VADA VOLATERRANA: A COMPARISON OF ROMAN HARBORS AND THEIR PLACE WITHIN MEDITERRANEAN CONNECTIVITY

by

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This thesis focuses on the site of Vada Volaterrana in modern day Tuscany in the context of its Mediterranean connectivity. In this study, Mediterranean connectivity in the ancient Roman world addresses how harbor sites interacted with their hinterlands and other coastal sites. To analyze Vada Volaterrana's place within the Roman world I compare it to other harbor sites, large and small, through a diachronic approach that addresses technological advancements and economic prosperity. Though it is a smaller harbor complex, larger sites are used for comparison to juxtapose the differences between urban and rural settlements and their roles within the Roman world. It also highlights the discrepancy between our knowledge of small and large port systems.

Vada Volaterrana is an example of a small harbor complex that served the needs of its hinterlands. I propose that Vada is an example of the norm in the ancient Roman world. Harbors were small to moderate in size and accommodated similarly sized vessels. Despite this, Vada Volaterrana shares technological and economic trends with other Roman sites which reflects the idea that harbors were centers of culture and trade. By sharing this study, I hope to inspire an interest in Mediterranean connectivity leading to studies regarding the functionality of smaller Roman harbor sites.

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Chapter One: Introduction

It is the purpose of this study to examine the harbor site of Vada Volaterrana within the context of Mediterranean connectivity to analyze its various components through diachronic comparisons of architecture and technology, economy, and the social aspects of Roman life in port and harbor structures. Roman port and harbor archaeology has evolved from studies focused on technology towards those concerned with the underlying features and functions of such sites and their interactions with one another. However, the majority of discussions still tend towards larger ports, such as Portus in Italy or Caesarea Maritima in Israel, due to historical evidence and project funding. This has resulted in smaller harbor structures gaining attention much later and being researched with less funding.

The site of San Gaetano di Vada is home to a smaller harbor facility, Vada Volaterrana. The Roman site was built during the Republican era; however, human occupation dates from the late Bronze Age (Pasquinucci et al. 2012:149). The *Itinerarium Maritimum* listed the harbor 25 miles from Populonia and 18 from Portus Pisanus, and its ruins lie just outside of the modern city of Vada. Currently the University of Pisa in conjunction with the ArcheoData Cooperativà conducts a field school on the outlying harbor neighborhood, but archaeological work has been conducted on the site since 1982 with support from the city of Rosignano Solvay Marittimo, the Ministero dell'Istruzione Universtà e Ricerca Scientifica, local banks, and local firms and collaboration with DipTeRis, CNR-ISTI, and CEREGE (Pasquinucci et. al 2002:93). They labeled their project, and consider all continuing research done by the University's Lab of Ancient Topography, a "total archaeology project" with special attention to "climactic changes and impacts" that extended beyond Vada into the territory of northwest Etruria, including the areas surrounding Pisa and Volterra (Pasquinucci et. al 2012:149). The project utilized diagnostic

technologies, including geomorphology, palaeogeography, surveying with remote sensing and geophysical and physical methods. This thesis discusses unpublished details from the 2015 field school season and uses a theoretical approach to add to the information we have about Vada. By looking at Vada as a node of connectivity we can compare it to other Roman nodes. This is a new approach for Vada Volaterrana that allows us to infer about its undiscovered harbor structures and economic importance.

At Vada excavations uncovered two thermal complexes, a *horrea* (warehouse), a *macellum* (market), a fountain, a *collegium* (seat of the guild), and what is currently interpreted as a temple (Comune di Rosignano Marittimo 2015; Genovesi and Bulzomì 2013:1). Such buildings are commonplace in ports and harbors with the size of the facilities dependent on the population in antiquity. Obviously, Vada is much smaller than the best known Roman ports and harbors; however, such grandiose sites should be considered anomalies. The shores of the Roman period were dotted with smaller landings such as Vada for several reasons, including efficiency and cost. The important aspect of so many similar, smaller sites is their contribution to Mediterranean connectivity. The idea of connectivity originated in graph theory and network analysis as a way to showcase the relationship between places in terms of cost and time rather than distance (Cioffi 2015:2-3). Such connectivity within the Roman Empire began with roads and then extended to fluvial routes before moving to the sea, where it was faster and less costly to move goods and ideas. The utilization of the Mediterranean Sea had allowed culture to spread for hundreds of years, and the Romans exploited sea transport to their advantage in spreading their economic and political dominion.

Connectivity allowed the Roman Republic to move its armies, and it allowed the Empire to move its agents and merchants, necessitating the construction of Roman sites, including

harbors, throughout the Mediterranean basin. Currently, the theory of Roman connectivity allows researchers to look at sites like Portus not only for their architecture, but also for their role in expediting Roman ideas and economy. As such, these sites should be considered part of clusters or groups that move goods. As stated, it is the purpose of this study to examine the harbor site of Vada Volaterrana within the context of Mediterranean connectivity in order to analyze its various aspects. The comparison of such features is fundamental to the recent change of harbor and port archaeology as opposed to the earlier focus of such sites as independent features of technology, which has hindered the fuller understanding of how port and harbor complexes functioned in groups, or nodes, of connectivity that moved goods throughout the Roman period.

Regarding ports and harbor structures in terms of connectivity reveals their importance as groupings. This idea is reinforced by ancient lists, such as the Antonine Itinerary, which detail locations of harbors and the distance between them. Connectivity has often been important to Mediterranean history; however, it is not always reflected in publicly accessible reports or journals. For this reason Vada Volaterrana must be compared with larger sites. Though several proponents suggest that connectivity be considered first and foremost in such studies, few attempts have been made to look at wider ranges of sites until very recently.

The earliest attempt to identify connectivity in the Mediterranean was Lehmann-Hartleben's list of its ancient harbors from 1923, which relied on literary sources which were mainly traveler's reports. In contrast, David Blackman's 1982 survey looked beyond structural remains, instead aspiring to reveal social and economic aspects, including administration, religion, and the projection of power, in order to understand the connectedness of the Greco-Roman world (Rickman 2008:6). G.E. Rickman repeatedly brings these aspects up in his works on Roman harbors, insisting throughout thirty years of writing that harbors should be studied in

relation to the purposes which they served and as part of networks to fulfill a specific function in the Roman world. He considers it crucial to study port placement in relation to geography, population, manufacture, or political need, as the information adds to our understanding and leads to further research questions (Rickman 1988:257).

In an earlier work Rickman noted that the location and functions of ports were dictated by geographical factors such as currents, winds, and the physical makeup of coasts. The Tuscan coast, for example, possessed extensive rivers and lagoons. The latter worked in Vada Volaterrana's favor; it was positioned between the Fine and Cecina river basins and used both to access its hinterlands. Lagoons offered a similar benefit, and several Roman ports were situated behind them. In the case of Cosa, the population utilized its position upon a lagoon to build a fishery and maximize its exports; however, the site eventually silted up and degenerated into marshland (McCann 1985:156). The various methods harbors used to access their hinterlands, including by roads and rivers, is a shared aspect best shown through Ostia's relationship with the Tiber before the construction of Portus. Another shared aspect is the lack of evidence for the daily workings of ports and harbors excluding Ostia and Puteoli.

Unfortunately, for twenty years after important questions were posed research remained refocused on harbors and ports as isolated, individual locations until 2011 when Katia Schörle presented studies that were aimed at specific regions and their political, social, and economic life as a group. She insists that hubs are dependent on their hinterlands which are comprised of their inland routes, foreland oceanic traffic, and the ports to which they are connected (Schörle 2011:93). It is then possible to view archaeological finds from ports and harbors in order to trace a diachronic story of an individual port with its "peers." This representation also reemphasizes

the importance of smaller harbor facilities within the Roman period, and because of Schörle's work in Italy we have examples of smaller ports with which to compare Vada Volaterrana.

Any archaeological or historical study of the ancient world requires primary sources, especially to detail how ports and harbors were constructed and how they functioned in their specific regions. Most ancient sources only give passing mention, in stories of travelers, to a port's role in a war or to important cargoes like grain fleets. Vada Volaterrana is referenced twice by the *Itinerarium Maritimum* and once by the geographer Strabo in his *Geography*, where its little harbor and the town's tuna watch are noted (Jones 1932:V.2.113). The poet Rutilius Namatianus gives more description to the area on his visit to his friend Albinus' villa and the nearby salt pans. He stated that the town was in a region of Volterra called "the shallows," apparently so named because it went through part of a treacherous channel, each side of which was marked by narrow pairs of trees affixed with laurels as boundaries for the shifting bank of seaweed below (Duff and Duff 1935:I.94-.98).

It is necessary to remember that most ancient historians were not engineers; they recorded their observations in a descriptive manner that other readers would understand. In fact, some of the most famous ancient sources give very limited information. Dionysius Halicarnassus' *Roman Antiquities* discusses the Tiber and transportation upon it, while Cassius Dio in *Roman History* and Suteonius in *The Twelve Caesars* both mention the Claudian harbor briefly. In *Antiquities of the Jews* Josephus describes in greater detail how Herod's harbor at Caesarea Maritima was created, and his description later aided archaeological projects at the submerged site. The most cited and detailed description comes from Vitruvius' *On Architecture* written during Augustus' principate (27 BC-AD 14) to aid engineers in the emperor's building program. Vitruvius insists that natural sites are preferable but notes that with hydraulic concrete

artificial ports can be constructed. The concrete construction he describes was used by Herod in Caesarea Maritima, but hydraulic concrete was used previously in the Bay of Naples where volcanic pozzolana, its key ingredient, originated. Besides Puteoli, the smaller site of Cosa may be the earliest usage of this technology.

Numerous archaeological and historical studies on Roman port and harbor sites have greatly assisted the research for this paper, but as mentioned, the majority of them focus on the grandeur of larger structures. One such work that is crucial to the study of Roman ports is Russell Meiggs' *Ostia* (1973). Though dated, it is still an authoritative book on various aspects of port and city life, including examination of warehouse facilities and *collegia* activities, which will be compared later in this work to the evidence at Vada Volaterrana. Meiggs used available archaeological work that had been compiled before his publication, and this study will also present findings from various projects throughout the Mediterranean, including the ongoing work at Vada Volaterrana's field school. Robert Hohlfelder and J.P. Oleson's work in Portus, which is still ongoing at the time of writing, is also important as is their work in Baiae and Puteoli. They have done studies throughout the Mediterranean with the ROMACONS (the Roman Maritime Concrete Study) project to examine the composition and use of hydraulic concrete in the Roman world. Marguerite Ann McCann's publications on her work in Cosa gives a very important insight into a smaller installation not too far from Vada Volterrana. This installation is considered one of the earliest Roman harbors found to date, and it is notable for serving a small community and using hydraulic concrete, fresh water springs, and a fish farm. It is perhaps most famous for the Sestii family's wine trade.

Of the best documented sites, Caesarea Maritima is only rivalled in studies by Portus. Documented archaeological interest in the site began in 1959 and then continued the next year

with the Sea Diver II research vessel. This project took aerial photos and diver surveys to develop a basic plan of the submerged remains. This success inspired several other projects by the Israel Underwater Exploration Society (IUES), namely, the Caesarea Ancient Harbor Excavation Project (CAHEP) and the Combined Caesarea Explorations (CCE). The most famous research was undertaken by Avner Raban of the Center for Maritime Studies (CMS) from the University of Haifa from the late 1970's to the early 1990's. He began with underwater surveys and then eventually collaborated with Hohfelder to create CAHEP which worked to create exhibitions for the Smithsonian and to extend research beyond the known limits of the Herodian inner harbor (Friedman 2002). As previously mentioned, several larger projects and sites will be used on a comparative basis in this study because they are the most accessible. Smaller projects limited in scope or else still ongoing will be compared with data from Vada Volterrana as well. The resources for Vada Volaterrana come from the University of Pisa's Laboratory of Topography as well as the ArcheoData Societa Cooperativà. The former includes work done in the area around Pisa and Volterra as well as along the coast for a better understanding of the region. The latter includes my own experience working at Vada Volterrana's field school in its 2015 season along with data from previous seasons.

