

OCNUS

Quaderni della Scuola di Specializzazione in Beni Archeologici
Alma Mater Studiorum - Università di Bologna

ALMA MATER STUDIORUM - UNIVERSITÀ DI BOLOGNA

OCNUS

Quaderni della Scuola di Specializzazione
in Beni Archeologici

33
2025

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ANVUR classification: Class A journal - Area 10

Journal abbreviations as indicated in the «Archäologische Bibliographie» (Deutsches Archäologisches Institut).

Ocnus logo is inspired by a small bronze figurine from the 6th century BC from the Marzabotto foundry (Museo Nazionale Etrusco "P. Aria").

Publisher and Subscriptions

Ante Quem
Via Senzanome 10, 40123 Bologna
www.antequem.it

Subscription

€ 40,00

Website

www.ocnus.unibo.it

Exchange requests

Library of the Department of History, Culture and Civilisation
Piazza San Giovanni in Monte 2, 40124 Bologna
tel. +39 051 2097700; fax +39 051 2097802; federica.rossi@unibo.it

Authorisation by the Court of Bologna nr. 6803 del 17.4.1988

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ISSN 1122-6315

ISBN 978-88-7849-211-0 (press); 978-88-7849-216-5 (online italian); 978-88-7849-217-2 (online english)

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UNDERWATER ARCHAEOLOGICAL INVESTIGATIONS IN THE PASSAORA TIDAL CHANNEL, VENICE LAGOON

Stefano Medas*, Alessandro Asta**, Barbara Mikac*, Paolo Mozzi***, Sandra Primon°

The article deals with the underwater archaeological investigations carried out in 2023 at the so-called Argine Passaora, in the Venice lagoon, referable to the typology of ‘embankments-roads’, important infrastructures that characterised the ancient lagoon landscape. The investigations made it possible to verify the state of conservation of the structure twenty years after the first intervention and to specify the chronology of its use, with continuity from the early imperial age to the late antique period.

Introduction

In November 2023, the Department of Cultural Heritage of the Alma Mater Studiorum - University of Bologna carried out a short underwater archaeological investigation in the Passaora channel, near the island of Sant’Erasmus in the northern Venice Lagoon. The investigation, carried out thanks to funding from Alma Scavi, took place under authorization of the Soprintendenza Archeologia, Belle Arti e Paesaggio per il Comune di Venezia e Laguna, with the participation and collaboration of the co-authors of this article.

The intervention is part of a broader panorama of research, protection, study and promotion initiatives of the lagoon’s underwater archaeological heritage, characterized in recent years by the presence of a multiplicity of actors (mainly Italian and foreign Universities) who supported the historic leading role of the former Soprintendenza Archeologica del Veneto. The principal aim is to examine, with a multidisciplinary approach, some

of the most relevant issues connected to the population of the Venice lagoon and the characteristics of its progressive infrastructure, at least in the period between the first millennium BC and the first millennium AD.

While waiting to define a Memorandum of Understanding with a broader perspective with the Soprintendenza, the investigations coordinated by the University of Bologna have made it possible to acquire new and interesting data on the so-called “embankments-roads”, for which the scientific literature has not yet allowed a definitive interpretation (see below).

A.A.

The geomorphological context

The archaeological site under study is located to the north of the island of Sant’Erasmus, in a lagoonal environment close to the ancient tidal inlet of Sant’Erasmus and the main tidal channels that branched off from it. The overall palaeoenvironmental picture of the area that can be deduced from the preliminary data, is that of a low-energy backwater lagoon context: a place with brackish waters subject to a good turnover thanks to its proximity to the open sea. It was a water space protected from storm surges, with salt marshes stretch-

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ing along the main tidal channels and with the large island of Sant'Erasmo alongside. In terms of lagoonal and coastal navigation, the proximity of a major tidal inlet and related tidal channel systems, allowed both a rapid exit of vessels into the sea and an easy transit towards the interior of the lagoon.

