Modern development and ancient maritime sites along the Tyrrhenian coast

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Introduction

Coastal management cannot disregard knowledge of the ancient underwater remains of archaeological interest found there as a result of changes in sea level. These remains were mainly maritime structures destined for residential or practical use: seaside villas, anchorages, quarries, fish tanks and fish-processing equipment, harbours, lighthouses etc. Such monuments are liable to suffer considerable damage from exploitation of the coastal zone in modern times.

The harbours, especially, have suffered heavy destruction; most of the ancient Mediterranean harbours have been lost for human use as anchorages. Moreover, Roman harbours were established in the best nautical locations, and the ruins encouraged their incorporation into the construction of new jetties, to save money in the new construction.

When an ancient harbour is covered by a modern harbour, we lose not only a monument, but also the archaeological remains beneath which are often destroyed by dredging. Above all, any possibility of learning about ancient techniques for building harbours is lost. These techniques are still not very well known; they only recently became better understood as a result of underwater archaeological research and detailed surveys. The concentration of Roman ports on the Italian coast of the Tyrrhenian Sea is understandably great. It comprises small docks for local use and grand commercial and military harbours, such as those at Ostia or Portus Julius.

Roman harbour construction

Firstly, some short accounts of Roman techniques for building harbour moles follow. According to Vitruvius (the Augustan-age author of *De architectura*), one could build maritime structures by casting concrete (*opus caementicium*) in two types of wooden moulds: 'waterproofed' or 'flooded'. In the first, a double-walled mould had to be emptied of water, for use by the 'normal' building method. In the second, a flooded mould was possible, concrete being cast directly in water, but the system needed the addition of volcanic ash, pozzolana (*pulvis puteolanus*), from the Puteoli region, which enables the concrete to harden under water. In both cases, the mould was reinforced by an internal wooden frame of posts (*destinae*, or *stipites*) and horizontal beams (*catenae*).[1]

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[1] Dubois, C. (1902). Observations sur un passage de Vitruve. pp. 439–67, in: Mélanges d'Archéologie et d'Histoire. *Rome.*

- *Felici, E. (1993). Osservazioni sul porto neroniano di Anzio e sulla tecnica romana delle costruzioni portuali in calcestruzzo.* Archeologia subacquea, *Studi, ricerche e documenti, I:71–104. Istituto Poligrafico dello Stato.*
- *Fensterbush, C. (1964).* Vitruv, Zehn Bücher über Architektur. *Darmstadt.*
- *Oleson, J. P. (1985). Herod and Vitruvius: Preliminary Thoughts on Harbour Engineering at Sebastos: the Harbour of Caesarea Maritima. pp. 165–72, in: A. Raban (ed.), Harbour Archaeology, Proceedings of the First International Workshop on Ancient Mediterranean Harbours (Caesarea Maritima [near Haifa], 1983),* British Archaeological Reports, *257.*
- *Oleson, J. P., Hohlfelder, R. L., Raban, A. and Vann, R. L. (1984). The Caesarea Ancient Harbor Excavation Project (C.A.H.E.P.): Preliminary Report on the 1980–1983 Seasons.* Journal of Field Archaeology, *3:282–305.*

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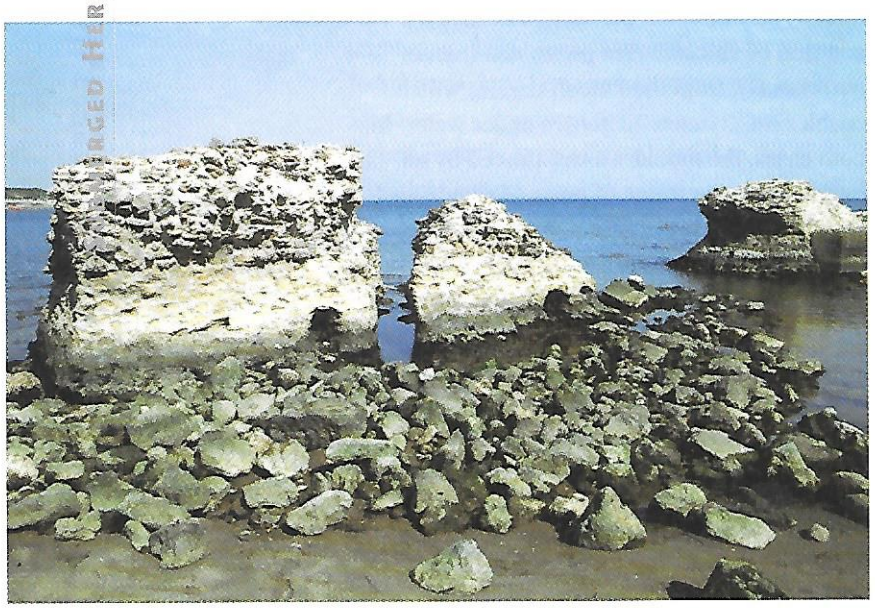
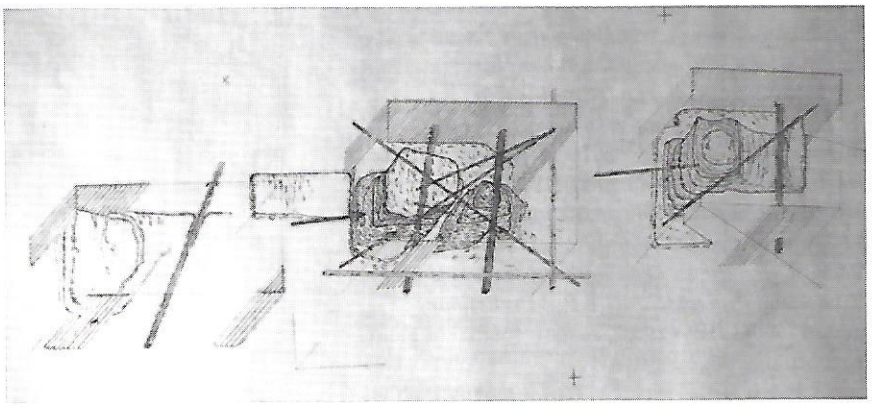
The harbour of Cosa