Research similar to this study has been relatively recent but reassuring in bringing such projects to academic attention. The most inclusive to date is Katia Schörle's work on harbors ranging between Cosa and Puteoli which considers the similarities between ports and harbors and emphasizes the size of ships based on docking facilities and warehouse space. She notes that if harbor's space is representative of its economic role then it should be reflected in the size of its facilities, especially if it is an artificial structure. Her work was limited to enclosed coastal spaces, which meant that river ports could not be included though they were crucial in the

Republican period and only dropped to secondary importance during the Imperial period. She notes that wharf length would be perfect for direct measurements, but the ravages of time and modern building projects usually make this measurement impossible. Instead, *TakeOff Live* software was utilized to compute the area of irregular polygons digitized from a plan with a known scale, meaning only ports with published plans and scales could be used (Schörle 2011:95-96). The purpose of her project was to inspire more work in cataloguing harbor installations in order to compare their sizes and, therefore, their economies. In 2012 Schörle and Victoria Leitch published the work they had done on a Lepcis Magna Costal Survey. More than other Mediterranean locations, North Africa's harbors have received little attention. David Stone, in his article on Africa's port structures in the Roman Empire, states that this neglect occurs in part because classical authors between 50 BC and AD 80 insisted the area was harbor-less and modern scholars were reluctant to attribute sophistication or wealth to the inhabitants of North Africa, as well as their predilection for larger site studies (2014:567).

Schörle's project received permission from the Department of Antiquities of Libya within the framework of costal surveys done in the 1990's by the University Roma Tre and the Istituto Superiore per la Conservazione ed il Restauro (ISCR) (Schörle and Leitch 2012:149). These studies were designed to investigate the costal landscape within 20km of Lepcis Magna, beginning from the Villa of Odeon and going towards Funduk al-Alus in order to understand the costal hinterland's use of its surrounding territorial and marine resources in reference to connectivity within Libya and throughout the Mediterranean. It found that the coast had a high population, including Roman period elite residences interspersed with rural sites and areas of production which included olive oil, wine, and fish salting. They had five years for their work, but unfortunately the 2011 revolution in Libya halted their activities (Schörle and Leitch

2012:149). The goal was to focus on the data needed to reconstruct the ancient shoreline, on exploitation of territorial and marine resources, and on evaluating the current state of preservation. Survey methodology depended on the landscape, time, and manpower, more often than not they employed rapid reconnaissance with more detailed recording of obvious and important sites including villas, farms, and the nature of the surrounding landscape. Plans were sketched, and photographic records were taken, though no gridded collections could be constructed. Pottery was collected for dating purposes as well for the representation of the range of sites. Unfortunately, much of the coastline was bulldozed for resorts, hotels, or modern villas, but the final results concluded that the coastal economy was busy and mixed with differing settlements (Schörle and Leitch 2012:150-151). The building of the modern over the ancient is an issue throughout the Mediterranean, including at Vada Volaterrana. This is why Schörle's attempt to analyze the size of ports by their economic facilities is indispensable to this study and will be addressed in the discussion of warehouses throughout the Roman world. Both Schörle and Stone hope for research to be extended to northern Africa and smaller harbors to highlight their roles within their regional context before comparing them and their impact to the rest of the Mediterranean. One way to aid this endeavor is to bring light to smaller establishments that have been studied but have yet to have that research brought to wider recognition. This study has two purposes: to bring the harbor site of Vada Volaterrana into this scholarly discussion in order to inspire similar work throughout the Mediterranean and to discuss its place within the context of Mediterranean connectivity.

Chapter Two: Timeline of Use

Studies on Roman harbor archaeology generally begin in the third century B.C. because the first Punic War (246-241 B.C.), which encouraged the Romans to fight on the sea, necessitated their having landing places around the Italian peninsula and eventually around the remainder of the Mediterranean basin. The end date varies dependent upon harbor or author; for Vada Volaterrana there is evidence of use until the seventh century A.D., though for others the end date is earlier. Of course these dates are for Roman use, but harbors were obviously used previously in Italy and elsewhere, with specific evidence for landings in the Bronze Age created by the Egyptians and the Mesopotamians who used them for fluvial transport, like those along the Nile, and for coastal travel. One of the earliest known harbor-works today is Yavene-Yam, a middle Bronze Age site on the coast of Israel dating to 2750-2480 B.C. (Morhange et al. 2015:246-247). Unfortunately, we lack abundant information for these early periods, and instead present knowledge has been enriched by works created between the eighth and the fifth centuries B.C. before larger facilities came into existence in the Hellenistic and Roman periods. For the purposes of this study, the dates above encompass a shared timeline between the chosen, Roman sites throughout the Mediterranean. Some were built, prospered, and fell to disuse before others began construction, while some smaller examples outlasted the more grandiose. The discussion of each harbor's place within an overarching timeline as its own chapter gives a basis of knowledge for future chapters, including differences between these sites as well as their shared attributes.

Travel on the Mediterranean Sea, though often facilitated by war, was actually more conducive to trade. Travel by sea proved to be faster and safer than roads, which needed maintenance and were prone to bandit attacks. Surprisingly, transporting goods by road was

more expensive than by boat. According to comparisons with Diocletian's Edict on Maximum Prices (A.D. 301), and depending on the time of year, prices could have been between five and 52 times more expensive to transport a wagon of goods by road than by sea (Cioffi 2015:4). The Mediterranean's size also enabled growth in cargoes and, therefore, in the size of ships on which they were carried. Phoenician harbors during the Iron Age used double ashlar walls with rubble fill in sites ranging from the Levant to later western Punic colonies. The Greeks continued this practice, joining their blocks without mortar and creating ports on important sea routes throughout the Aegean as well as to the Levant, and even towards the west along the route to Sicily and Italy. During the Hellenistic period they may have used wooden piers. The Etruscans, until 400 B.C. utilized river mouths, lagoons, or beaches. For example, those headed for Pisa anchored in natural lagoons that would lead them along rivers into the interior. Eventually they adapted rubble mound breakwaters at Pyrgi and Graviscae to provide extra protection for natural bays (Oleson and Hohlfelder 2011:811).

What is the same in each harbor are its geographical components: the hinterland and the foreland. The former is connected to the harbor by inland communications where the demand of goods originates. This area also provides exports to be shipped out. Yehuda Karmon gives three groupings into which hinterlands can be placed: continental or semicontinental, regional, and local. The first group uses gaps or passages between mountain barriers to reach inland plateaus or mountain valleys, for example the Po delta. Regional groups lie within peninsulas or on large islands along the northern section of the Mediterranean. Local groups are small areas between ports that may take a day's travel for small sailing boats. The foreland is the coastal width of the sea, including ports in a narrow sense and the routes that lead between them. Usually there is a correlation between types of ports and the vessels that land at them. For local traffic, the

hinterland is visited by those engaging in local trade; usually small boats with a shallow draft and oars enter and leave ports which meant they needed to dock nightly. For long distance trade, the boats had to be of a greater size since they needed to carry cargo and provisions as well as provide sleeping areas (Karmon 1985:1-6).

During the sixth century B.C., Roman ships were confined by a series of treaties enabled by Carthage's thalossacracy. Confinement to the waters surrounding the Italian peninsula meant that many harbors could not be considered ports in the true sense because they lacked extensive facilities. Boats engaged in cabotage needed harbors of refuge in order to dock every 40 to 50km (Rickman 1988:260). These sites were chosen for strategic reasons by both land and sea. Travelling in such a manner was the norm for merchants, officials, or soldiers, despite the bias of ancient literary sources prioritizing private travel. Such travel was for the wealthy or those on pilgrimages (Blackman 1982:188). Between 200 B.C. and A.D. 200 there was a period of intense traffic unrivaled until a thousand years later. Still, trade was more important in the early Republican period than formerly believed. For example, in 313 B.C., the Pontine islands were occupied, and two years later offices such as the *duumviri navales* ("to repair and equip a fleet") and the *quaestores classici* ("quaestors of the fleet") were stationed in coastal towns like Ostia. The military role became apparent with *navalia*, that is, sets of docks and ship sheds for warships, located on the Campus Martius (Rickman 2008:7). Furthermore, many of the ships created during the Punic war were kept in reserve at Rome. These vessels were created shell-first with double planking and with their edges joined with mortise and tenon joints.

Eventually the Romans put frames and half-frames to keels to make rounder hulls and flatter bottoms to stabilize the increase of cargo with less draft. Such ships allowed cargoes of 70 tons (or less) up to 300 and 400 tons, which were rare in comparison to the former construction

methods (Oleson and Hohlfelder 2011:820). Ports and harbors had to accommodate the increase of trade. The most convenient way to do so was to build artificial landings, which was made possible with hydraulic concrete. Made from pozzolana, sand-like volcanic ash from the area of Puteoli (present day Pozzuoli in the bay of Naples), this innovation allowed mortar to set underwater. It is of no surprise, therefore, that this area hosts one of the earliest harbor structures built with the material. It allowed concrete piers or breakwaters to be built on submerged rubble foundations placed on top of the sandy seabed (Blackman 1982:185). This construction, though seen in sites such as Cosa and the Bay of Naples as early as the second century B.C., was more common of the late Republic and early Empire. Most harbors were on the seacoast near the mouths of rivers that extended inland and allowed river valleys to be used as major trade routes. Such is the case of Vada Volaterrana and its placement between the Cecina and Fine Rivers. Vitruvius warned not to build in such places due to issues with silt and the forward movement of river mouths. This may have been based on Etruscan port and harbor sites which often used river mouths across coastal lagoons—many of which had turned to marshes due to deforestation and silting (Blackman 1982:186-187). Roman Ostia had been constructed with quays along the sides of the Tiber as it moved inland, allowing ships to unload in Ostia. Because of Ostia's smaller size and silting problems during the Republic, however, bigger ships preferred to use the larger facilities at Puteoli 150 miles to the south.

Rickman questions whether seaborne traffic was empire-wide, as might have been necessitated by taxes, payment for soldiers, and the purchase of food for its people and armies, with the city of Rome at its center, or if seaborne trade was facilitated by dividing the Mediterranean into smaller, regional areas. It is a question that has been asked before in different periods of Roman history. With any subject, however, the truth as uncovered by archaeologists

and historians is not so black and white. In support of the former position Rickman provides evidence that the Roman navy increased its travel over the Mediterranean Sea. After Augustus defeated Antony at Actium remnants of that fleet moved first to southern Gaul, then permanently to bases at Misenum in the Bay of Naples and Ravenna on the Adriatic, which also would have reduced piracy and raiding. He cites the fact that the late Republic and early Empire secured grain supplies by offering special benefits to people who served the *Annona* for a certain length of time. Eventually this practice gave way to *collegia* and *corporationes* managing ports and harbors for the state. However, studies such as this one show that not all seaborne trade was either tied to or directly beneficial to Rome as an all-powerful city.

Rome, among other large cities and ports, developed export points for local commodities. The best examples for Rome were Alexandria and places within North Africa for grain, points in the east like Caesarea Maritima for silks, spices, and papyrus, while Iberia offered metals, fish sauce, and olive oil (Blackman 1982:188). These are common knowledge because of the great extent of resources available on such broadly populated areas. Ultimately we can safely say commercial harbors throughout the empire were essential for any inhabited area, but our present knowledge is swayed by the overwhelming information from grander cities like Rome. It is important to note that larger harbors were separated from their cities and were meant to move people and goods in and out of it. As for the people, foreign traders were allowed only in harbor areas, especially in Ostia and Puteoli. As for goods, at Portus a wall around the back of the quay closed in the warehouses in order to keep tighter control over the movement of men and imports (Blackman 1982:196). Eventually during the Pax Romana (27 B.C.-A.D. 180) the walls of Rome extended to include the harbor to protect it against sieges. Walls were not a luxury for smaller ports and harbors, such as Vada Volaterrana, but maritime villas along the Bay of Naples had

their own small harbors and mooring facilities without walls in order to catch the attention of passing traders. These villas usually dealt in the shipment of wine, oil, and pottery (Rickman 2008:9-10).