The entire geomorphological system is marked by the presence of tidal channel levees that develop on the banks of the tidal channels fed by the current inlet of the Port of Lido. From the latter, the S. Erasmo channel, which is connected to the Passaora, Tresso and Carbonera channels, the Treporti channel and the San Felice channel, branch off towards the interior of the lagoon. This delineates what is known in literature as a 'tidal delta' (Bondesan, Meneghel 2004). This is a tidal sedimentary system made up of salt marshes, defined in this case as 'lagoon channel salt marshes', and mud flats that connect with the lagoon bed.

A similar system of water and sediment distribution from the main inlets must have developed in the Roman age (fig. 1), with the probable presence of several inlets, as the wide Punta Sabbioni spit, which was only formed in the 19th century, did not yet exist. The Argine Passaora was probably located along one of the tidal channels that branched off from the ancient tidal inlet of S. Erasmo.

In order to verify the possible continuation of the embankment structure below the present-day salt marshes along the Passaora channel, some manual boreholes were carried out near the margin of salt marshes along an alignment perpendicular to the embankment itself (fig. 1a). Fig. 2a shows a geological section with N-S orientation based on cores SE4, SE1 and SE2.

The section shows that the deposits crossed by the cores consist mainly of silty clays and clayey silts, sometimes sandy, with whole shells and fragments of lagoon bivalves and gastropods, predominantly *Cerastoderma* and *Bittium*. The sedimentation environment is typically lagoonal.

In the upper portion of cores SE2 and SE1 within the first 90 cm from the surface, sand and sandy silt are present. In SE2, at an elevation of -2.50 m MSL¹, a silty clay level with abundant plant remains was recognized and interpreted as the A horizon of a salt marsh soil. In SE1 and SE4, at an elevation of -2.85 m and -2.70 m asl respectively, a level of silty clay and silt with a concentration of shell fragments and whole *Bittium* shells was intercepted.

Wood fragments are present in SE1 between -2.25 m and -2.55 m MSL and in SE4 between -2.80 m and -2.90 m MSL. In SE4, a 3 cm brick was sampled below the wood fragment.

From the bathymetric survey carried out during the archaeological intervention, the sector of the bank structure cropping out along the bottom of the channel and closest to the soundings is at a depth of approximately -1.79 m MSL.

As is well known, the Venetian area is subject to a phenomenon of continuous geological subsidence that has been accompanied during the Holocene, starting from the end of the last glaciation, by the progressive eustatic rise of the sea level. The average estimated rate of relative sea level rise in the Northern Lagoon over the last few thousand years, based on geological and archaeological data, is 1.2 mm/year (Serandrei Barbero, Albani, Zecchetto 1997; Serandrei Barbero, Albani, Bonardi 2004; Ammerman *et alii* 1999). Assuming the estimated mean rate is also valid for this area, it can be calculated that the mean relative sea level was about -1.80 m around the 5th century A.D. (cf. fig. 2a). The presence of traces of *teredo* at the top of the piles (which now emerge by a maximum of 10 cm from the channel floor) and in the planks, is consistent in suggesting that they may have been close to the mean sea level at the time of construction and use of the structure.

Projecting these data onto the geological section of fig. 2a shows that the embankment structure would have been located close to a salt marsh. The presence of stone elements, bricks and wood fragments (cf. SE4 in fig. 2b) represent probable evidence of the continuation of the Argine Passaora under the present-day salt marshes.

P.M., S.P.

The site, the goals of the investigation and the evidence found

The survey was aimed at updating the study of an ancient embankment structure, named *Argine Passaora* and referable to the category of the so-called *embankments-road* (or *embankments-paths*), of which there is other evidence in the Venice Lagoon² (fig. 3). These are multifunctional embankment structures, mostly varying in width between 2 and 4 m which in some cases has been recog-

¹ MSL (Mean Sea Level) referred to the Altimetric Network of Punta della Salute 1897.

² Fozzati, Toniolo 1998; Rosada, Zabeo 2012: 247-250; Canal 2013: 59-60, *passim*; Felici 2016: 209-212; Zabeo 2016; Asta, Medas 2023: 68-72, 76-81, 137-139.



