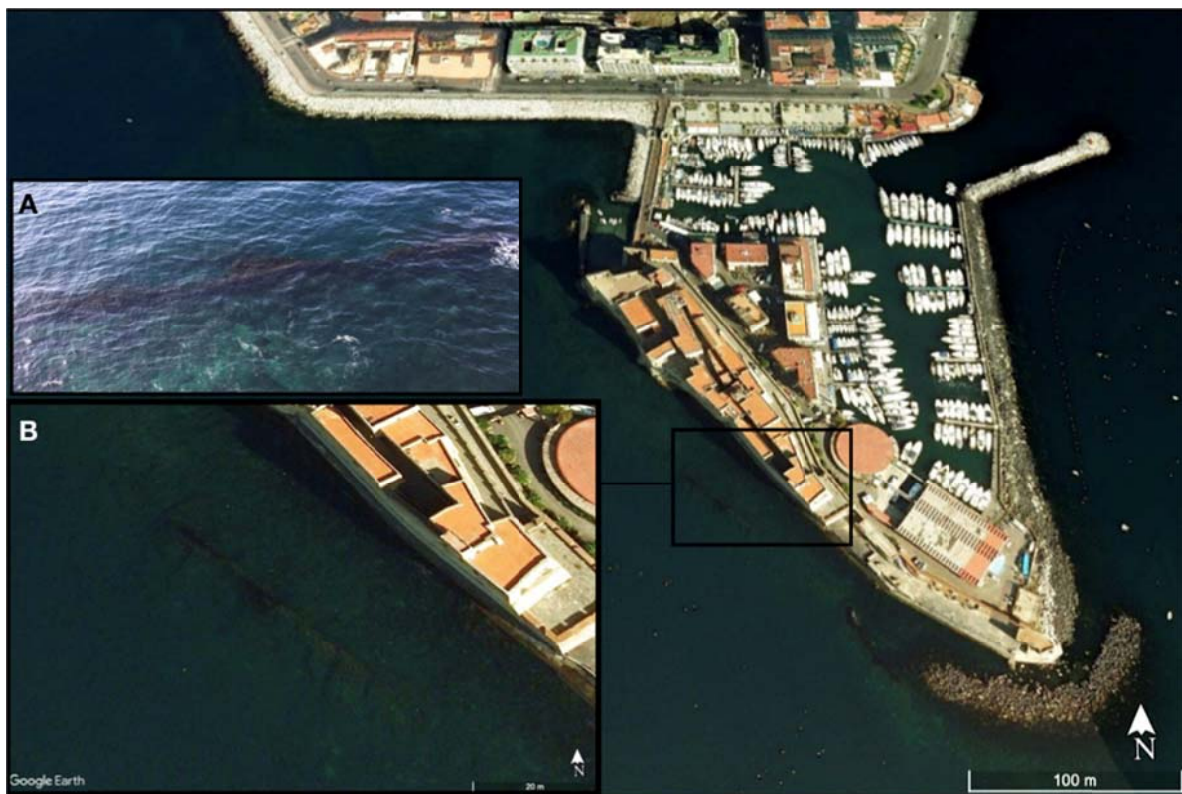


Fig. 2 - Location of the surveyed area - The structure seen from Castel dell'Ovo (A) and from Google Earth (B). (Image: R. Valentini and C. Zazzaro)