Overall, it is difficult to state precisely who had control of ports. There is little evidence of state officials in expected places such as Ostia and Puteoli, so it is assumed that local municipalities gave the positions to the local elite. The emperors did have interest in the commercial dealings of their larger harbors. Claudius created a new basin four kilometers from Ostia known as Portus, Trajan added his own hexagonal basin behind it in addition to making repairs at several other harbors throughout the Italian peninsula, and Severus helped his home harbor at Lepcis Magna among others (Cassius Dio 1927:LXVIII.7). However, this interest thus benefited the harbor and garnered support for the emperors and earned them the title of benefactor. The state only intervened in emergencies and the central control of the harbors apparently fell under provincial governors with public and private holdings in the hands of *collegia*.

The weakening of the western Roman Empire in the fifth and sixth centuries A.D. resulted in a reduced population. This population, handicapped by inflated money and the draining of their wealth and people to the eastern half of the Empire, could not afford large shipments of grain, oil, and wine (Rickman 2008:16). Trade from around the Empire fell away, with North African wares being the largest imports in localized circulation, a trend which can be seen at Vada Volaterrana. The lack of large shipments and decline of wealth meant that harbors and ports were no longer maintained. Dredging to combat silt had been undertaken for years at places such as Marseilles and Naples. Work on the former continued between the third century B.C. and the first century A.D. as shown by archaeological finds of three dredging boats (first

and second centuries A.D.). Investigations into Naples' Piazza del Muncipio found the absence of pre-fourth century B.C. layers, and grooves 165-180 cm wide and 30-50 cm deep meant that the inhabitants worked on the site between the fourth and second centuries B.C. and continued into the late Empire. Eventually the abandonment of these sites and the use of smaller vessels for smaller cargoes meant human waste products, sand, and silt plugged basins to the point of near inaccessibility.

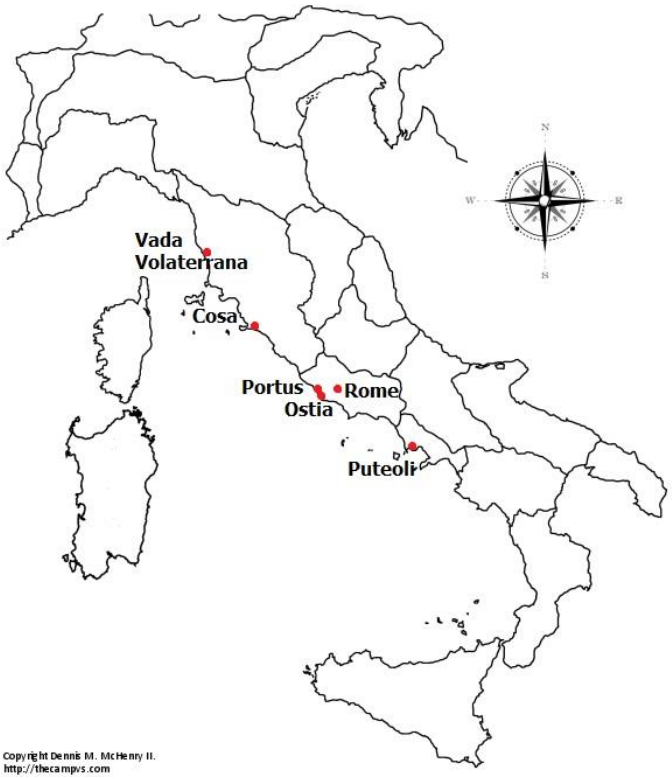


Figure 1. Harbor sites in the Italian Peninsula (Courtesy of the Campvs Website http://thecampvs.com/wp-content/uploads/2009/11/Regions-of-Ancient-Italy.png).

The Italian Peninsula

Ostia and Portus

As rivers often are to cities, the Tiber was an essential part of ancient Rome. It rises in the Apennine mountains and exits into the Tyrrhenian Sea. Dionysius of Halicarnassus claimed that its mouth was not blocked by sandbanks, and thus its lower end was easily navigable. Oared

ships and merchantmen up to a capacity of 3,000 bushels could travel along it, though larger vessels needed to be unloaded at the river mouth (III.44.1-3). According to Eutropius, Ancus Martius, the fourth king of Rome, founded Ostia (I.V). Later sources projected ideas back upon Rome's regal period; for example, desire for wealth or for control of salt sources are often projected back, but such ambitions are unattested in that early period (Meiggs 1973:16-17). In fact, archaeological evidence supports wider contacts and greater wealth in the seventh and sixth centuries B.C. The town of Ostia developed around a rectangular fort known as the *Castrum* in the fourth century B.C. The stone and pottery studied in the area dates no earlier than that period. Before the construction of large harbors there was an open roadstead at the mouth of the Tiber, and as time passed quays and warehouses would be built up along the banks. To navigate the shallow water lighters known as *lenunculi auxiliarii* or small barges delivered goods to the docks or directly to the warehouses (Casson 1965:32). While war may have made sea routes a necessity, interest was most certainly stoked by economic purposes. Grain was shipped to Rome through various means, but over sea would prove to be the most cost effective. In 508 B.C. after the expulsion of the kings, grain came from the Volscians and Cumae. In 492 B.C. the city experienced a famine, and grain began to be funneled from additional areas along the Etruscan coast and Sicily, which most likely resulted from Rome's treaty with Carthage. Presumably this grain went straight to Rome on the Tiber, which would provide a good reason for Ostia's original settlement (Meiggs 1973:18-19).

In the fourth century B.C. there was unrest within the Italian peninsula. Tensions between the Romans and the dwindling power of the Etruscans led the latter to attempt raids on Latium by land and sea. Additionally, Gauls were attacking by land, and Greek fleets were sailing along the coasts between Antium and the Tiber. Caere, which had possessed strong fleets, declined in

this period but still launched their own attacks on Roman territory. The Romans had no one to trust and so implemented maritime colonies in the form of forts such as Antium (338 B.C.), Terracina (329 B.C.), Minturnae, and Sinuessa (296 B.C.). A precise founding date for Ostia is hard to place, but the materials of its early walls do not date before the conquest of Veii in the early fourth century B.C. Red-figure Attic pottery made between 400 and 340 B.C. supports this suggestion (Meiggs 1973:21). Meiggs places the original settlement to around 350 B.C., some 225m from the river. The castrum was five and a half acres, the walls were made of tufa, and it housed perhaps 300 colonists. The materials of the wall and the datable pottery place its founding at the same time as a treaty with Carthage (348 B.C.), which kept Rome out of Iberia and Africa but allowed the Carthaginians to keep their influence in Sicily (1973:22).

Lack of control in Sicily would prove to be a problem for the early Republic which drew on the resources of the fertile island as well as from the Tuscan coast. Throughout the fourth century B.C. Rome conquered more enemy territory throughout the Italian peninsula. Once threats in the mainland had been eliminated Rome was able to turn its attention to Carthage. Recently implemented quaestors began to collect money and ships from those now dependent and allied with Rome. For now, new additions would be to the navy until it could establish control and eventually repurposes the vessels for trade. The fight for Sicily in the First Punic War (264-241 B.C.) necessitated a force on the sea, but the place where it was built remains unknown, though it is natural to assume that Ostia would have been a landing spot for Rome's fleets. Ultimately peace was made, and the Romans retained a portion of Sicily, Sardinia, and Corsica in the aftermath. From that point a detachment of ships was stationed at Ostia. These vessels would not see much action during the Second Punic War (218-201 B.C.) in which the majority of battles were fought on land. According to Livy, in 217 B.C. transports carried

supplies to Iberia but were captured near Cosa by the Carthaginians and then pursued by the ships docked at Ostia. In 215 B.C. envoys from Philip of Macedon to Hannibal were successfully intercepted, prompting the Ostian fleet to Tarentum in order to carry an army across the Adriatic if needed. Finally, in 207 B.C. when Hasdrubal entered Italy the maritime forts dotting the coasts were forced to supply men. Usually these forts were exempt; however, only Ostia and Antium were needed for crews and maintenance services and to get supplies to and from the nearest cities. The end of the second Punic war resulted in Roman victory and their dominance over the western half of the Mediterranean Sea. Meiggs believes that Carthage's defeat meant the decline of Rome's naval power since they would begin to rely heavily on allied ships in the eastern Mediterranean. Later, Augustus would organize standing fleets for waterways and safeguarding trade, making Misenum the head of the western fleet, but the sea, once claimed, was traveled by merchant vessels more than those for war (Meiggs 1973:24-27).

Ostia quickly became a commercial harbor, growing in conjunction with Rome's own surging population due to migration and slavery. Grain came from Sicily, Sardinia, and later from Africa. To the south Puteoli in the bay of Naples was the port of choice for goods from the east because of its larger harbor and Greek ties. Ostia accepted trade from the west, much of which was limited to grain and other resources for a burgeoning city. In 174 B.C. *emporia* (warehouses) were built by the Tiber, followed by other buildings with similar design (later built over in the second century A.D.) meant to house grain and other goods for travel upstream. The docks that lined the Tiber were home to workers such as the *porticus extra portam Trigeminam inter lignarios* who handled the timber carried into Rome. There is a good chance that one of Gaius Gracchus' laws (154-121 B.C.) sanctioning distribution of subsidized grain increased in need for grain and sea transportation. Even the duties of the quaestor overseeing fleets at Ostia

had changed to the management of grain. This importance of this new role was exploited during the late Republic while civil war raged between the Sullans and Marians (83-82 B.C.). Marius came from his self-imposed exile in Africa to join his forces and advance to Ostia, which they plundered on their way to Rome. Sulla, learning from this experience, placed his commanders there in order to starve Rome. After his victory Sulla built new walls around Ostia to reduce its vulnerability, which completed its transformation from naval base and maritime fort to self-governed commercial center (Meiggs 1973:28-36).

Ostia's importance carried into Augustus' principate and under his leadership underwent a revival. Though his additions are hard to see under even newer layers, he built at least three temples, one of which was to Bona Dea. There are also the remains of a large cistern before the construction of an aqueduct was finished. Nevertheless, though Ostia continued to play an important role, after the battle of Actium (31 B.C.) the new, longer merchantmen from Alexandria docked to the south at Puteoli. Its harbor and granaries were most likely larger than what Ostia could provide since Ostia's over-crowded river mouth could not accommodate large ships. Likewise, Augustus created the Julian harbor at Baiae in order to train his fleets that would go on to defeat Sextus Pompeius. That is not to say that Ostia's warehouses did not house grain; in 22 B.C. Augustus took over the *cura annonae*, a quaestorship he bestowed upon Tiberius as his first political appointment. Augustus would later make a special department under the *praefectus annonae* in order to meet the continual demand. Enhancements to the city and its port continued under the Julio-Claudians including upgrading to marble. Travertine was used in some columns in the Horrea of Hortensius, which is considered the earliest warehouse and one of the largest built there (Meiggs 1973:43-45).

Major changes occurred under Claudius (A.D. 41-54) culminating in the creation of Portus four kilometers north of Ostia, which would displace the former harbor in favor of the construction of the larger basin. Just in front of this new harbor he sank the ship that had carried a great obelisk from Egypt during Caligula's principate, secured the wreck with piles, and then built atop its remains a lighthouse modeled after the Pharos of Alexandria. He installed curving breakwaters on the right and left of the harbor, and in front of its entrance he placed a mole, thus opening the port to the sea on the northwest. Two channels were cut in order to maintain a connection with the Tiber (Suetonius 1914:20.2-3). Ultimately, this design protected the harbor from the southwest wind, which was a nuisance to the river mouth. Connecting Rome to the new port by road was the *Via Portuensis*, most likely built by Claudius, which was 24km long. Nero focused more on the area around the Bay of Naples, Baiae in particular, but he did link the southern outliers of Campania to port facilities on the Tiber with canals and waterways. He also inundated Portus, giving it the title of Portus Augusti. In A.D. 103 Trajan (A.D. 98-117) added an inner, hexagonal basin for Claudius' harbor, and created additional harbors at Terracina to the south and Citavecchia north of the Tiber (Rickman 1988:259). This basin was 39 hectares and connected to Claudius' basin, the Tiber, and the sea. Built upon it were numerous *horrea* to store grain and other imported goods waiting for transfer to Rome, some administrative buildings, and new temples. At this point both Ostia and Puteoli faced decline. The new basins allowed mooring for larger ships, though they had to be towed into the harbor with tugboats (Casson 1965:34). Even so, the creation of Portus facilitated a more direct route for the large grain carriers of Egypt to cater to the needs of Rome, eliminating Puteoli as Rome's premiere port and reducing it to local service.