Fig. 1. Reconstructive hypothesis of the central-northern sector of the Lagoon of Venice in the Roman age. The lagoon channels are taken from 17th century historical cartography and are shown in this diagram as an example of the circulation of lagoon waters in the pre-industrial age; the then active barrier islands are highlighted in yellow; the possible tidal deltas are marked in blue (from Mozzi and Primoni, 2023). The area of the Argine Passaora is highlighted in red. Box 'a' shows in detail the area of the embankment with the location of the boreholes in the geological section of Fig. 2a (P.M. and S.P. processing).

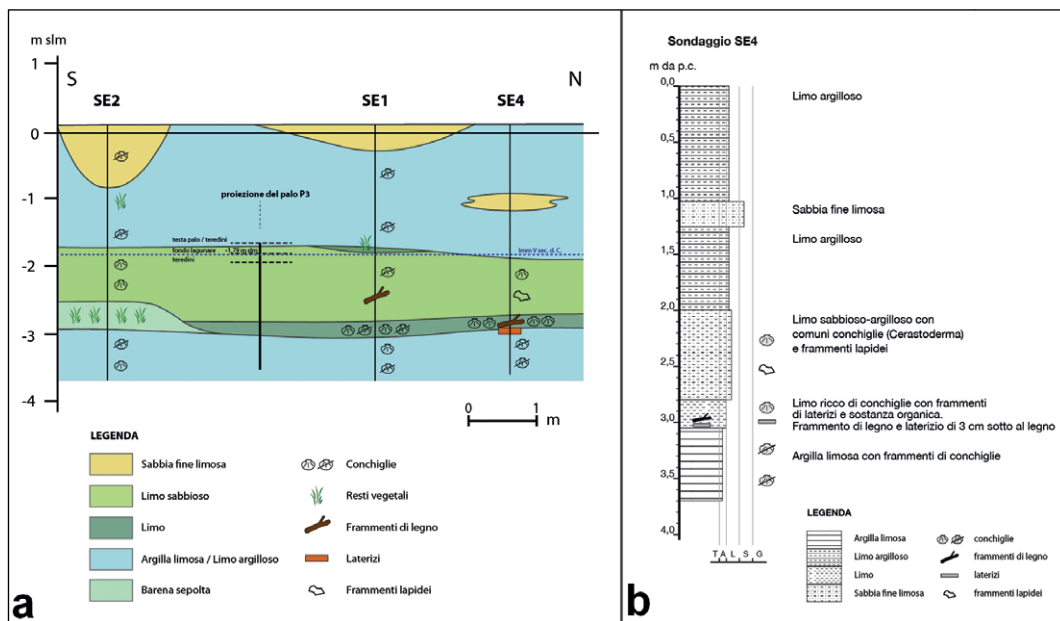


Fig. 2. a) Geological section perpendicular to the Argine Passaora; b) stratigraphic log of core SE4 (P.M. and S.P. processing).



Fig. 3. Location of the survey area in the Venice lagoon and detail of the position of the embankment in the Passaora channel. The continuous yellow line indicates the section identified on the bottom of the channel, the dashed line its probable development towards the west, identified by means of metal probe survey and coring under the shallow area and under the sandbar (S.M. processing based on GoogleEarth).

nized to be over 100 m long. In many ways still enigmatic, these structures are very important for the study of the ancient lagoon territory and its anthropic landscape, in relation to the management and exploitation by man, the subdivision, delimitation and regimentation of water spaces, and the contextual and probable use as dry connection routes between islands, islets and other dry land (hence the name ‘embankment-roads’). From a structural point of view, they are composed of two parallel wooden retaining walls, made with only piles or with piles and planks, between which there is a compaction of earth, mud and re-used materials functional for stabilization and drainage. These are mostly fragmentary bricks, whole or sectioned amphorae arranged in a vertical position³,

fragments of amphorae, common and fine pottery, remains of worked stone elements, unworked stones and pebbles.