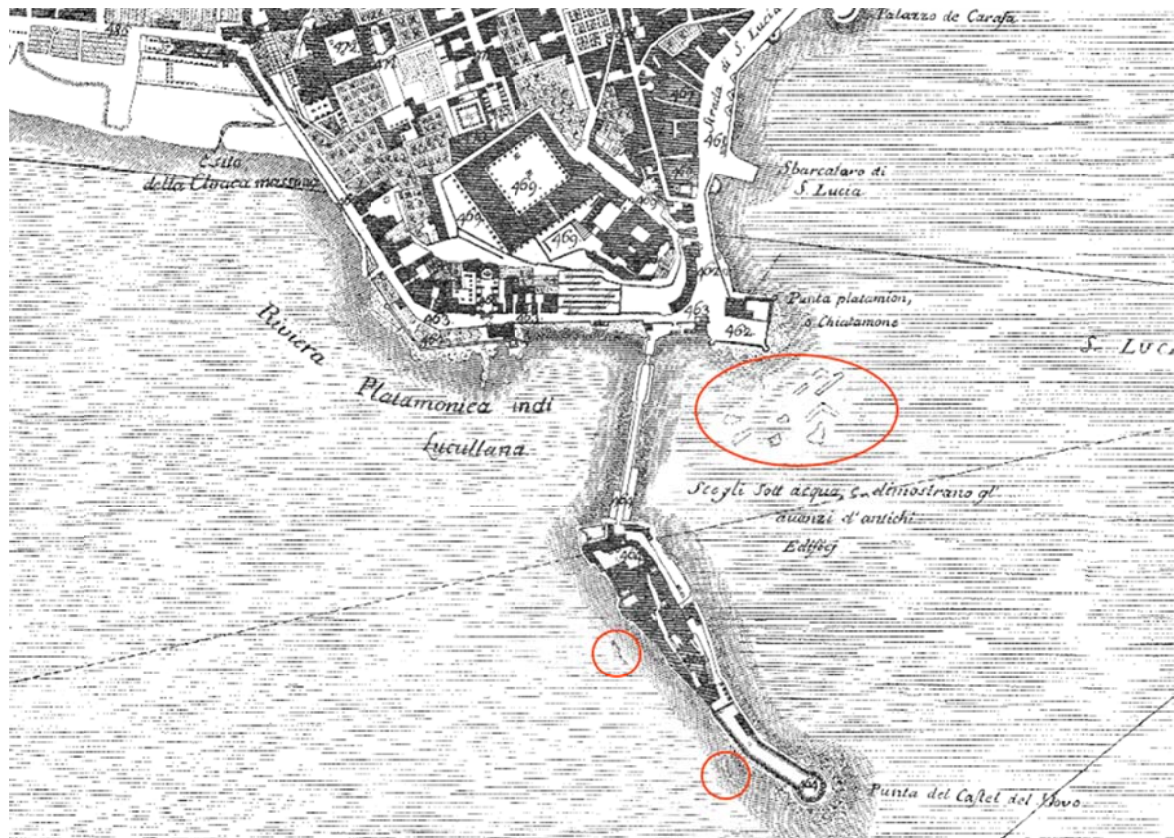


Fig. 3 - Map of the Duke of Noja showing the “ancient ruins” on the East side of Castel dell’Ovo and a tuff outcrop partially emerging from the water on the West side of Castel dell’Ovo

Archaeological Underwater Survey - DIVELOG FORM		
Location: Castel dell'Ovo		Dive log number: 1
Diver 1 Alissia Cerotto	Date 10/01/2020	Area 0
Diver 2 Giuseppe Ferraioli	Time in 11.45	Time out 11.00
Standby Diver	Bottom Time 45	Max Depth 5m
Dive Supervisor Chiara Zazzaro	Bar Start Diver 1: 200 Bar Start Diver 2: 200	Bar End Diver 1: 150 Bar End Diver 2: 130
DP Diver 1:	Breathing mix	Wind
DP Diver 2:		
Number of pictures: 0	Number of videos: 0	Camera:
<b>Task</b> -Osservazioni e documentazioni dell'intero sito subacqueo -Fotogrammetria		
<b>Result</b>		
<b>Comments</b> La prima immersione della giornata è stata effettuata dallo studente Giuseppe Ferraioli e dal collaboratore archeologo Rosario Valentini sotto la guida della studentessa Alissia Cerotto. Una volta raggiunto il fondo(5m), si è fatto il check attrezzatura e controllo assetto. Durante l'immersione è stato predisposto un giro subacqueo per far conoscere a Giuseppe Ferraioli l'intero sito mentre Rosario Valentini ha documentato il tutto con la gopro. Terminata la prima immersione la professoressa Chiara Zazzaro ha utilizzato la bombola precedentemente usata da Giuseppe Ferraioli, carica a 130 bar, per fare alcune fotografie.		
<b>U/W Conditions</b>		
UW Current direction & strength Low	UW Visibility 10	UW Temperature 15

Fig. 4 - Example of a dive log form employed for the data management system developed by the Honor Frost Foundation



Fig. 5 - Detection of the targets positioned underwater. The prism operated in the water (A). View of the artillery battery "Ramaglietto" from the site (B). Georeferencing (C). (Image: R. Valentini and C. Zazzaro)