Rome's trade was dependent on Portus, and during the second century A.D. the buildings surrounding Trajan's basin were continually constructed and reconstructed. Both Portus and Ostia were reconstructed with updated techniques through the late second and early third centuries under the Severans, though for Ostia this building was more inclined towards the needs of Rome. Archaeological evidence indicates that Portus continued its commercial activities until well into the fifth century A.D., when, late in the century a wall was built around the important buildings on the Trajanic basin, as well as those closest to the sea, in order to protect them from growing outside forces. This change led to a decrease in trade, compounded by the eventual silting of Claudius' basin. Though there were clashes during the Gothic Wars (A.D. 535-553), most of the structures were subsequently abandoned and built over with churches or used as burial spots. Partial silting of the Tiber where it connects to Portus meant what small traffic existed was once again redirected back to Ostia. When its port facilities had dwindled, Ostia had yet managed to thrive as a city. It had been gifted with reconstruction and renewal under the emperors, and during the time of Constantine I (A.D. 306-337) it had become more of a resort town for the wealthy elite. By the end of the fourth century and into the early fifth century, however, prolific writers such as Augustine and Rutilius Namantianus commented on the city's decline as seen in their travels. Ultimately, the end of the Roman Empire meant Ostia's collapse into decay, though it was not until the ninth century that the last inhabitants, weary of invasion, sacking, and nearby naval battles, departed.

Puteoli

Puteoli, modern Pozzuoli, is located 12km from Naples. Nearby was the ancient harbor of Misenum, base of the ancient Roman fleets which docked in its port, Portus Julius. Like many such sites in Campania, Puteoli was originally a Greek colony. Founded by the Samians in 520

B.C., it was dependent on Cumae and used primarily as a defense against Neapolis (modern Naples). It was conquered by the Samnites in 421 B.C., though ample archaeological finds mostly date to 334 B.C. and later. At this date Rome had captured most of Campania (Comfort 1976). In 215 B.C. the city was able to withstand Hannibal, though it was not until 194 B.C. that it was settled as a *colonia maritima* for Rome (Benefiel 2004:353). Its port was situated near the Via Appia, which made it more appealing than Neapolis in transporting goods to Rome, and it was designated as home for a fire service to preserve the safety of grain storage (Meiggs 1976:56). At the end of the Republic and in the early part of the Empire, Puteoli was the destination for shipping headed for Rome. Its Greek roots and history made Puteoli, for all intents and purposes, an emporium for receiving Alexandrian grain shipments and exporting Campanian goods of glass, mosaic, metals, and marble. The site was eventually given further colonial status, possibly by Sulla and Augustus, but certainly by Nero and Vespasian, the latter of whom gave further land grants to the city (Comfort 1976). Puteoli was different from many coloniae in that it was not settled exclusively by veterans with the idea of rewarding them while they safeguarded the area against nearby enemies. In fact, Nero's grants honored the city by giving its harbor imperial status because of its economic importance (Benefiel 2004:351-353).

Puteoli had other famous qualities, but none more important than its volcanic surroundings. *Pulvis puteolanus* or pozzolana, the local volcanic sand, was discovered to have world changing properties. It reacted chemically with water to effectively create concrete. Upon mixing the sand and lime with water it formed a mortar that could bind lumps of aggregate into structures strong enough to bear significant weight. The concrete was used in the cupola of the Pantheon, but more importantly for this research it was used in the creation of artificial port and harbor structures because it could set underwater. Virgil and Pliny both claimed that the

structures in the Bay of Naples were man-made wonders of Italy because of the perceived difficulty of making them. In Portus Iulius, Christopher Brandon, Robert Hohlfelder, and John Oleson working with the ROMACONS project focusing on Roman concrete discovered fragments of the wooden formwork used in pilae off one of the moles in the harbor which dated to around 50 B.C. Baiae, the important resort town located on the bay, has proven to be harder to date though it was an important bathing and villa center from the early first century B.C., and so its structures could very easily have predated the military installations (Brandon et al. 2008:375). Cosa, as we will see, also has concrete structures that are even older.

Baiae was not the only site in the Bay of Naples that appealed to the elite. Much of the area was settled by aristocrats drawn to the wealth of the port and the luxury of the local resort towns. The town had been famous for receiving shipments from the eastern Mediterranean after Delos became a free port in 166 B.C. However, as Claudius' and Trajan's new basins at Portus drew the larger grain fleets away, Puteoli became more dependent on providing goods for its own local populace and exporting to other parts of the Empire in the second century A.D. In this way Puteoli became much like Ostia in that while its harbor facilities dwindled, the importance of its city-center did not. It was a place of extravagance blessed with the attention of emperors and the social and political elite. The people engaged in several recreational and other important activities thanks in part to the city's numerous temples, baths, and amphitheaters. Again, the surrounding areas were very popular for elite villas and vacation homes. The construction of the Via Domitiana linked directly to Rome to provide easier access over land, and made the area even more popular (Comfort 1976). Ultimately, again like Ostia, Puteoli survived by providing for local needs of the wealthy, but declined with the rest of the Roman Empire. Villas were sold or abandoned, and the influence of the emperors dissipated. Eventually the town and its port

were abandoned in the sixth century A.D., leaving the harbor facilities to silt up and become clogged with debris.

Cosa

The remains of Cosa lie at the northern boundary of Tuscany along the present day Maremma. Although it was certainly not the largest Roman colony, its place in history has been defined by multiple seasons of excavation under the American Academy in Rome. In particular, Frank Edward Brown, John D. Lewis, and Marguerite McCann published several articles and a book detailing their techniques and discoveries. McCann worked the site for twenty-two years after Brown's original excavations focused on the city; she employed archaeologists, geologists, engineers, and other specialists to help her understand Cosa's port. Cosa and its surrounding territories had belonged to the Etruscans, and, therefore, shared their Greek connections, but during the first half of the third century B.C. Rome concentrated on conquering its neighbors. In 280 B.C. Roman legions were sent to the northern and southern extremities of Etruria's city-states and tribes. Volsinii and Vulci were defeated by Tiberius Coruncanius, and forced to join Rome and give up a third of their territory, which then gave the Romans control of fertile coastal plains inland where they promptly settled (Brown 1980:1). This tactic eventually enhanced Rome's strength, and enabled the burgeoning power to push outward against the Carthaginians in the Punic Wars. By the mid-second century B.C. Rome became the naval and commercial power of the western Mediterranean by reimagining conquered coastal cities as defensive and commercial colonies.

The official date of Cosa's founding is placed at 273 B.C., and between then and 241 B.C. fortifications and the structure of the town and surrounding areas were established. Earlier activity occurred at the site, as shown by Greco-Italic amphorae sherds dating to the later fourth

and early third centuries B.C., which places the port in use before the founding of the colony. The Roman plan reflects the city's foreign connections by following Etruscan-Italic and Greek traditions (McCann 1987a:25). Still, Roman colonies were very different from the Greek *apoikiai* before them because they retained their connection to Rome. These colonies helped feed Roman interest with their natural resources in terms of land and industry. Many areas in Etruria were utilized for just this reason and were settled with farmers. The land around Cosa was likewise valuable for its fertility and its access to the sea. It possessed alluvial and lagoon deposits good for travel and fishing, had ample streams for watering, and supported vineyards, and it was home to various types of trees. It was also hilly and had promontories on the coast adding to its defensive resources. Cosa was situated on a right angle formed by the Albegna and the coastal strip along a lagoon, with the center of the town laid out on top of a hill which allowed a fortified wall to follow along its natural slopes as well as provide a view of its surroundings, where over one hundred farm sites have been identified (Brown 1980:3-10). Two roads link the hilltop town to the port, which was most likely the source of its wealth.

Located 140km north of Rome, Cosa's high promontory was recognizable for ships going around the Argentario peninsula to the northwest of Cosa and up along the coast into Gaul and onward to Iberia, which necessitated control of this headland for defense and trade. At its founding, and even after, it was one of the only protected anchorage for hundreds of kilometers. This stop was beneficial to sailors because it had a fresh water spring located directly in its port. (During excavations in the 1970's, it gushed out some 1,500 liters per minute.) Travel inland was even encouraged by several natural inlets cutting across sand barriers into Cosa's nearby lagoon which stretched to the Tafone River 20km away. During the Republican period Cosa was a port of importance in the western Mediterranean and this was reflected in its architecture. The port

contained a harbor with concrete piers, a lighthouse, a fishery, amphorae factories, and a spring installation. Cosa is the earliest Roman site that employed hydraulic concrete. To be such a small site with such revolutionary technology means that its owners were probably very wealthy. It is likely that the famous Sestii family, known for their international wine trade, were patrons not only of technology, politics, and commerce, but of the city itself (McCann 1988:102). The Sestii were prominent in the last two centuries of the Roman Republic, controlling trade and exporting products from Cosa in their labeled amphorae and dolia. *Horrea* were built near the northwestern gate of the port. The city remained loyal to Rome throughout the wars that followed, even petitioning for new colonists in 197 B.C. Several wealthy, land-owning individuals called the city home; some of them senatorial or office-holding elite made more wealthy through commerce, for example, in slaves or Greek luxury items. The Social War and civil wars of the first century B.C. forced small farmers and herdsmen from their holdings outside the hilltop town, which allowed the wealthy to claim those holdings as their own. Unfortunately, Cosa's zenith ended between 70 and 60 B.C., and the site was abandoned for 40 years (McCann 1987a:25-27).

There have been several theories as to why the port and city declined so rapidly. One aspect is silting, with sea sand filling the fishing channels and spilling into the lagoon, essentially clogging the city's most prosperous facilities. Silting is a problem that the Romans had combatted before in their ports and harbors; however, if silting rendered Cosan facilities useless, then the site was most likely too costly to save. Thus, the economic aspect that tells us by the end of the Republic there was less of a need for Cosa's port. Rome's own trade focused on imports such as grain and luxury goods directed to Ostia and Puteoli. The nearby Port of Hercules remained free of silt, and so Cosa's local traffic could easily be redirected there. The port of

Cosa was probably used sporadically after that by a small villa that remained in the area (McCann 1988:109). As for the town, it was partially revived under the early emperors. Nero turned its basilica into a roofed theater, and there are finds of coins from Marcus Aurelius and Commodus. It was revived as *Respublica Cosanorum* under Caracalla (A.D. 198-217), and Maximus Thrax (A.D. 235-238) restored some of the buildings around the forum early in his reign. The last datable inscription came from Aurelian's reign (A.D. 270-275). The site was abandoned again by the later third century A.D. Its remains were used as personal agricultural estates, and eventually a Christian church utilized the basilica in the fourth century (McCann 1987a:27). Even with its abrupt end, Cosa is an example of Roman connectivity. It was a successful absorption of local people and land to the Roman way of life as a planned coastal colony and its subsequent transformation into a port of commerce.

Figure 2. Map of Caesarea Maritima (Courtesy of Holy Land Photos http://s3.amazonaws.com/hlp-section-images/288_CaesareaMap01.jpg).