Recent American surveys interpreted the mole of the Roman harbour of Cosa as being a pier building, dating to the early 2nd century BC (Fig. 1).[2] A later Italian technical survey reconsidered the building system, suggesting that the mole's structure was based on spaced piers as the main loadbearing points, and that the gaps between were filled later. This suggestion is supported by the fact that there are two hollows on the north faces of the piers, one of which was surely due to the insertion of a small amphora in the wet concrete. The hollows served as receptacles for the ends of the horizontal beams of moulds used in the construction of the small pier. This was a cheap way to build an uninterrupted mole (Fig. 2).

Figure 1. Cosa harbour mole, Western side.

Figure 2. Cosa harbour mole, axonometric projection of the building technique.





The interpretation of the mole's structure as a pier building sprang from a gap between piers 2 and 3, but this gap is probably the result of the recent demolition of a part of the mole to facilitate the drainage of a quagmire behind the coastal dune. An indication of this is the modern ferroconcrete mouth of the drain, which partially encased the mole. This is an example of a modern intervention which, by altering an ancient ruin, can induce archaeological misinterpretation.

[1 - cont'd]

• *Oleson, J. P. (1988). The Technology of Roman Harbours.* International Journal of Nautical Archaeology, *17(2):147–57.*

• *Oleson, J. P. and Branton, G. (1992). The Harbour of Caesarea Palaestinae: a Case Study of Technology Transfer in the Roman Empire. pp. 389–420, in: Atti del Simposio [Symposium Proceedings],* Geschichte der Wasserwirtschaft und des Wasserbaus im Mediterranen Raum *(Merida, 1991). Braunschweig.*

• *Schläger, H. (1971). Die Texte Vitruvs im Lichte der Untersuchungen am Hafen von Side. Bonner Jahrbücher, pp. 150–61.*

[2] Gazda, E. K. (1987). The Port and Fishery: Description of the Extant Remains and Sequence of Construction. pp. 74 et seq. *in: A. M. McCann* et al., The Roman Port and Fishery of Cosa. *Princeton University Press.*

• *Felici, E. and Balderi, G. (1997). Il porto romano di Cosa: note per l'interpretazione di un'opera marittima in cementizio.* Archeologia subacquea, *Studi, ricerche e documenti, II:11-19. Istituto Poligrafico dello Stato.*

[3] Lugli, G. (1939). Saggi di esplorazione archeologica a mezzo della fotografia aerea. Istituto di Studi Romani, *pp. 5-6. Rome.*

• *Lugli, G. (1940). Saggio sulla topografia dell'antica Antium.* Rivista dell'Istituto Nazionale di Archeologia e Storia dell'Arte, *VII:153* et seq.

• *Blackman, D. J. (1992). Ancient harbours in the Mediterranean. In:* International Journal of Nautical Archaeology, *Part 1, 11(2):79–104; Part 2, 11(3):185–211.*

• *Gianfrotta, P. A. (1980). Anzio. pp. 9* et seq. *in: (cat. mostra)* L'aerofotografia da materiale di guerra a bene culturale: le fotografie aeree della R.A.F. *Roma.*

• *Lehmann-Hartleben, K. (1923). Die antiken Hafenanlagen des Mittelmeeres.* Klio *XIV. Leipzig.*

• *Schmiedt, G. (1970).* Atlante aerofotografico delle sedi umane in Italia. *Parte seconda:* Le sedi antiche scomparse. *Istituto Geografico Militare, Firenze.*

The harbour of Antium

The western dock

This impressive harbour near Rome was, according to Suetonius, built by the emperor Nero. A lot of the main dock was silted up when the adjoining modern harbour was built in the 18th century (by Pope Innocence XII), and later occupied by the modern town. A lot of the eastern mole was encased by the new mole.[3]

Recent surveys have documented the structure of the moles' foundations. The moles appeared to be uninterrupted (Fig. 3), built by flooded moulds reinforced by internal wooden frames made of posts and horizontal beams, and filled with pozzolanic concrete and tuff fragments. The elevations (above the water surface) of the moles were also brick-faced (Fig. 4).

The same technique was used for building the wharf on the western side of the port, on which there are many barrel-vaulted service rooms (Figs. 5 and 6).