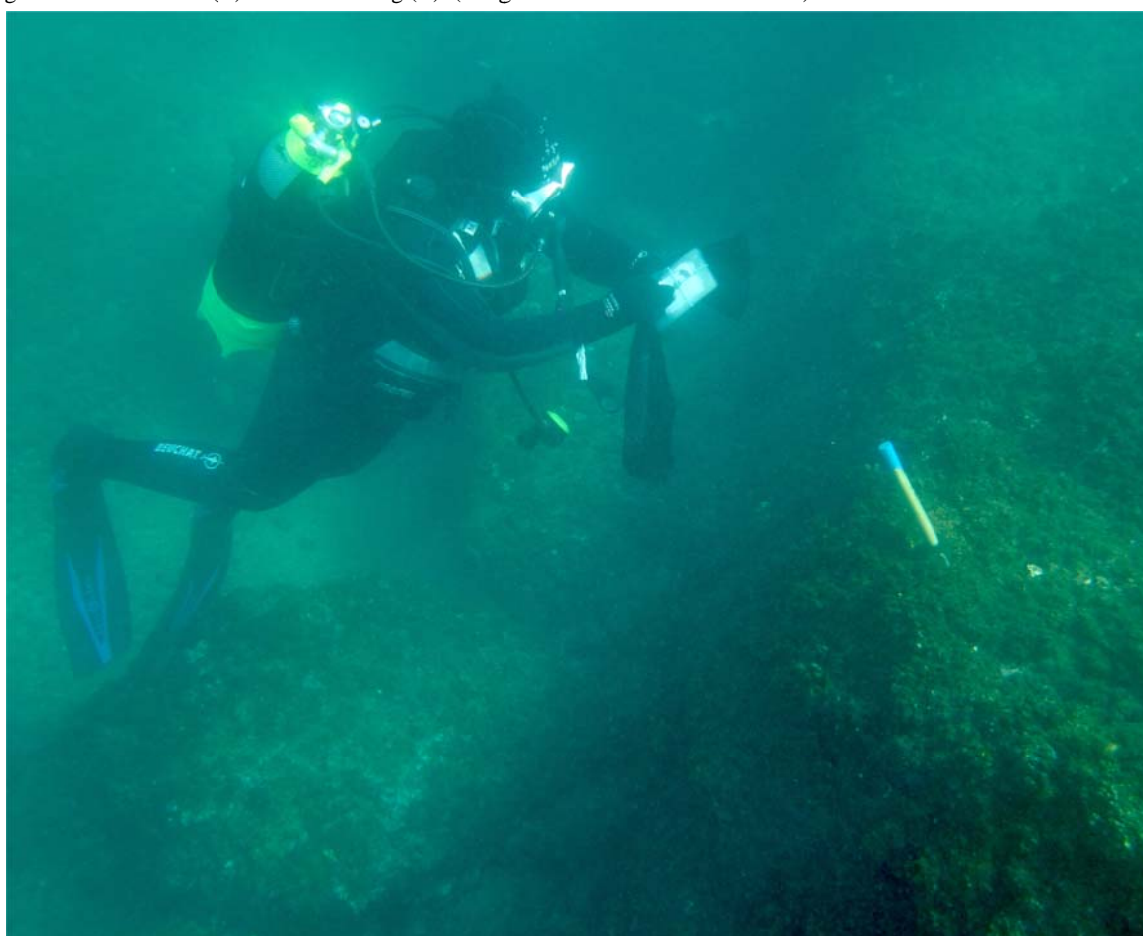


Fig. 6 - A diver positioning a target on the structure. (Image: C. Zazzaro)