Caesarea Maritima

Caesarea Maritima is often discussed when referring to ancient Roman harbors because of its grandeur and the amount of archaeological research undertaken on the site. Built during the

reign of the first emperor, it seemed to be a symbol of Rome's overarching political and cultural power. Of course, like the other ports referenced in this work, Caesarea Maritima was home to other harbor facilities before Roman reinvention. Before the Hellenistic period the coastal area was given to the Phoenicians by the Persians, and thus a town and harbor were built in Phoenician style and called Straton's Tower. The area was named for its even earlier inhabitants, the kings of Sidon who each had the name Strato (Beebe 1983:195). The Phoenicians were sailors who interacted often with other cultures throughout the Mediterranean basin, as evidenced by the landing of an Egyptian official in 258 B.C. to collect taxes from the harbor. Beginning in 130 B.C. Zoilos, a tyrant, conquered the area and used Straton's Tower as the capital of his own small kingdom. He was able to withstand siege by the Seleucid Empire and by the Hasmonean king Alexander Jamnaeus until 100 B.C. when Ptolemy Lathyrus helped the latter in obtaining it (Raban 1995:11). Roman involvement in the site began when Pompey annexed cities along the coast in 63 B.C. in order to undermine Hasmoneans economic strength (Friedman 2002). In the years following, Rome had many interactions in the eastern Mediterranean against the Parthians in 53 B.C. and then again in 40 B.C. when they backed Antigonus and were able to push to Jerusalem against a surge of Jewish nationalism. The next year Marc Antony was able to retake Syria but in 37 B.C. he was beaten by Parthia as he had been in 41 B.C. Ultimately, this defeat threatened to cut trade from the east.

Octavian took further measures by backing Armenia as a buffer state so that he would not drain Rome's treasury by keeping an army in Cappadocia. After the Battle of Actium, he brought the eastern Mediterranean under Roman influence, with Syria as an Imperial province holding three legions with 18,000 men at Antioch (Beebe 1983:202). With holdings in Antioch it made sense for a port to be built there, and the placement could provide military and economic power

beneficial to King Herod and his ties with the west. Even Strabo claimed that Straton's Tower was just a small coastal settlement with a simple anchorage (Raban 1995:11). Antioch proved hard to defend because it was a day trip up the Orontes River, and at the time great mud deposits made it undesirable. Not much later a demand from Rome for the east to provide money and grain under Augustus' *Cura annonae* after the flood of the Tiber in 23-22 B.C. left surrounding farms abandoned. While Egypt had become Rome's main source of grain, the remainder of the east could provide luxury items and in return receive benefits from the strongest power of the day (Beebe 1983:204-205). The idea of grand harbor facilities was planted in Herod's mind, but he may have been further inspired to action after visiting with Marcus Agrippa at Mytilene as well as his later trip to Rome at the *ludi saeculares* in 17 B.C. Alexandria's port was also certainly an inspiration because of its mix of cultural design. Between 22 and 10 B.C. the port was built, named Caesarea for Latin speakers with Sebastos as its Greek equivalent, both in honor of the emperor. Herod was eager to show his work even as it was in progress. When Agrippa was sent abroad from Rome he visited Syria in 15 B.C., and he noted that the harbor was under construction atop the ruined Hellenistic anchorage (Roller 1998:47). Augustus' patronage went even further: above the main harbor a temple was dedicated to the goddess Roma and the deified emperor after his death. Herod also allowed Jewish and Greek populations to mingle within the city. Essentially, Caesarea Maritima acted as a city-state with a council and magistrate under a royal resident general (Friedman 2002). His enjoyment of the new city and harbor was short lived, however, as Herod died in 4 B.C. and Archelaus, whose own rule would be even shorter, assumed the kingship.

In A.D. 6, Archelaus was deposed, and Judea was annexed to the empire and ruled as a province with Caesarea as its capital. It would remain the base of the provincial governor and his

administrative center until the end of the Byzantine period. In A.D. 66 there were clashes between the gentile majority and the Jewish inhabitants over citizenship rights which sparked the great Jewish revolt. Vespasian and his son Titus used Caesarea as their headquarters and were able to crush the revolt four years later, when it was refounded as a Roman colony (Raban 1995:11). Throughout the second and third centuries it continued to benefit the empire, and later emperors such as Hadrian (A.D. 130), who expanded the aqueducts and was gifted a temple in return, Septimius Severus (A.D. 199 or 201), and perhaps even Severus Alexander (A.D. 231-232). The largest coins in Caesarea date to the middle of the third century and depict Tyche the city goddess followed by a genius holding an anchor. Thus, operations may have still been ongoing during this time and lasted even into the end of the fourth century, according to some Rabbinic entries and other literary sources (Raban 1992:111-112). By A.D. 500 the port was in need of major renovations. Tectonic plate action and coastal surge had battered away at the breakwaters, creating dangerous, submerged reefs which Anastasius (A.D. 492-517) undertook to offset. New walls and a larger urban space served Caesarea well through the sixth century. Unfortunately, Christian and Jewish relationships deteriorated and resulted in the burning of churches. In A.D. 614 the Persian army attacked and had fully taken the area by A.D. 642. From the second half of the seventh century through the ninth the city faced depopulation, degeneration of its buildings, and desecration until the harbor was only a memory of more prosperous times (Friedman 2002).

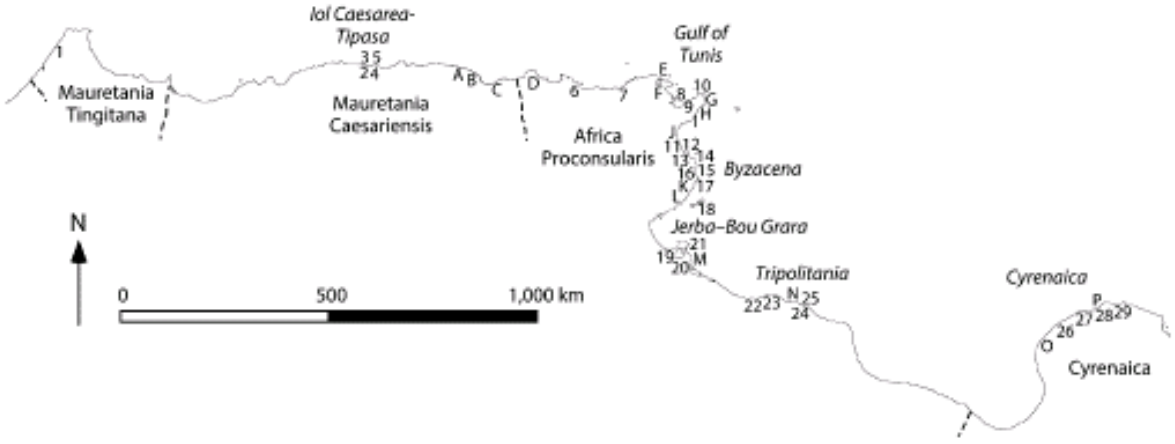


Figure 3. Harbors along the North African Coast (Stone 2014).

North Africa

Roman ports and harbors in North Africa have not been as extensively studied as their counterparts elsewhere. In large part because modern revolutions endangered the lives of archaeological researchers. Work has been done on the site of Lepcis Magna, and there have been attempts to expand that attention along the coast in consideration of important ancient villas by researchers such as Katia Schörle. Phoenician anchorages reach as far back as the twelfth century B.C. Lepcis Magna may have been founded as early as the seventh century B.C., though there is little evidence until the third century B.C. Agriculture and trade picked up in the area beginning in 201 B.C. when new markets developed after the second Punic War. By the Roman period the economic prosperity increased settlement numbers, and the North African coast bloomed with wealthy coastal villas, farms, and pressing sites for wine and oil (Schörle and Leitch 2012:152). Under the emperors, Lepcis Magna was developed as a harbor to support the growing trade between it and Rome. Nero placed it at the end of a wadi (a seasonal river) east of the city proper. Severus later created a circular basin for the harbor with a circumference of 1,200m, and surrounded this area with docks, colonnades, and quays for ships. In the northwest

stood a pier with a lighthouse, and on the eastern arm stood another small tower. The harbor was built with concrete faced by square stone blocks, and it could support larger ships with a quay surface of 800m^2. During Hadrian's reign a dam was built on the wadi from the south, though when it broke in the fourth century A.D., silting eventually diminished the use of the facilities (Beltrame 2012:321-322).

The interesting part of North Africa in terms of Roman ports and harbors is the prosperity of the coastal community. The landscape was mixed with settlements, villas, and production centers. These areas were advantageous because of the fertility of the land and their easy access to transportable centers. There was abundant land for farming, raw ingredients, and fishing as well as manufacturing centers for the amphorae, needed to meet the demand throughout the western Mediterranean. Several researchers have showcased the relationship between Lepcis Magna and other maritime networks. Many of the surrounding villas and farms continued functioning after Lepcis Magna's decline in the third century A.D. An ample amount of North African pottery made its way to the Italian peninsula well into the seventh century A.D., indicating that these installations avoided the decline faced by most of the empire. If there is any decline in these centers it is due to decreased demand after the fifth century A.D. from former prominent partnerships.

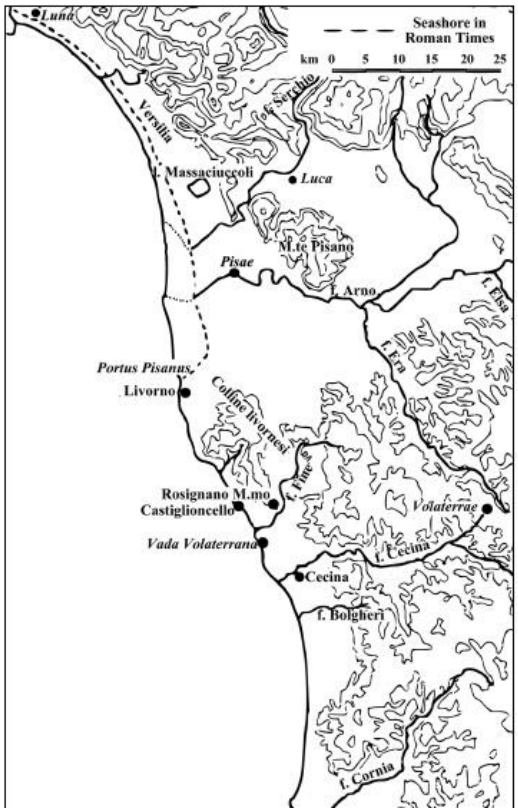


Figure 4. North coastal Etruria (Pasquinucci et al. 2008:379).

Vada Volaterrana

The general trends seen throughout the timeline of Roman harbors and ports is reflected in the evidence from Vada Volaterrana. The most abundant information for this harbor site comes from analyzing its timeline. As previously mentioned, the archaeologists and researchers from the University of Pisa who worked on the site used various methodologies to assess the site. The northern coast of Tuscany, including the Fine and Cecina river valley in between which Vada lies, consists of alluvial Holocenic plains which are formed by sand and silt deposits with sounding hill and mountain ranges. Though these areas, and Vada, had been studied by the university since 1982, in the 1990s the Carta Archeologia della Regione Toscana Project was responsible for expanding the methodologies to include GIS and other integrated studies, resulting in 600 topographic unit (UT) sites and off-sites. These sites ranged from the Paleolithic to late antiquity (Pasquinucci and Menchelli 2012:1008; Iachophini et al. 2012:56). At Vada

beneath the Roman settlement lie the remains of a hut village dating to the ninth century B.C. These remains included wooden posts, pieces of daub, and coarse pottery. The pottery was covered by sand with fossils from a lagoon environment and clear sedimentation suggesting that the area had been submerged by a high sea level (Pasquinucci et al. 2001:199). This submergence was relatively short-lived as the abandoned land was resettled by the Romans by the late Republic (Pasquinucci and Menchelli 2005:394).