An archaeological underwater investigation was carried out on the Passaora embankment in autumn of 2003, as part of the archaeological assistance works involving the wide area of mudflats and sandbanks adjacent to the Passaora channel, on the inner lagoon side of Sant’Erasmus island, where other sites referable to ancient embankment structures were identified (Medas *et alii* 2023). This embankment presents an approximately east-west orientation (precisely 100° - 280° compass), transversal to the channel, developing from the western bank of the channel itself and continuing eastwards for a maximum length of approximately 12 m and with an average width of around 2 m (Medas *et alii* 2023: 35-38) (fig. 4). The structure, which emerges a few centimeters

³ So in a similar way to drainage and reclamation works (Cipriano, Mazzocchin 2020).

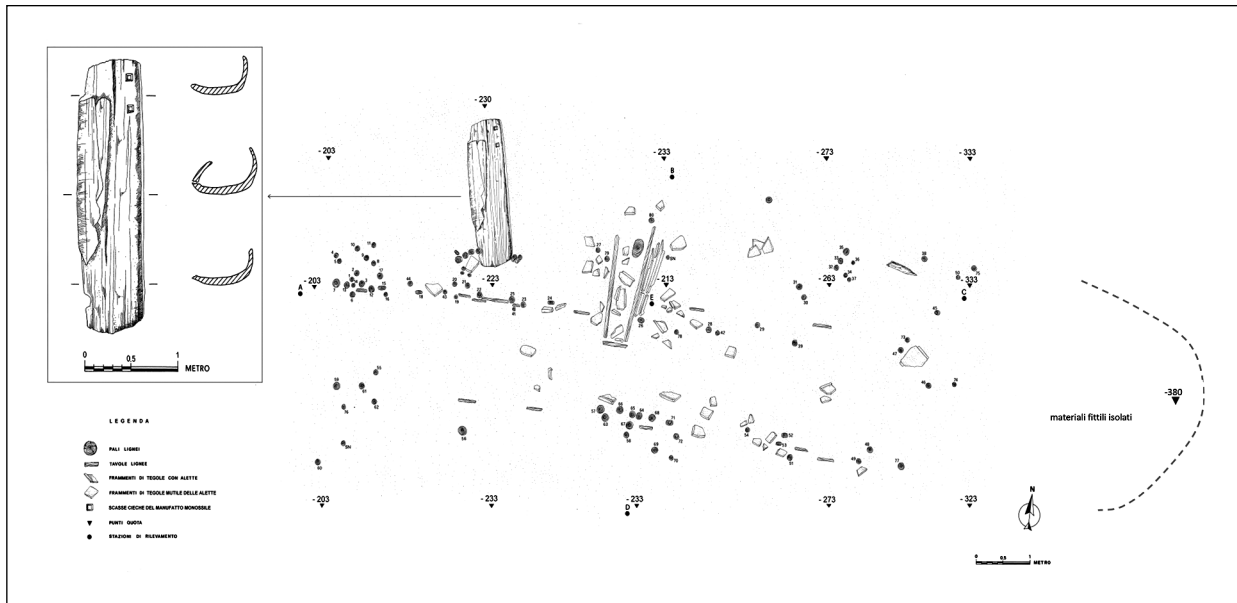


Fig. 4. Planimetric survey of the remains of the ancient embankment (2003) and the eastern boundary, towards the channel centre, where scattered terracotta finds were identified in 2023 (dotted line on the right) (S.M. survey, V. Gotivola graphic).

above the channel bottom, has been identified at depths between -2 and -2.30 m MSL⁴ in the western section, the one closest to the bank. Proceeding towards the eastern end, i.e. towards the channel centre, where erosion is greater because the dynamic energy developed by the tidal currents is stronger, these gradually increase to around -3.50 m. The structure has been preserved at a residual level and was composed of the discontinuous remains of the two wooden walls, made of piles and planks fixed vertically in the mud, and of a compaction consisting mainly of fragmentary bricks (mostly tiles with fins).