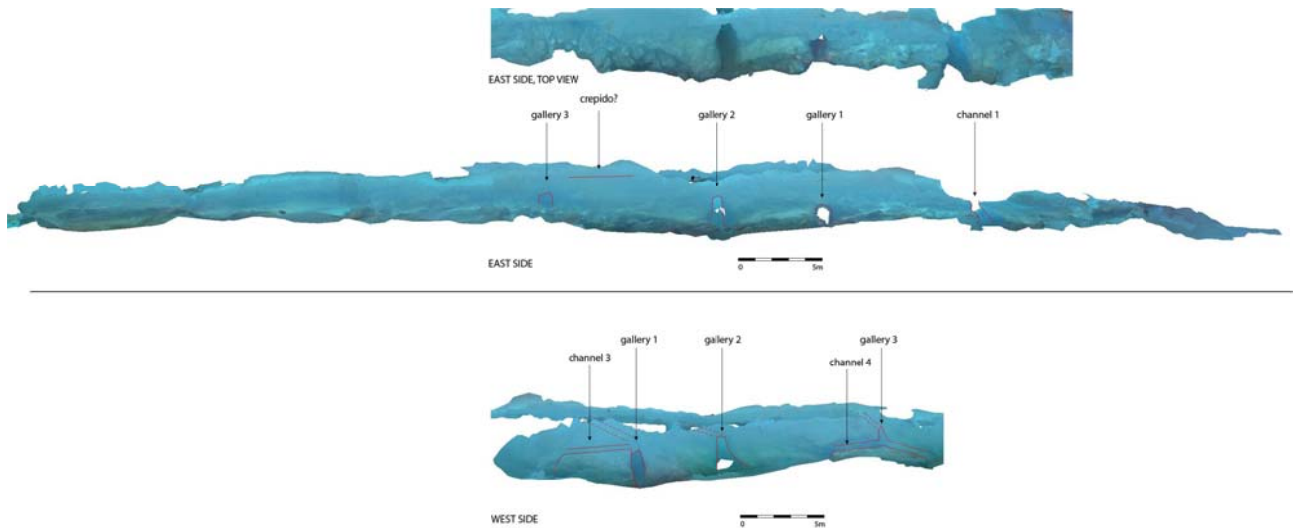


Fig. 7 - The result of the first attempt to obtain a 3D model of the structure with the use of Photoscan’s Agisoft Software. (Image: C. Zazzaro)