In the surrounding area just before Roman preoccupation, Volterra and Pisa had become cities of prestige in Etruria. Volterra was conquered by the Romans in the first half of the third century B.C. while Pisa became a part of the *civitas foederata* in the middle of the same century and served as a base during the wars against the Ligures in the following century. In 180 B.C. some of this land was used to create the Latin colony of Luca, and three years later the Ligures were defeated (Pasquinucci et al. 2012:149). The decades since Volterra became an ally of Rome were profitable for the city and its countryside, especially towards the end of the Republic when Octavian gave land in Etruria to veterans after Actium. Farms and villas grew around Volterra, and they boasted impressive mosaics, marble floors, painted plaster, and even baths, which hint at the prosperity the area experienced (Pasquinucci et al. 2012:149;Iacophini et al. 2012:58). The hinterlands around Vada Volaterrana were also densely populated, hosting six centers for producing wine amphorae of the Dressel 1 type, bricks, and other pottery. These were spread via the nearby Via Aurelia and Via Aemilia. Of the almost thirty farms and villas created in the era of the Republic only ten were not in use by the second century A.D. (Iacophini et al. 2012:59-60). Geoelectrical surveys in the late 1990s used restitivity to examine pseudo-depth sections (not common at the time) to measure potential excavation sites, using profile spacing between two and five meters in order to examine the extent of the site. They uncovered massive walls and

other anomalies, pinpointing the port's settlement during the beginning of the empire (Pasquinucci et al. 2001:200). Research done in the hinterlands of the rural settlements beginning in the second century B.C. and leading up to the establishment of the port show the need for it. Campanian Graeco-Italian amphorae, cooking wares, and black glazed vessels mark the high demand for trade while steady Romanization can be seen in the addition of painted plasters, mosaics, marble slabs, and bathing elements, which turned many simple farms into larger villas (Pasquinucci and Menchelli 2012:1008).

The Augustan period was one of expansion for Volterra and its surroundings. As previously shown in other parts of the Roman Empire, ports and harbors upgraded from their natural states or minimal designs into artificial structures had become a necessity for many important cities. Volterra may not have been one of these behemoths, but it acted as the main hub for its hinterland's residents, and in order to import and export goods it needed to update its own port. Though Vada's earliest settlement was overcome by the lagoon, once the waters receded the rivers and nearby lagoons were used for trade in Etruscan times (Sangriso 2011:171). Vada was a known landing place, and with the Cecina and Fine rivers and the nearby road systems Vada was a good candidate to engage in trade for its own hinterlands and into Tuscany all the way to Volterra (Pasquinucci and Menchelli 2005:394). There had always been some form of natural harbor at Vada Volaterrana before the Augustan revitalization. Pliny claimed it was an important stop on the route to Gaul from Italy between 83-81 B.C., and so it is unsurprising that it would be enhanced to suit the growing area's needs at the turn of the era. Ancient Vada Volaterrana lies underneath the modern town, though its port lies in a sheltered basin between the modern jetty of the Solvay company and the sea south of the Torre-Vada. It is still an area good for docking and unloading or loading goods. Rutilius Namatianus recalled his

own entrance into the ancient port through narrow channels over shallows which were marked in warning by boughs and poles. Solvay claims to use the same entry, which is one kilometer long (Pasquinucci and Menchelli 2005:394). Unfortunately, the modern port facilities, larger than the ancient ones, rest over the ancient remains; thus one of the purposes of this research is to estimate ancient Vada's facilities by comparing them with the Roman world's timeline, the different construction designs of period harbors, and overall economic trends.

Similar to other areas discussed, between the first and second centuries A.D. Vada Volaterrana grew in response to the development of local manufacturing areas, including thirteen for the production of wine amphorae (Dressel 2-4 types and Spello), other pottery, and bricks (Iacophini et al. 2012:60). Surrounding these production centers in the hinterlands were farms and vineyards. In response the port area underwent systematic renovation, which lends credence to the idea that the actual port facilities would have been renovated as well. The port buildings included a *collegium* for guild members who may have run the inner workings of the port. One of the two *thermae* built was made solely to meet the needs of those members. There was also a fountain for local watering needs, a *serola*, a triarch building, a cistern with several tanks, and a drying-kiln. One of the most important buildings for study is the *horreum* which has survived (Pasquinucci et al. 2012:150). As elsewhere in the Roman world, Vada Volaterrana experienced a decline in the third century A.D. Eleven of its hinterland settlements were abandoned, though the port facilities and city seem to have come through without too much damage. Eleven other villas remained, and more than half of the 66 farms settled in the area since the Augustan period remained well into the fifth century along with five manufacturing centers. Still, the dating of a skeleton found buried in the port necropolis between A.D. 267-377 suggests that people remained, and that so too did the economic relationship with the port and its hinterland

(Iacophini et al. 2012:60; Pasquinucci et al. 2012:152). By the end of the sixth century and into the seventh, however, only two villas and four small settlements remained active; thus there was still importing and exporting activity in a district of Vada, which may have continued on a very limited basis even for small communities in the Middle Ages (Iacophini et al. 2012:60). The buildings and neighborhoods of the port itself were eventually phased out and abandoned in the seventh century, and the area became a graveyard for both humans and the remains of a once-thriving site (Comune di Rosignano Marittimo 2015; Pasquinucci and Menchelli 2013:143).

Chapter Three: Harbor Technology

Though technology should not be the only medium by which harbor and port facilities are judged, it will always be an important aspect to consider in the overall picture of Mediterranean connectivity. These developments, or lack thereof, are representative nodes of Roman culture built and used in similar fashion throughout the Mediterranean basin. They not only act as landing places for Roman era vessels, but as landing places for goods and ideas. Therefore, connectivity was enhanced by technology and lead to an empire-wide ease of access. The most direct example of this is found in Vitruvius' *On Architecture* which includes a book on harbor construction discussing both natural and artificial sites. Navigation in the ancient world was dependent on wind and human motivation, and it began with coastal profiles and recognizable landmarks, making harbors of refuge necessary every 50 to 70km. Cabotage led to regular stops and thus increased socioeconomic activity. The important part of these varied factors is that ancient harbor design "never followed a linear development" because it was dependent on topography, available materials, and local economic status (Rickman 2008:12-15). The Roman ability to adapt to their surroundings is mirrored in the success of their ports which were placed variously in artificial basins, natural landings, canals, and lagoons.

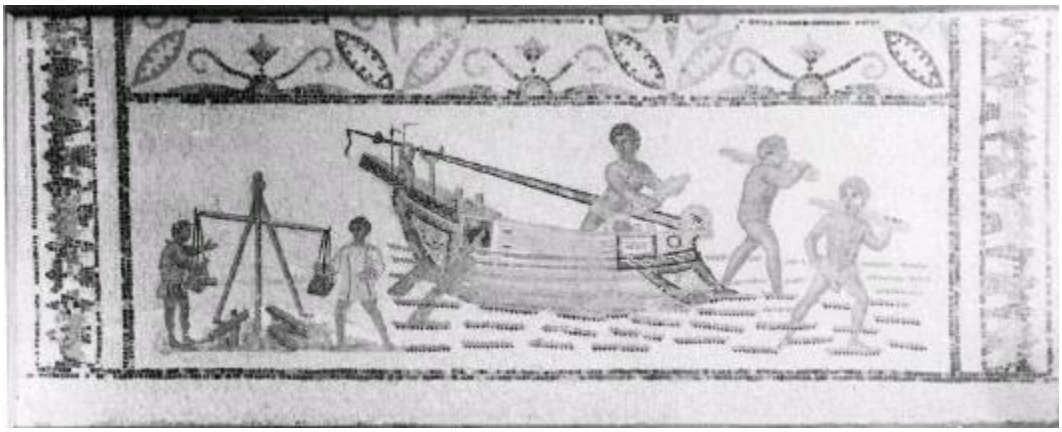


Figure 5. North Africa mosaic depicting a boat beaching (Houston 1988:561).

The easiest and most cost effective sites were the natural ones, especially early in Roman seafaring. These harbors had shallow waters forcing vessels to have correspondingly shallow drafts, which reduced the amount of product carried onboard. Still, Vitruvius, writing in the time of Augustus, knew that this was the most widespread practice used during and prior to his own time. He claimed that the best harbors were "naturally well situated" with "rocks or long promontories jutting out," which could be used to shape a basin as well as support buildings, road surfaces, and towers on either side (1914:5.12.1). Such alterations were undertaken by the Phoenicians in the Bronze Age between the eighth and ninth centuries B.C. with ashlar-built quays and added breakwaters (Oleson 1988:148). Rivers, like the Tiber, were also identified as good points of refuge. Unfortunately, with the exception of some mildly altered Phoenician sites, it is hard to find evidence for natural facilities. Beaches are subject to the tides, much of the Italian shoreline has changed over time, and lakes and lagoons have not been explored or have disappeared. Rivers have fared better due to numerous citations in ancient literature; examples are Rome and the Tiber or the Fine and Cecina rivers for Vada Volaterrana.

Vitruvius' advice on building artificial harbors recommends the use of the powder from Puteoli, mixed with water and lime. To construct piers, or *pila*, dams were placed in the water with piles of oak tied together and driven into the sea floor. Between these pilings a bed needed to be dug and leveled with stones and mortar until all empty spaces were filled. If doing the work in water was impossible, a strong wall needed to be built at the edge of the mainland, laid horizontally with an overhang over the water. The area beneath this overhang would be filled with sand, held in by place by a structural component, and then on top of this as long a pier as possible would be built. After setting for two months the structure holding the sand would be removed, and the surge of the water would wash away the sand, forcing the structure above to

sink into the water. The repetition of this process can extend piers further and further from the shore. However, Vitruvius noted that not everyone in the empire had access to this powder, and so also described an alternate way to make *pila*. It began in the same way, with double dams with planks tied together, though the area between needed to be filled with clay and marsh weed instead. The water inside would then be removed with screw pumps or water wheels, allowing for the foundation to be dug so that the area was larger than the intended wall and for the wall to rest on firmly solid ground. If finding solid ground proved fruitless, charred alder, olive, or oak piles could be used with intervals filled with coals. The wall would then be raised with squared stones, preferably long stones so that middle stones could be tied in; the inside is then filled with rubble or masonry. This wall provided a starting point for a tower. Arsenals should be constructed to the north, since heat came from the south and increased the chance of rot, worms, or other insects, which, in addition to fire, is why the use of timber should have been reduced. Ultimately, the materials created a final structure suited to welcoming large vessels (Vitruvius 1914:5.12.2-7).

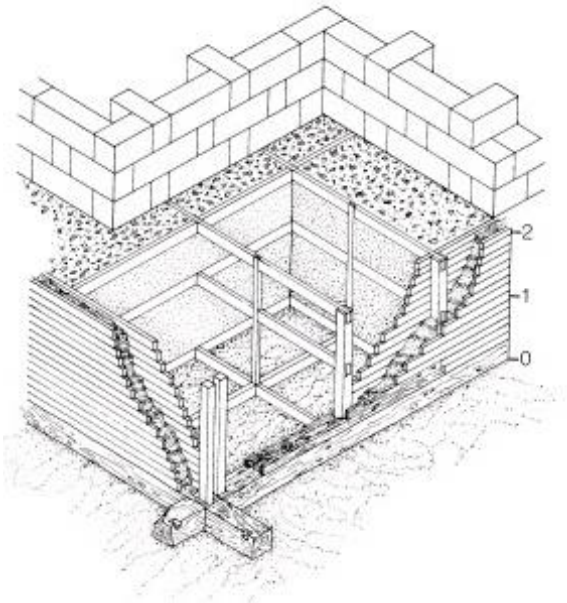


Figure 6. Reconstruction of formwork for setting hydraulic concrete (Oleson et al. 1984: 297).

Vitruvius wrote in the age of Augustus when the use of artificial structures, especially those enhanced with hydraulic concrete, were utilized throughout the Mediterranean, as we will see with Caesarea Maritima (though Cosa used this technology at least a century earlier). With the use of hydraulic concrete or ashlar, artificial harbors contained structures important to any landing place and have aided archaeologists in estimating the size of incoming ships and their cargoes. The centerpiece of these structures is the enclosure, or the artificial basin connected to the sea, lake, or lagoon in which vessels could be moored. The enclosures are created along with jetties and breakwaters, or by excavation at the shoreline. A jetty extends from the shore into the water, acting as a landing pier for sheltering boats; on the end of the jetty a platform can be added to maximize docking capacity.