The specific targets of the 2023 campaign concerned: 1) check of conservation status of the embankment structure twenty years after the previous survey; 2) in-depth study of the chronological discrepancy between terracotta finds and wooden samples, by taking new samples for laboratory analyses; 3) check of the possible continuity of the structure towards the west, i.e. towards the sandbar, by means of metal probe and manual coring; 4) analysis of the environmental context and of the xylophagous organisms that cause the degeneration of the wooden elements emerging from the bottom. The operating conditions were those

characteristic of lagoon channels and of the Passaora in particular, with strong tidal current progressively increasing as one proceeds eastwards, i.e. towards the channel centre. Underwater visibility was between 30 and 70 cm.

The problem of the chronological discrepancy between the terracotta fill material and the two wooden margins also affected the other sites identified in the mudflats and sandbanks area of Sant'Erasmo, where material all clearly attributable to the Early Imperial period was found to be associated with wooden poles of the Late Antique or Early Medieval period, although it should be noted that the 14C analyses were conducted on only one wooden sample per site⁵. In fact, it seems difficult to think of structures built ex-novo in late Antique or early Medieval times by using only ancient materials – which had already fallen into disuse three or four centuries before. As documented also for wetlands drainage and reclamation contexts, the reuse of amphorae still intact or partially intact must have taken place relatively close to the time when they stopped being used. Radiometric analyses of the three wooden samples taken in 2023 returned

⁴ MSL (Mean Sea Level) referred to the Altimetric Network IGM Genova 1942, which is 23,56 cm higher than the tidal zero of Punta della Salute 1897.

⁵ Pesavento Mattioli 1998; Antico Gallina 2011; Cipriano, Mazzocchin 2020. On the other hand, there are examples of chronological coincidence between the finds of the compaction and the wooden piles (Asta, Medas 2023: 76-81, 113-114, 121-125).