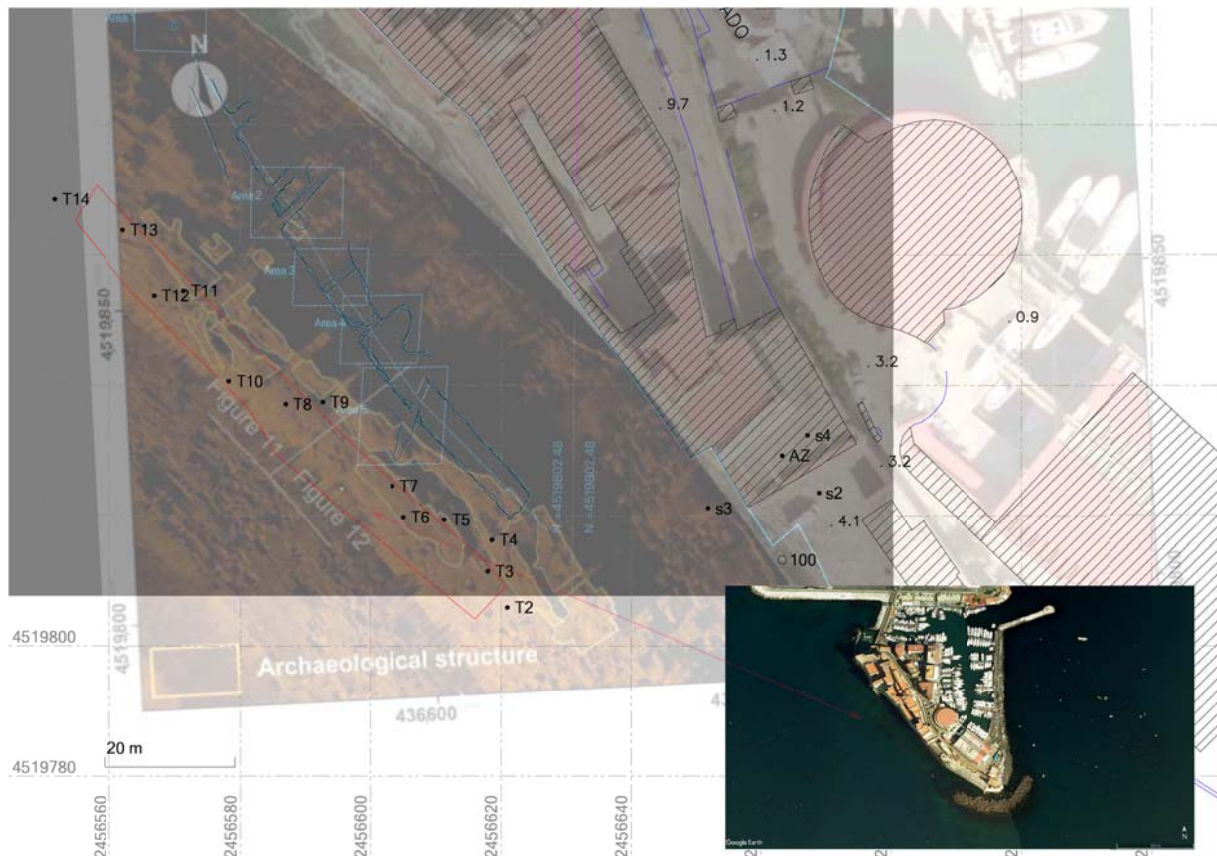


Fig. 8 - The topographic map overlaps the Google Earth image, the Terra Mare S.r.l . map, the SSS mosaic map (Pappone *et alii* 2019) and the targets positioned in 2020. (Image: R. Valentini and C. Zazzaro)

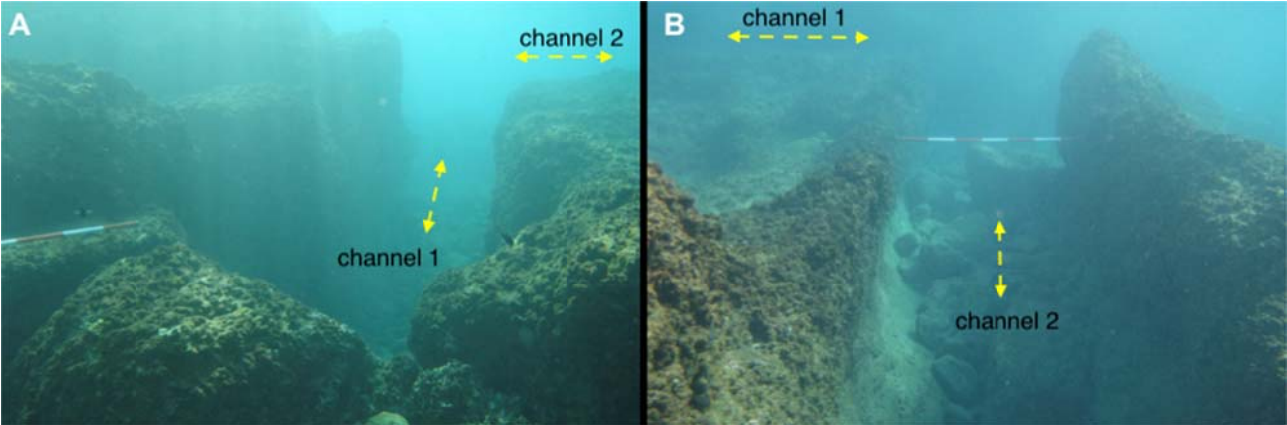


Fig. 9 - Channels 1 (A) and channel 2 (B). (Image: C. Zazzaro)