The eastern dock

Hitherto, Anzio was known as a one-dock harbour. Plans from the 18th and 19th centuries and photographs from the early 20th century show the *Molo Panfili*, a masonry ruin now encased by a modern tourist wharf. According to the literature, this *pennello* was built in the early 18th century, shortly after the construction of the port ordered by Pope Innocence XII, to limit its siltation. This 18th-century *pennello*, according to some building documents, was built by erecting piles (*passonate*) and filling them with stones (a building technique used by the Papal States); they were abandoned immediately after completion because they were ineffective against siltation.

The photographs otherwise show an obviously Roman construction, made in brick-faced *opus*

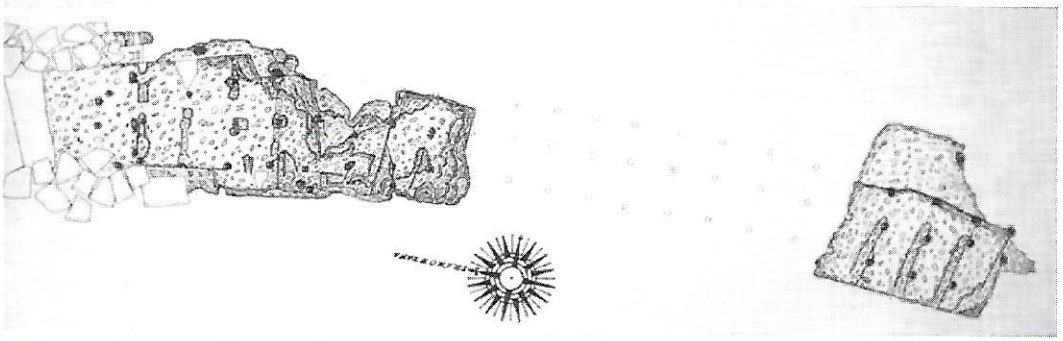


Figure 3. Antium harbour, Western dock, plan of the left mole.

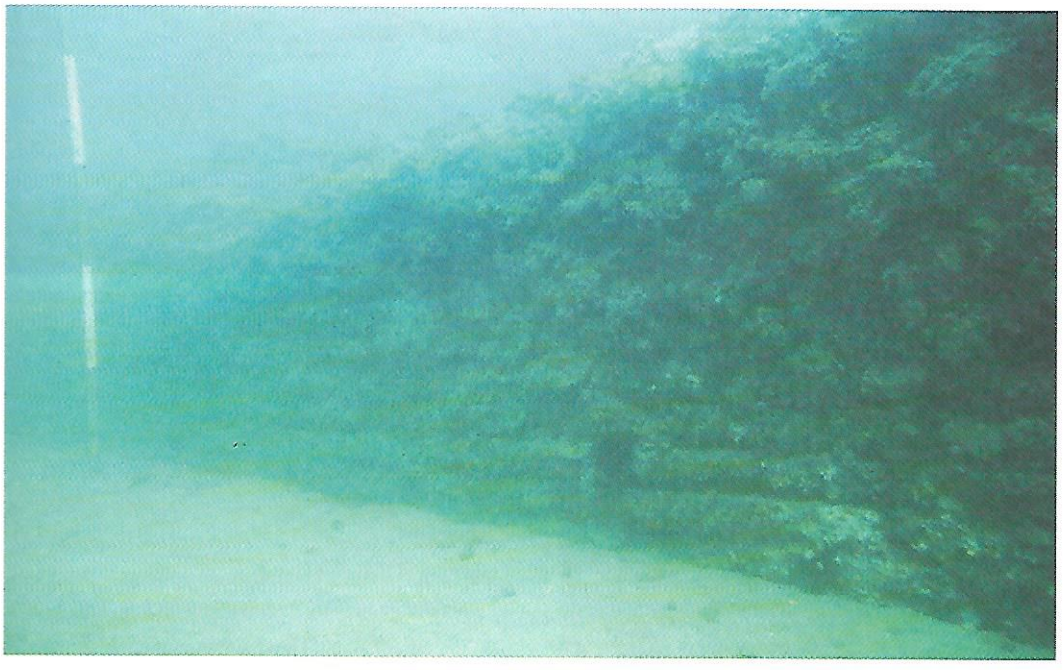


Figure 4. Antium harbour, Western dock, a brick-faced ruin on the seabed.