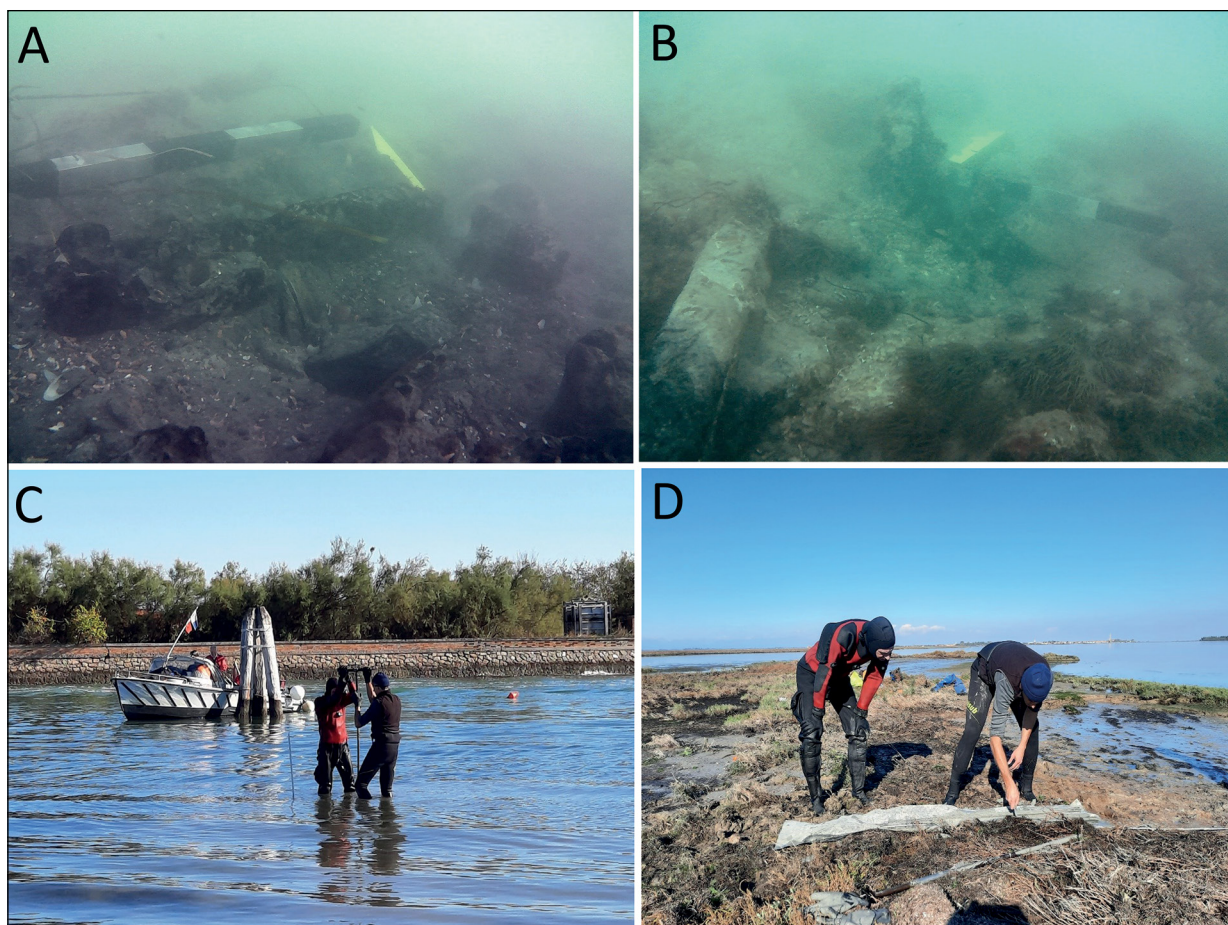


Fig. 5. A) planks and wooden piles near the western end of the embankment, along the northern edge; B) terracotta finds in the eastern sector of the embankment (in the foreground on the left, a fragment of a tile with fins); C) coring in the shallow area; D) sandbar west of the channel, reading of a coring (S.M. photo, courtesy Soprintendenza ABAP per il Comune di Venezia e Laguna).

a chronological range with extremes between the second quarter of the 2nd century AD and the first half of the 6th century AD (128-202 AD, 378-424 AD, 416-540 AD respectively)⁶.

The underwater survey showed that most of the structure remained substantially well preserved compared to 2003, although eroding had occurred towards the east end (fig. 5).

Since the 'embankments-roads' are structures with a large longitudinal development, an investigation was carried out to check the westward continuation of the recognised underwater sec-

tion. To this end, a survey with metal probe (Asta, Medas 2023: 51-62) and coring (Mozzi, Primon, *supra*) were carried out, which indeed revealed the probable continuation of the structure towards the west, under the sediments at the edge of the channel and under the sandbar. The section of embankment identified would therefore present an overall length of at least 60 m and an almost straight development, although, of course, only the opening of excavation tests will allow certain findings to be made.

S.M.

⁶ Dating by the ISOCORE laboratory, University of Campania Luigi Vanvitelli (laboratory codes DSH12249-12251_CE). The costs of the analyses were borne with funds from the Superintendency ABAP for Venice Municipality and the Lagoon.

Environment, flora and fauna

The environment in the Passaora channel is exposed to a strong tidal current. The sediment



Fig. 6. Flora and fauna of the sediment. A) sediment, br = gastropod *Bittium reticulatum*, mp = marine phanerogam; B) galleries and calcareous tubes of the bivalve mollusc *Lyrodus pedicellatus* and/or *Teredo navalis*; C) bivalve mollusc *Pholas dactylus* in the gallery; D) bivalve mollusc *Pholas dactylus* (B.M. photo, courtesy Soprintendenza ABAP per il Comune di Venezia e Laguna).

is sandy-muddy with a high amount of shelly detritic material, mainly composed of whole and fragmented mollusc shells, and organic material, deriving from pieces of wood, including those of the ancient bank structure, and leaves of marine phanerogams *Cymodocea nodosa* (Ucria) Ascher-son, 1870⁷ and the genus *Zostera* (fig. 6A). Flora and fauna of the sediment is typical of lagoonal and brackish environments (Curiel, Rismondo 2009; Tagliapietra, Minelli 2009). Among the other organisms, we found the green algae *Ulva rigida* C.Agardh, 1823, the red algae of the ge-

nus *Gracilaria*, the anemones (phylum Cnidaria), the polychaetes (Phylum Annelida) of the family Terebellidae, amphipod crustaceans, the gastropod mollusc *Bittium reticulatum* (da Costa 1778), the echinoderms of the class Ophiuroidea.