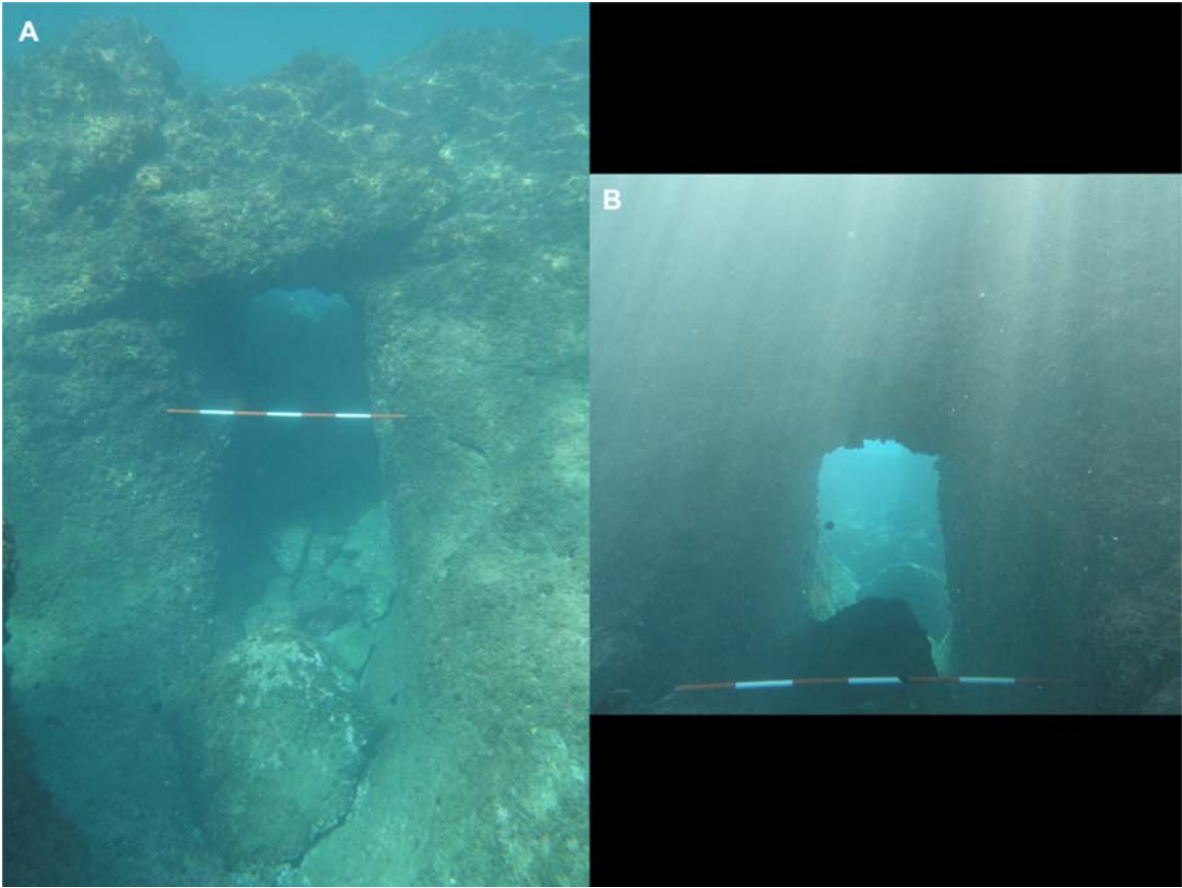


Fig. 10 - Gallery 1, West entrance (A) and East entrance (B). (Image: C. Zazzaro)