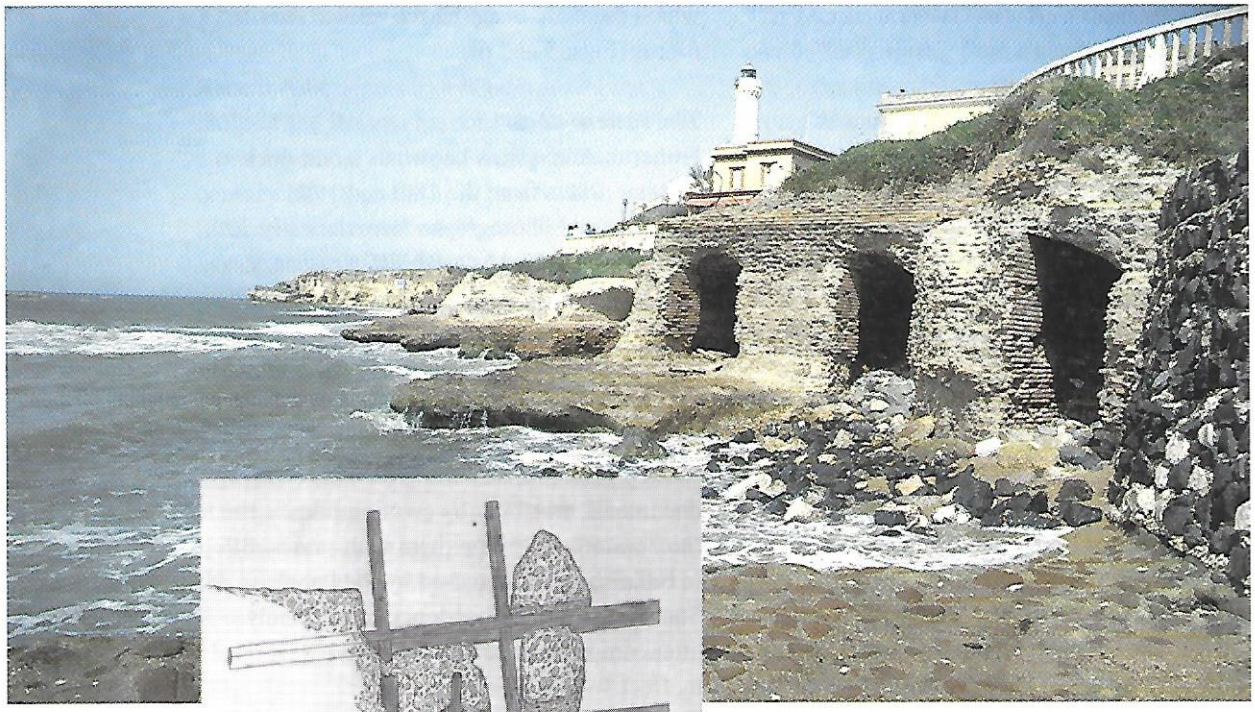


Figure 5. Antium harbour, axonometric projection of the concrete bed's building technique.

Figure 6. Antium harbour, barrel-vaulted service rooms.

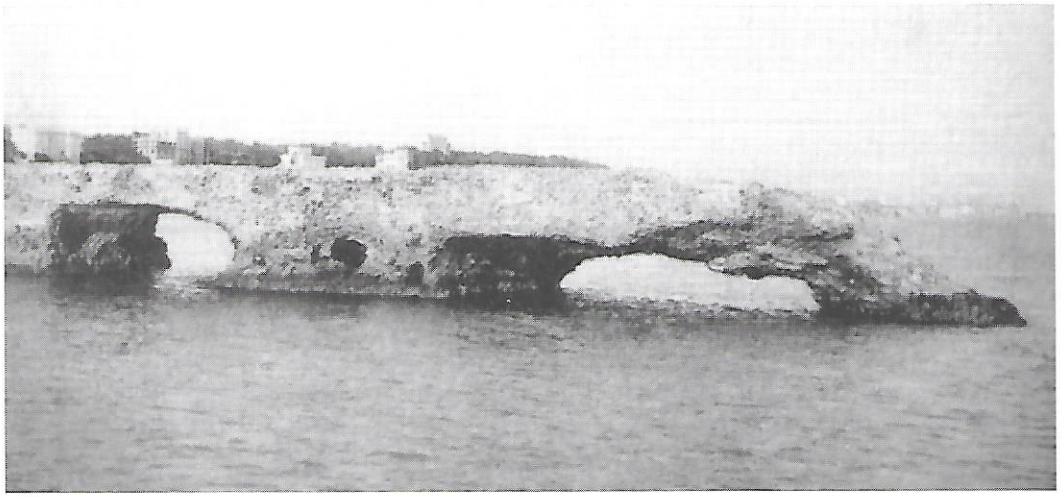


Figure 7. Antium harbour, Eastern dock, the roman mole in an early 20th century photograph.

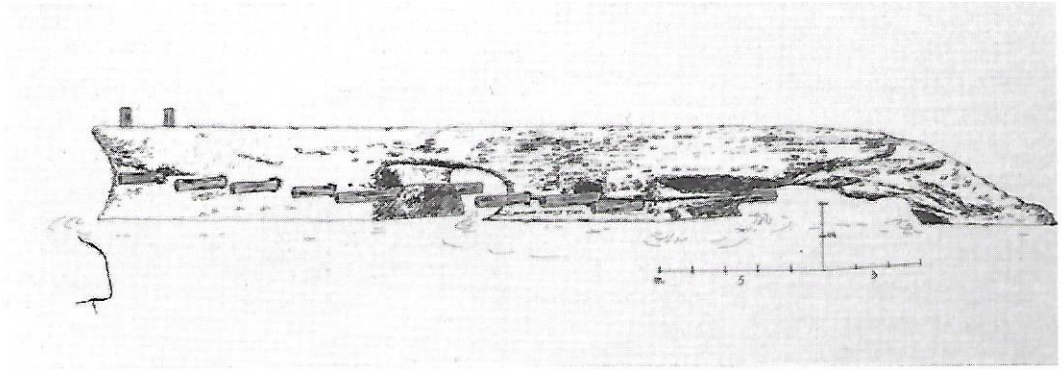


Figure 8. Antium harbour, Eastern dock, axonometric projection of the roman mole's building technique.