There is additional docking at quays, which are mooring docks on the actual shoreline. Moles are like jetties as well because they act as artificial landing piers in the water, though they may be connected or not to the shore, so that their purpose is the subject of debate (Stone 2014:569). A breakwater is a wall not connected to the shore but parallel to it, acting to minimize the force of waves and protect moored ships. A breakwater can be either natural or artificial. Many sites used natural foundations upon which to build stronger breakwaters, preferably sloping to prevent undermining. Natural breakwaters were cut away to level their platform and then built up with excavated stone and rubble. It is difficult to determine their height due to decay over time, but some had buildings, especially lighthouses or lookout towers, perched atop them; over time in certain harbors, moles were used for this as well (Blackman 1982:196). With the use of hydraulic concrete, the Romans had an easier time in shaping their harbors with free standing structures. The Romans hoped that their augmentations would allow sea water to flow in and out to help reduce silting.

Arguably, wharf length is the most important aspect of a harbor in aiding researchers to determine its size. Wharf length is the total length of docking space for ships with cargoes and includes all sides of a jetty, any platforms or quays that were connected to water. David Stone calculates wharf length as equal to half of the jetty's length, plus the perimeter of the platform, since he believes that only the outer half of the jetty was serviceable for docking. He and Katia Schörle believe that harbor area, which can be determined from measured drawings without excavation, is useful for statistical comparison (2014:582). The inner side of moles were sometimes used as quays, though the primary quays were on the shore. Both moles and quays evolved from being rock-cut to paved rubble to ashlar embankments, and then finally to concrete structures under the Romans.

Their shapes eventually evolved to provide more space and included different designs like the hexagonal basin Portus or the circular one at Carthage. Some were still faced with ashlar, others with *opus reticulatum* or brick. Certainly some quays and jetties were wooden structures, though they have long since vanished, leaving only remains of durable stone and concrete for study. Most of these structures were one level in ancient times and stood about one meter above the water level for uploading or unloading. Ancient vessels moored stem to stern at nearly right angles to the quay to maximize the use of the space. They were secured to mooring stones, bollards, or iron rings, which were spaced apart according to expected maximum ship size. So wharf length was also of utmost importance since it is where most of the work in the harbor took place. Wharves would host not only ships but also crane-operators, divers, ballastmen, harbor boatmen, and other services supplied by guilds in order to expedite trade. Behind these quays roadways and storage buildings were abundant (Blackman 1982:199-204).

Different harbors welcomed vastly different vessel sizes dependent on locality and need. Vada Volaterrana, for example, would not see the same massive grain carriers as Portus. Larger facilities had to accommodate all kinds of ships from small merchant vessels between five and 20m to larger carriers between 15 and 40m. Large ships necessitated quays and moles, or even timber quays and jetties, to bring items ashore, but they also made direct exchanges between two ships on opposite sides of a quay or a mole (Rickman 1988:263). While the size of ships and their cargoes led to the increased size of Imperial ports, smaller vessels and small ports still handled a fair amount of Roman trade; often in areas with little to no harbor facilities, which is difficult to see in the archaeological record. Such conditions still happened in England in the 1880s and even today in the protected beaches of the Mediterranean. River mouths, most famously with the Tiber, were utilized as often as beaches. These facilities used lighters and barges to carry cargo inland (Houston 1988:560-562). Wealthy villas could also afford to have their own private harbors, which were often capable of mooring only a boat or two at a time. It seems obvious to state that the size of a harbor's hinterland, and thus of its dependent population and economy, is reflected in the size of its enclosure, wharf length, and warehouses. But the lack of evidence for the size of the harbor enclosure and for wharf length in the case of Vada Volaterrana forces us to look to the use of its warehouse as our only recourse. Still, comparative data from villa sites or a city such as Cosa can help to fill in the gaps of our understanding.

Cosa has been an odd but extremely important case for understanding Roman ports. It is the oldest harbor to use hydraulic concrete, which pushed back the export and use of this material from the Bay of Naples area to the second century B.C. As previously stated, not all harbors used hydraulic concrete often due to size and expense, but it is possible to estimate harbor size with or without remains. This information can be gleaned from boat and cargo

shipwreck remains, from warehouse cells, or from studying the total area, as done by Schörle on the coastal strip between Puteoli and Porto Santo Stefano in central Italy (nine substantial harbors in total). These sizes ranged between the largest harbor at Puteoli at 67.9ha to the miniscule one at Pandateria at .7ha (Stone 2014:581-582).

The ROMACONS project is a large-scale study that has catalogued the use of hydraulic concrete in these ports and others throughout the Mediterranean during Roman rule; it is led by John Oleson and Robert L. Hohlfelder. They have estimated that the volcanic ash from the area around Puteoli was used to make mortars starting in the seventh or sixth millennium B.C. Because of its "chemically reactive aluminosilicates" it creates "hydrated calcium aluminates and silicates" when mixed with lime and water, thus creating the concrete made famous by the Romans (Oleson et al. 2004:199-200). Concrete has survived, but the boards that help set its shape do not. However, at Cosa, marks left from the boards remain and show that the mixture was put in box-like forms with vertical shuttering along the sides, held in place by beams and reinforced with horizontal beams along the interior. These forms could also be floated into position then ballasted to sink on a formation under the water (Oleson 1988:150).

To study these sites ROMACONS took large cores from well-dated structures. One of their goals was to see how closely the Vitruvian formula was actually followed during the building process throughout the empire. They found that it depended on local practices at different times. Again, this harkens back to Roman adaptation, a trait of connectivity. Different variables needed to be addressed differently in each harbor. Similar formwork as has been found at sites such as Caesarea Maritima, Cosa, and Carthage, but the methodology was not exactly the same. The final analysis, thanks to core-drilling and analyzing the holes and marks left in the concrete by wooden boards, taught researchers a great many things about hydraulic concrete and

how it was placed in the sea. Wooden formworks were meant to contain mortar and aggregate while protecting a semi-liquid concrete mass from the waves and currents until it had hardened. Luckily, the mixture set and hardened remarkably quickly so engineers did not have to wait for substantial amounts of time. Formwork was dependent on depth and locality. Cosa and Portus were deemed regular in design and measurement while Caesarea had barge-like frameworks built to later sink and fill with layers of concrete and other materials (Oleson et al. 2004:204-218). It is still difficult to estimate the cost of shipping pozzolana and building with it due to these variables. It is likely that pozzolana was easily shipped throughout the Mediterranean along with the lime aggregate needed to mix with it, as shown by the number of sites analyzed by ROMACONS. Italy possessed sixty-two sites, with North Africa and Greece following, as well as Portugal, Iberia, and Massalia in Gaul (Brandon 2014:123).

Unfortunately, even after the installation of concrete many harbors became clogged with sediment. Massalia utilized dredging from the third century B.C. onwards, though it was most extensive between the first and third centuries A.D. Some of these dredging boats were unearthed after being abandoned at the end of their use. In a way the shifts in granularity of ancient harbor sediments helped to protect harbor remains. Additionally, water quality was affected by artificial harbor facilities which encouraged the accumulation of sediments, which included human waste, sand, and silt because of the sheltered nature of these harbors. Dredging of some sites was continued into the Romano-Byzantine era, but as widespread economy turned away from the western Mediterranean to focus on the east many sites were abandoned to the elements, which effectively froze parts of the harbor in time for important archaeological research and projects in the future (Morhange et al. 2016:91-98).

The Italian Peninsula

Ostia and Portus

Ostia was reportedly founded under Ancus Marcius, the fourth king of Rome because of its abundant lagoons and salt works. Its name derived from *ostium*, meaning mouth, because of where the Tiber river linked to the sea (Goiran et al. 2014:390). The earliest port established in Rome was Portus Tiberinus between the Tiber and the Capitoline and Aventine hills in the sixth century B.C. Lack of space caused other facilities to be built further to the south (Keay 2005:34). Archaeological evidence does not appear until the third century B.C., however, when a *castrum* of tufa blocks was built (Goiran et al. 2014:390). Along the banks of the Tiber several warehouses were built for the storage of goods, and along the front of these were 1.5m of quays for docking. These river facilities continued to be of use even with the Ostian harbor becoming of greater importance during the Punic Wars. While the harbor could welcome both military and commercial vessels the Tiber was still the literal connecting factor between Ostia and Rome since the harbor basin was less than 600m from the early *castrum* and joined with the river mouth (Keay 2005:34; Goiran et al. 2014:392-397). As Rome began to grow and demand more from Ostia, its population swelled with people of different backgrounds including a 'middle class' who would go on to dominate the overseeing guilds, veterans, slaves, and even foreigners who slowly introduced different cults to the city (Meiggs 1973:70-71).

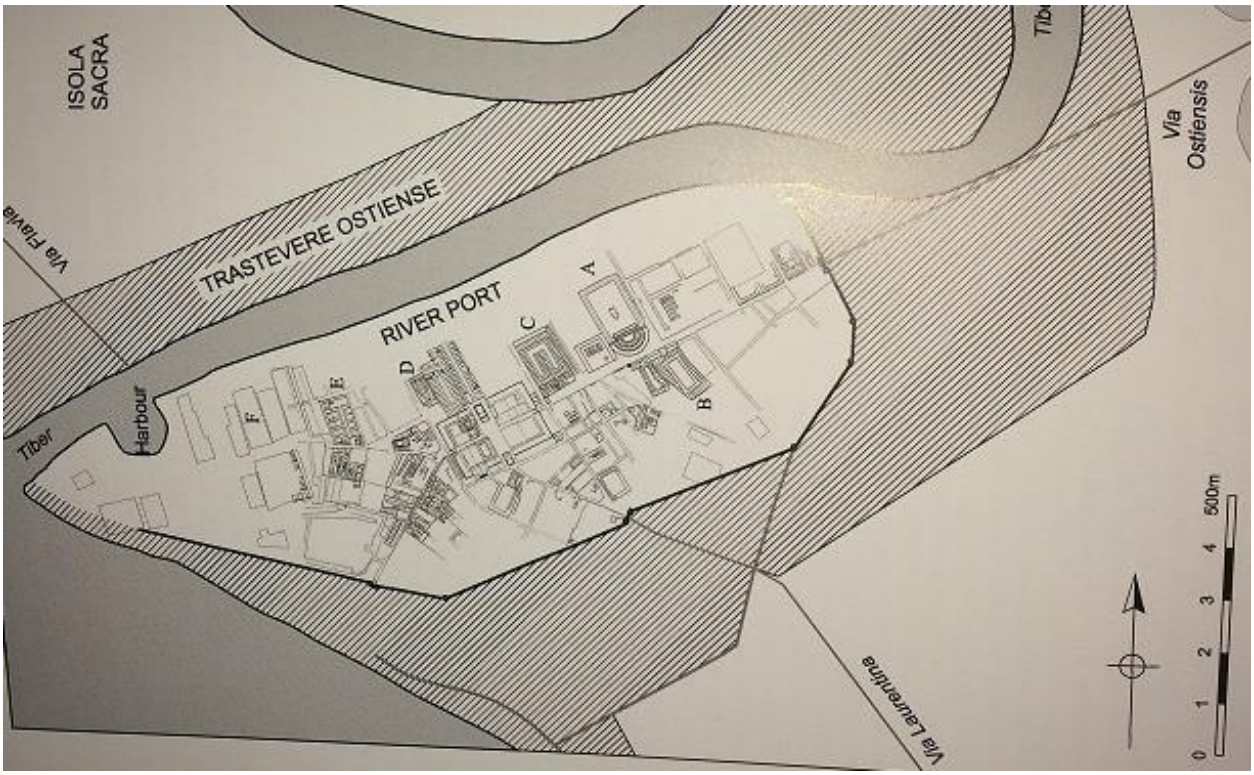


Figure 7. View of Ostia (Keay 2005:42).