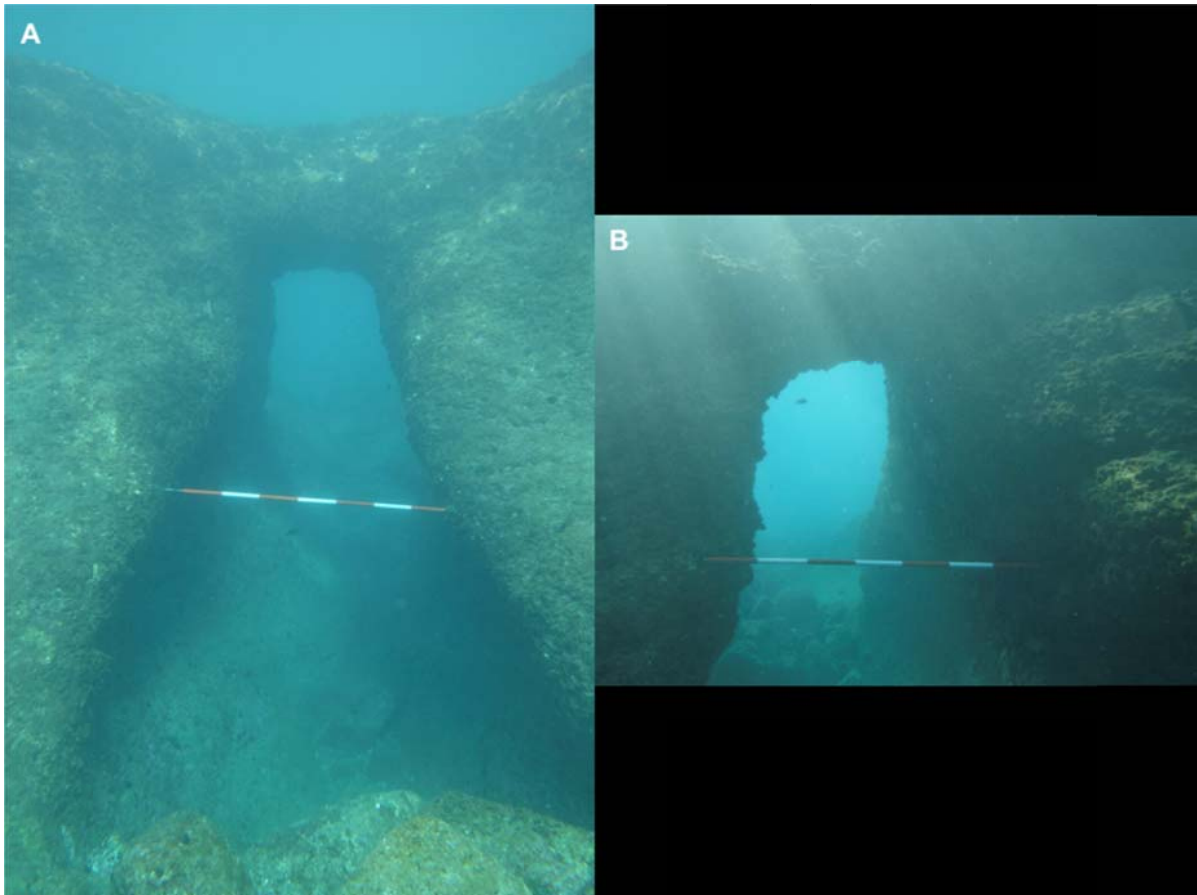


Fig. 11 - Gallery 2, West entrance (A) and East entrance (B). (Image: C. Zazzaro)

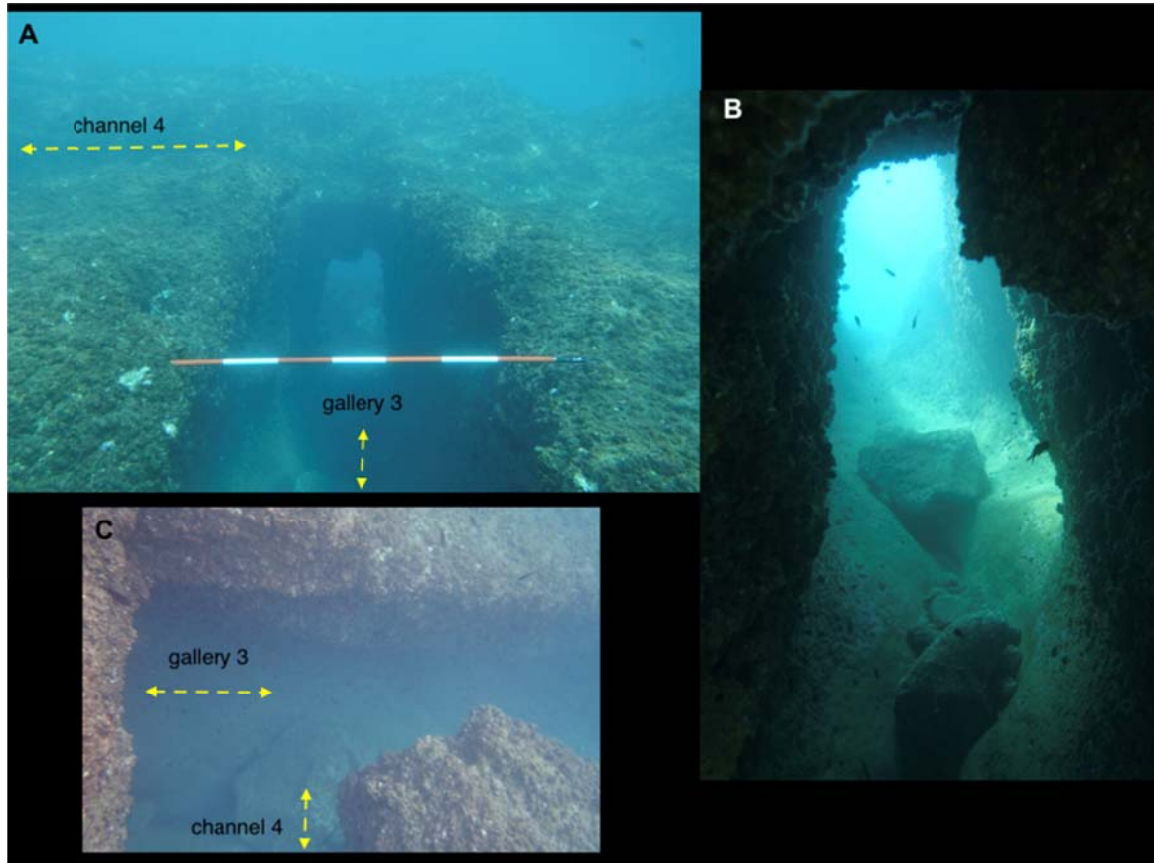


Fig. 12 - Gallery 3 (A, B, C) and channel 4 (A, C). (Image: C. Zazzaro)