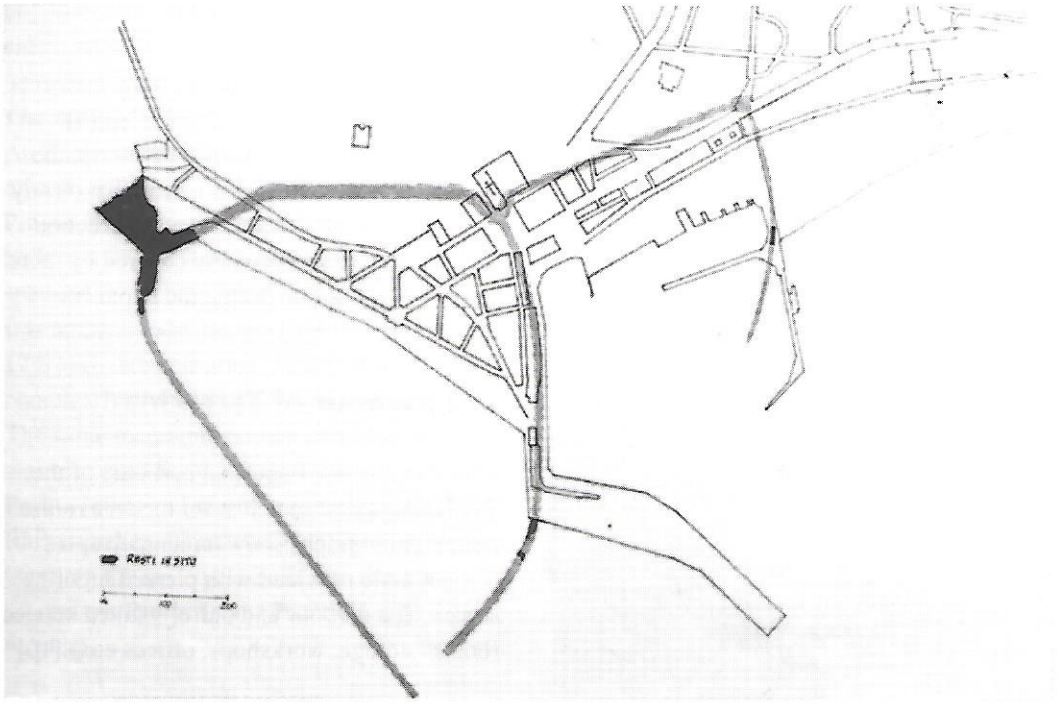


Figure 9. Antium, a new topographical hypothesis on the two harbour docks in a planimetric sketch.

caementicium, most probably built simultaneously with the neighbouring Neronian harbour (Figs. 7, 8). The *Molo Panfili* absorbed these ruins to simplify the construction works, as was often done in Anzio.[4] This method also led to the covering of the lefthand mole of the Neronian port.

Anzio's harbour complex during the Imperial era therefore comprised two docks (Fig. 9), which also explains the discovery, during late 19th-century construction work, of a Roman shipwreck, later sanded in, that had sunk in the eastern dock.

The lost fish tanks at Nettuno

The recent building of tourist wharves destroyed two Roman fish tanks, as shown by an aerial photograph (Fig. 10).[5]

A harbour at Astura

The famous seaside *villa*, complete with a large fish tank and a harbour, owes its preservation to the absence of tourist facilities (it being military property), in spite of some destruction due to wave action. The fish tank and the harbour moles and wharf were built in concrete.[6] The mole's

[4] Felici, E. and Balderi, G. (1997). Nuovi documenti sulla 'topografia portuale' di Antium. pp. 11–20, in: Atti del Convegno *[Conference Proceedings]* Nazionale di Archeologia Subacquea, *(Anzio, 1996). Edipuglia, Bari.*

[5] Gianfrotta, P. A. (1997). Le peschiere scomparse di Nettuno (RM). pp. 21–4, in: Atti del Convegno *[Conference Proceedings]* Nazionale di Archeologia Subacquea-A.I.A. Sub. *(Anzio, 1996) Edipuglia, Bari.*

[6] Castagnoli, F. (1963). Astura. Studi Romani, *XI(6):1–8.*

- *Gianfrotta, P. A. and Pomey, P. (1981).* Archeologia subacquea. *A. Mondatori, Milano.*
- *Piccarreta, F. (1977). Astura,* Forma Italiae. Regio, *XIII. L. Olschki, Rome.*

Figure 10. Nettuno, roman fish tanks in aerial view.