In the wooden parts of the ancient embankment structure, clear signs of erosion by xylophagous organisms that dig into the wood creating galleries and causing the deterioration of the wooden structure, were observed. The sediment next to the wooden posts was covered with pieces of wood coming from the posts, in which there were long and dense galleries lined by the calcareous tubes of the bivalve molluscs of the family Teredinidae, *Lyrodus pedicellatus* (Quatrefages 1849) and/or *Teredo navalis* Linnaeus, 1758, well known wood borers (Borges 2014) (fig. 6B). However, no living organisms of these species were observed. Furthermore, in the posts protruding from the sediment, large galleries excavated by the bivalve

⁷ Following the rule of the International Code of Zoological Nomenclature (ICZN), the scientific binomial name of the species is followed, on its first mention in text, by the surname of the scientist(s) who first published the name, and the year of publication (International Commission on Zoological Nomenclature, 1999).

mollusc *Pholas dactylus* Linnaeus, 1758 were observed (fig. 6C-D). The largest living specimens were 8 cm long with a diameter of 3 cm, while the diameter of the holes dug in the wood were approximately 3.5 cm. *Pholas dactylus* is a mollusc distributed along the north-eastern Atlantic coast, in the Mediterranean and the Black Sea (Lopez *et alii* 2021). Historically, this species had a wide distribution range, but is now rare, due to habitat destruction and pollution, and overexploitation by humans for food and as fishing bait. The species is highly protected and included in the Bern and Barcelona Conventions. In addition to being an important ecosystem engineer, this species has great cultural and archaeological importance and could be used as an indicator species. *Pholas dactylus* can be frequently found in the Venice lagoon (Russo 2017).

B.M.

Conclusion

As for the problem of chronology, the new radiometric analyses confirm the long lasting life of the Passaora embankment, probably built between the 1st and 2nd century AD (as seem documented by the scarce fragments of amphorae and pottery found) and with continuation of use until the 5th-6th century AD; a continuation which determined the maintenance and progressive renovation of the wooden retaining walls. The situation is similar to that of the other sites investigated under the mudflats and sandbars of Sant'Erasmo. Also in this case the evidence of use continuation refers basically to the radiometric dating of wooden samples, because amphora and pottery fragments substantially refer to the installation chronology of the structures in the early Imperial Age (at least referring to excavation tests with a good sample of finds useful for dating), while there is no, or is very uncertain, the presence of late antique or early medieval finds. It seems like the inner core of the structures, the compaction, had not been refilled with soil and reused materials over the centuries following the first installation; or that it had been refilled with soil no-containing reused materials or with a very low material percentage, which would explain the difficult of its clear identification. In essence, it seems that the structures core remained fundamentally that of the early Imperial Age, perhaps because it was stable enough not to require major maintenance works, which instead was periodically necessary to preserve the wooden walls

from consumption due to erosion, rotting and attack by xylophagous organisms.

S.M.

Acknowledgements and institutional collaborations

The investigations was carried out under ministerial permission (DGABAP 47-2022, MIC SABAP VE LAG UO2 | 16/02/2023 | 0003075-P. Prot. n. 0000197 del 17/02/2023). Operational support in the field, both technical and logistical, was provided by Archeotecnica S.r.l. of Venice, the specially appointed underwater works company (technical underwater operators Eros Turchetto, Nicolò Turchetto, Massimo Sinibaldi, Rocco Sinibaldi). Federico Orsacchi, then a student at the Department of Cultural Heritage, master's course in Archaeological, Artistic and Landscape Heritage, collaborated on the activities.

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