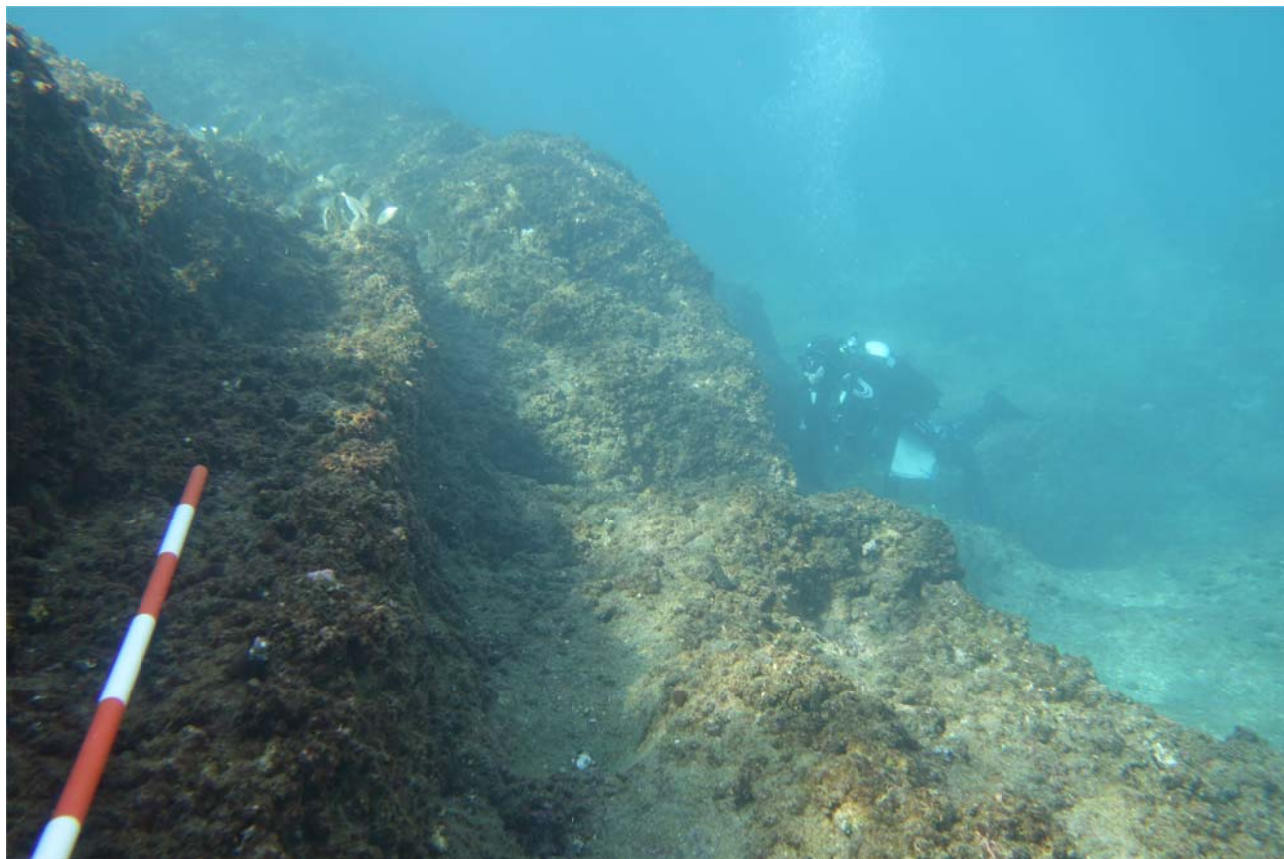


Fig. 13 - The possible *crepido* and a diver at the East entrance of gallery 3. (Image: C. Zazzaro)