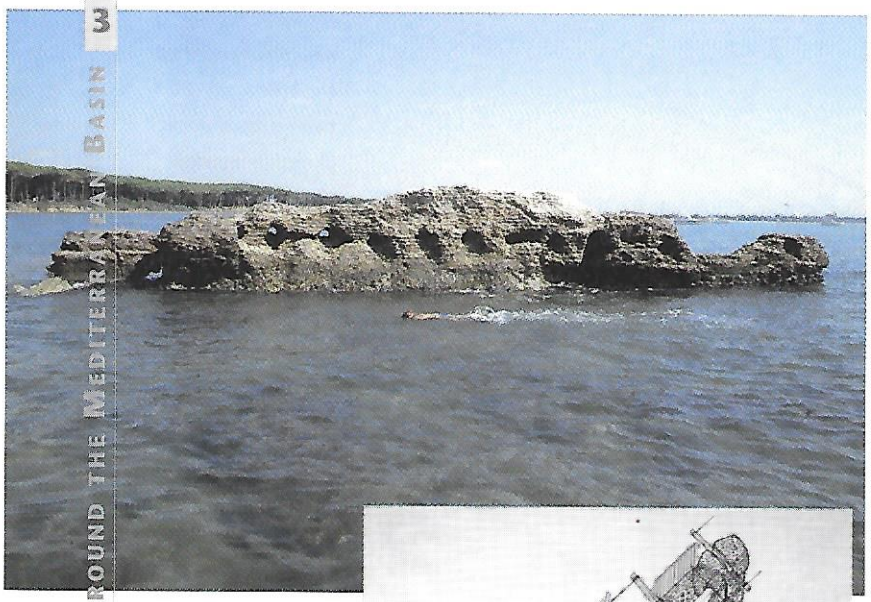


Figure 11. Astura's harbour, the left mole, Western side.

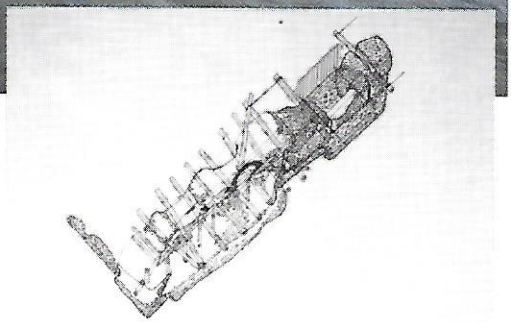


Figure 12. Astura's harbour, left mole, axonometric projection of the building technique.

remains (Fig. 11) reveal clearly enough the technique of construction, for which wooden moulds were used (Fig. 12). Some authors have thought the mole was built on piers (*pilae*), but a filling technique applied between the main load-bearing piers was most probably used.[7]

The sea gate of Circeii

This sea gate, perhaps built by Nero, connects the Paola Lake with the sea at Circeii.[8] It has two uninterrupted concrete moles, the righthand one of which has a head that clearly shows the use of moulds in the construction (Fig. 13).[9] The moles were covered by more modern construction during the Papal era.

The harbour of Tarracina

This is one of the important harbours of the Tyrrhenian coast; it is lost for modern re-use. Period photographs show an uninterrupted cement mole provided with pierced mooring stones. The harbour had barrel-vaulted service rooms (storage, workshops, offices etc.).[10]

The Phlegraean Fields

The Phlegraean Fields were an important centre of marine engineering. This region had a strategic position, excellent for navigation on the Mediterranean. Many of the harbour installations discovered were part of a complex system that had complementary functions: military and commercial. Today, most of these ruins are submerged as a result of the geological

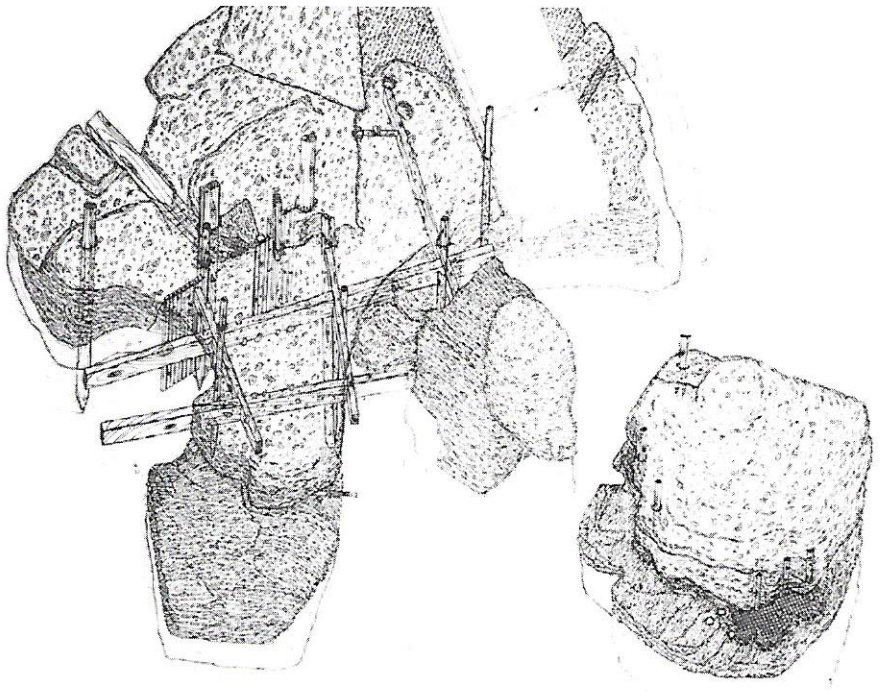


Figure 13. Circeii's gate, right mole' head, axonometric projection of the building technique.

phenomenon (bradyseism) that affects the entire area, and lost for human use.[11]

The mole of Puteoli

An image of the Puteoli mole often appears on souvenir glass flasks such as those made in Prague, Odemira, Populonia etc.[12] It was built as a 372 m-long breakwater (Fig. 14) spanned on arcades supported by piers (*pilae*). It is attested to by many maps drawn in the 17th and 18th centuries. Today, it is completely covered by modern renovation. The same technique (called *opus pilarum*) was also used for the external part of the Portus Julius and more frequently along the Baia coastline. The technique was also used to lengthen the structures built into the sea around the Rione Terra (Pozzuoli, near Naples).

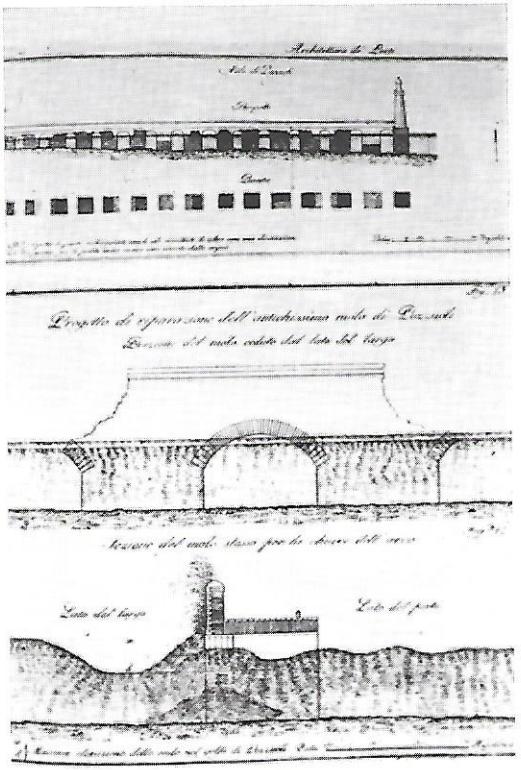
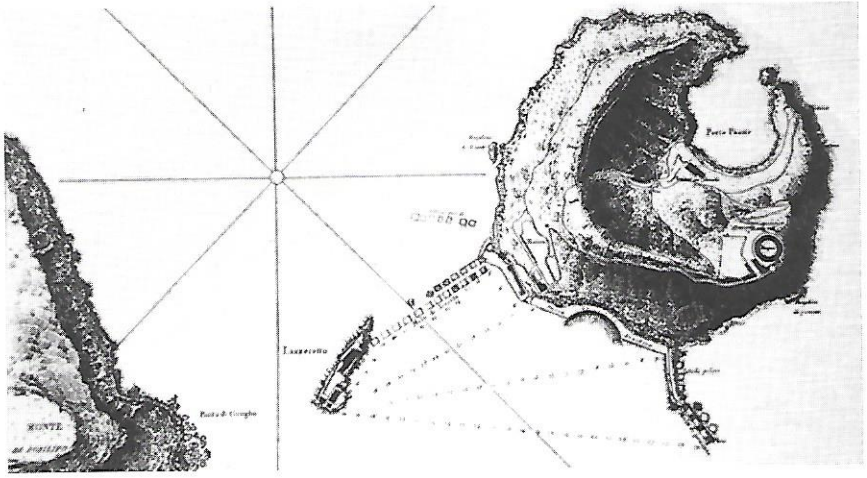


Figure 14. The Puteoli's mole in an 18th century survey.

Harbour structures at Nisida Island

Some other similar structures were built on the north-eastern side of the island of Nisida (Fig. 15). Few have survived, but many others, documented by maps of the Bourbon period, have been covered by modern jetties. Remains of some ancient harbour installations were hitherto unknown, but recent underwater archaeological research has revealed three *pilae* still in place. One of these is perfectly preserved: it is a 'tower' 9.5 m high, the top of which is 180 cm below sea level. It was built in *opus caementicium* with tuff fragments which, on the sides of the *pila*, seem to form a sort of *opus reticulatum*. In some sections, there are holes left by the wooden posts and beams of the double-walled moulds.

Figure 15. Nisida island: a pier jetty in a 19th century plan.



[7] Felici, E. (1993). op. cit.
[8] Lugli, G. (1928). Circeii, Forma Italiae. Regio, *I:2. L. Olschki, Rome.*
[9] Felici, E. (1993). op. cit.
[10] Lugli, G. (1926). Anxur-Terracina, Forma Italiae. Regio, *I:1. L. Olschki, Rome.*
[11] Castagnoli, F. (1977). Topografia dei Campi Flegrei. pp. 41–79, in: I campi Flegrei nell'archeologia e nella storia, *Atti dei Convegni [Conference Proceedings] Lincei 33, Roma (1976).*
[12] Gianfrotta, P. A. (1996). Harbor Structures of the Augustan Age in Italy. pp. 65–76, in: Atti del Convegno[Conference Proceedings] Caesarea Maritima, a Retrospective after Two Millennia, *(Caesarea Maritima, 1995). E. J. Brill, Leiden, New York, Cologne.*

- *Ostrow, S. E. (1979). The topography of Puteoli and Baia on the eight glass flasks.* Puteoli, *III:77–137.*
- *Di Fraia, G., Lombardo, N. and Scognamiglio, E. (1985–1986). Contributi alla topografia di Baia sommersa.* Puteoli, *IX-X:211–99.*
- *Di Fraia, G. (1993). Baia sommersa. Nuove evidenze topografiche e monumentali.* Archeologia subacquea, *Studi, ricerche e documenti, I:21–48. Istituto Poligrafico dello Stato.*
- *Dubois, C. (1907).* Pouzzoles antiques. *Bibliothèque des Écoles Françaises de Rome et d'Athènes, 98.*

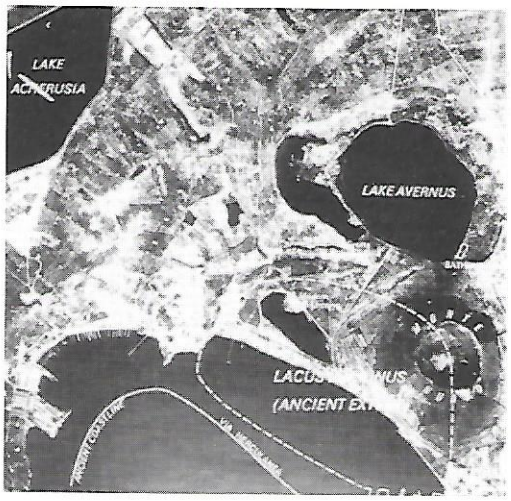


Figure 16. An aerial view of Phlegraean Fields, showing the location of the ancient coastline. Portus Julius occupied the two ancient lakes of Lucrino and Averno.

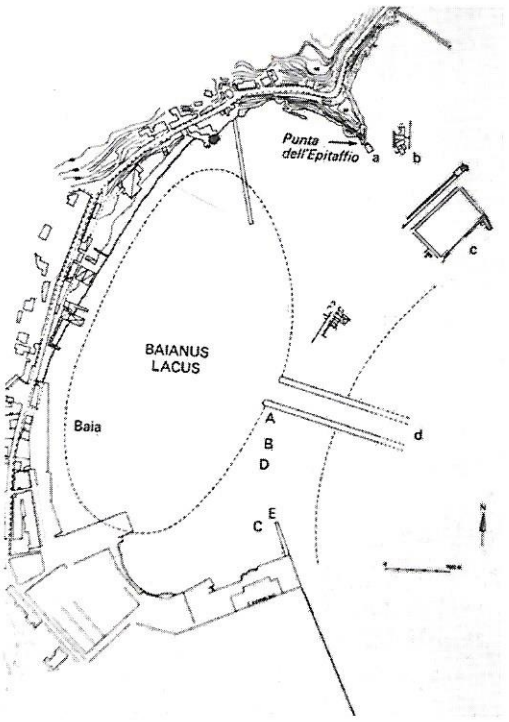


Figure 17. Baia, plan of the submerged evidence and the ancient coastline.

Figure 18. Baia, fragment of an Egyptian 'stele' from the sea.

Harbour structures at Misenum

The same type of construction is found in the breakwaters that protected the two entrances to the harbour of Misenum. On the Punta Terone side, the underwater structures[13] consist of a row of eight *pilae*, most of them still standing. A long breakwater runs alongside them, but today it is hidden by blocks of a modern breakwater. The *pilae* are parallelepipeds; some of them have holes left by the vertical and horizontal beams of the scaffolding. The curvilinear concrete head of the breakwater remains, in which some mooring stones are visible; four can be distinguished, all cut in the middle, with the cut part having been found on the seabed.

The Portus Julius

It was a great military harbour, built in 37 BC by Agrippa in the Lucrino and Averno lakes (Fig. 16).

The submerged town of Baia

This residential settlement is for the most part submerged to depths of 6 to 19 m as a result of bradyseism. In spite of the Archaeology Office's efforts, the ruins have been damaged by the modern activity of vessels loading pozzolana: the keels of loaded ships have, for a long time, abraded the submerged remains. The hulks of some modern ships have been abandoned on top of them. The villas of the Republican and Imperial eras, which have yielded important historical data and sculptures, continue to reveal buildings and objects of archaeological interest (Fig. 17, 18).[14] Among these, also, evidence of the relationship between the Phlegraean coast (particularly the harbour of Puteoli) and Egypt, and perhaps with the harbour of Alexandria, has been found.

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[13] Gianfrotta, P. A. (1993). Puteoli sommersa. pp. 115–24, in: Puteoli. *Banca Sannitica, Napoli.*
[14] Gianfrotta, P. A. (1983). L'indagine archeologica e lo scavo. pp. 25–39, in: AA.VV. [various authors], Baia. Il ninfeo imperiale sommerso di Punta Epitaffio. *Napoli.*
• *Scognamiglio, E. (1997). Aggiornamenti per la topografia di Baia sommersa.* Archeologia subacquea, *Studi, ricerche e documenti, II:35–45.*
• *Schmiedt, G. (1972).* Il livello antico del Mar Tirreno. *Firenze.*