Ostia experienced prosperity in the late Republic and the early Empire, though later it became inadequate as ships got larger and the sand bar at the river mouth more dangerous. The river supported smaller trading vessels, leaving larger ships at sea, as well as having the unfortunate quality of sweeping out silt as water rushed to the coast (Meiggs 1973:51). The main city grew around the original *castrum* and the south side at the Tiber developed into a grand port area that supported the city. Ostia's basin was at the western limit of the port and was about .2 hectares in size. The extent of its quays is not clear, but as previously mentioned they were built up along the bank of the river as well as numerous warehouses putting the 1.2 km estimate at the minimum (Keay 2005:42-43). Although it had once been used in the Punic Wars to host all kinds of vessels, its smaller facilities demoted it to commercial enterprises only. Even so, in 194 B.C. Puteoli to the south acted as the maritime port of Rome until well into the first century A.D. It had a larger, natural harbor and welcomed the largest merchantmen bringing grain.

In addition to welcoming smaller vessels, Ostia was needed for the storage of imports. Warehouses originated in the Republican period, but they became essential at the beginning of the Empire, steadily increasing under Trajan, Hadrian, and the Severans. While the remains of the port itself could not be excavated due to the Tiber's change of course in the sixteenth century, the changes made to Ostia highlight its importance to the surrounding city and Rome. For example, *horreum* space increased from 17,677 m^2 in the first century A.D. to 31,882 km^2 in the early second century and even further towards the end up to 46,118 km^2 (Keay 2005:43). The largest of these were the Piccolo Mercato, the Horrea Epagatiana et Apaphoditiana, the Horrea di Hortensius, the Grandi Horrea, and the Horrea dell'Artemide which were publicly owned and located along the river and the *Decumanus Maximus*. These buildings largely stored grain and faced the river port for ease of access, though sometimes goods stored there were shipped along roadways. Often they were built around a courtyard and had cells within for holding goods. The floors were raised above ground level, and the walls were thick to protect stored goods from moisture or sudden temperature change. The walls were made of brick and had open gaps to allow for some air circulation, and evidence indicates that ramps and staircases were used for two-storied buildings (Ward-Perkins 1981:55; Pagliaro et al. 2015:561-562).

Figure 8. Access to a warehouse storage cell at Portus (Pagliaro et al. 2015: 562).

Figure 9. The floors beneath a warehouse cell (Pagliaro et al. 2015:562).

Reportedly, Caesar was the first to consider a new harbor. His plan included draining the Pomptine marshes and creating a canal to divert the Tiber below Rome, running around to the Circaean promontory and then into the sea at Terracina (Meiggs 1973:51). Claudius addressed the issue with Rome's port; his primary concern was to make it easier for grain shipments to go straight to Rome in time of need. Cargoes only arrived in the summer when they were stored so supplies became sparse in the winter (Cassius Dio 1927:LX.II.1-2). In order to ensure that shipments were made Claudius had to offer incentives to anyone keeping a ship for the grain supply, and he had to insure them against losses during storms. He knew that building a new harbor would be an expensive endeavor, but in A.D. 42 construction began two miles north of the Tiber (Meiggs 1973:54).

The project took more than twenty years to complete, and it began with the digging of canals between the river and the sea to alleviate flooding. These canals were already lauded in inscriptions by A.D. 46, which claimed that they were built to promote the harbor and to free the city from flooding; as a result these canals may not have been intended as a main route for barges

to head upstream (Keay et al. 2014:29). At the harbor site two curving moles made of travertine blocks and tied by iron clamps were built out in the sea, and an island serving as a foundation for a lighthouse was made between them by sinking a merchantman that had carried an obelisk from Egypt (Meiggs 1973:55; Sear 1982:92). The new harbor aimed at keeping ships safe, but in A.D. 62 two hundred vessels within the basin were destroyed by a storm. Though the size of the harbor welcomed larger ships, half of the grain supply was still unloaded at Puteoli in the south (Sear 1982:92).

Unfortunately, the site of Ostia is now inland after centuries of silt and changing coastlines. Now the hills surrounding modern Ostia conceal moles and, presumably, the Claudian lighthouse. Because these moles have yet to be analyzed researchers use iconography to estimate their appearance. Nero's coinage shows the moles on arches, like at Puteoli, which might allow sand and silt to drift in and out instead of piling up against a regular block (though this is still controversial). Recent research undertaken at the Claudian basin puts its depth at seven meters and its area at 200 hectares, though these measurements may reflect a later time when the Claudian basin acted as a holding spot for ships waiting to get into the Trajanic basin. As mentioned, the basin was subject to silting and needed constant dredging, and even with the canal system in place flooding still occurred at the mouth of the Tiber (Keay 2005:46; Keay 2014:12). Nero considered creating another canal between Rome and Terracina, where he had focused his own efforts on the harbor, but the route from Lake Avernus to Ostia was expensive and reportedly was disregarded although it would have drained coastal marshes and perhaps alleviated flooding (Meiggs 1973:56).

The ship-destroying storm and the silting inspired Trajan to construct yet another addition to Rome's port facilities by adding an inner basin connected to Claudius' outer harbor. His

workers excavated an inland, hexagonal basin linked to the outer basin by reconstructed canals. Another canal to the south of the harbor linked the bend of the Tiber to the Trajanic basin (Sear 1982:124). Its entrance was in the center of the southwest side through which larger vessels were welcomed while smaller boats remained in the Claudian harbor. The Trajanic basin's sides measured 357.77m with a diameter of 715.54m for a total area of 321.993 square miles. Each of the sides held *horrea* parallel to the banks which were filled with large, deep rooms, of at least two stories, and which opened onto the portico for ease of access (Meiggs 1973:162). The 32 hectare, hexagonal shape provided at least 13.89km of quay space, allowing larger ships to anchor at its 5m deep center until an opening became free. Columns and mooring rings around the sides had different markings indicating a strict system was in place for proper docking (Keay 2005:46). The facilities were made of primarily travertine blocks, concrete, and brick and reticulate masonry which supported the baths, temples, and other public buildings that were built between the new harbors (Meiggs 1973:163; Ward-Perkins 1981:85-86).

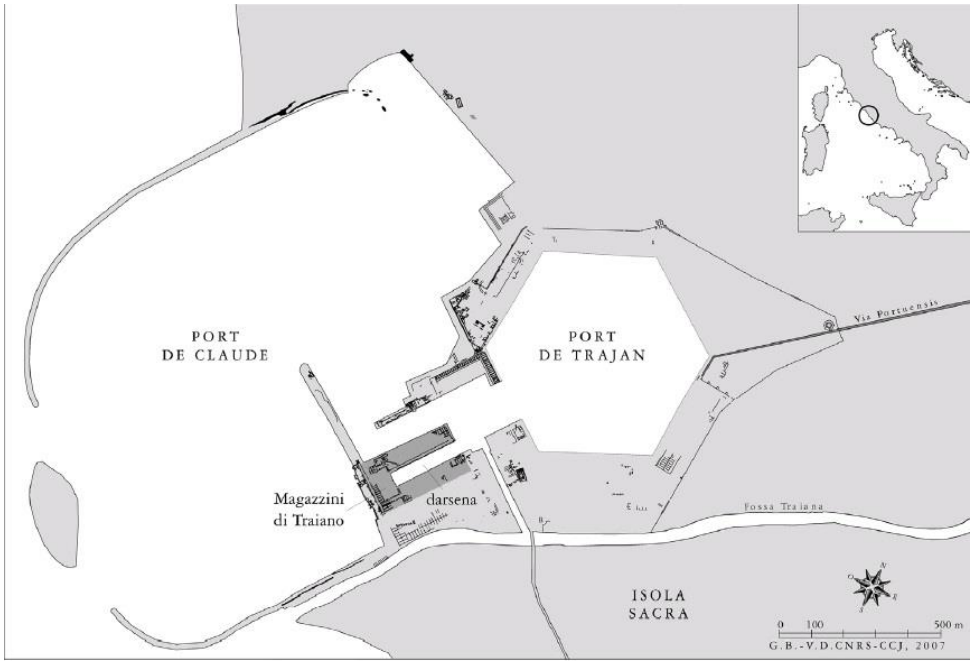


Figure 10. Portus (Pagliaro et al. 2015:561).

Portus' growth signified a decline in nearby Roman ports and their impact on Rome. Great patronage was given to Ostia and Portus by Trajan, Hadrian, and Lucius Aelius as well as by senators and knights of high rank. While Trajan had gifted Rome with an enhancement of its harbor, later emperors realized the importance of the cities that had grown up around it. Hadrian embellished the city of Ostia, as did Antoninus Pius with the Horrea Epagathiana et Epaphroditiana. It was seen as a town for the working class, though that did not seem to diminish its importance. Its decline came in the second century as it did elsewhere in the empire. It benefitted the "middle class" by seemingly passing the responsibility of the port and cities to the guilds which enrolled both freeman and citizens. Later, Commodus and then Septimius Severus rebuilt the Grandi Horrea for grain storage, which indicates that the port facilities were still needed into the third century A.D. After the end of the Severan dynasty, however, instability overwhelmed the empire and forced imperial control to become more direct. There is clear evidence of a decline in the populations of Ostia and Portus as trade diminished and led to the abandonment and decay of several buildings (Meiggs 1973:83-85). While the *horrea* continued to be maintained, the influx of Christianity drew attention away from pagan temples to burgeoning churches. In A.D. 313, Ostia was named an independent community by Constantine, as was Portus a year later. Between 337-341 the Claudian harbor was dredged extensively because of what appears to have been the collapse of a mole. Unfortunately, this work could not be completed due to wars and conflicts that drew Rome's attention elsewhere. Ostia's warehouses were neglected and left to rot while workers moved elsewhere.

The city became better known as a seaside resort than an imperial harbor. In A.D. 410 Alaric with Goths, Huns, and the Alans sacked Rome, ignoring Ostia to take Portus due to its greater importance. The following years saw several coastal raids, once again Rome and Portus

was sacked in 455 by the Vandals. By the end of the fifth century the water supply in Ostia was no longer being maintained, and the remaining populace reopened old wells. Portus managed to recover and retain its importance, though eventually another attack by the Gothic leader Vitgis (537-538) led to its abandonment. By the middle ages Portus had silted up, the Tiber was once again used as a river port, and Ostia, as the closest city, survived on this traffic, the old salt beds, and what agriculture could still be found (Meiggs 1973-96-97).

Puteoli

In the Bay of Naples region Puteoli and its surrounding areas were popular places to live and to vacation. The first and foremost reason for its fame is the local origin of pozzolana, the powdery volcanic ash used to create hydraulic concrete. It had long been used as a mortar, but it has been estimated that its use in concrete began in the third or early second century B.C. However, the earliest formwork containing this concrete was used at Cosa between the second and mid-first century B.C. (Brandon et al. 2008:374). It is very likely that Puteoli's own facilities had undergone later reconstruction, and any sign of its early concrete has thus disappeared from the historical record. This situation may have been compounded by the process of dredging, which we know was necessary for many harbors, including Marseilles, Sidon, Tyre, and the nearby Naples. Each of these sites began dredging in the fourth century B.C., but at Naples dredging may have begun as late as the second century B.C. since no pre-existing layers have been found (Morhange and Marriner 2008:23-26).

Other harbor or coastal sites such as Baiae and Portus Iulius were created or embellished later when harbor technology was more widespread. Portus Iulius (31 B.C.) was used as a naval port by Marcus Agrippa, and its wooden formwork has been dated to 50 B.C. Concrete was found in its *pilae*, which are the cubes or square piers that acted as discontinuous breakwaters or

defenses for the shoreline or at the entrance of the harbor. Portus Iulius' entrance was 220m long, 20-30m wide with a channel of 40m width ended by moles which were defined by a series of six large, concrete *pilae* on its port side and one on the starboard. Baiae's moles also provided concrete samples for the ROMACONS project. This site was built around a lagoon formed by a dormant volcanic crater now located beneath modern Baiae. Its two concrete moles stood in the 32m wide entrance channel, the northernmost 209m long and the southern 232m, both with a width of 9.5m. Like Portus Iulius, there was evidence of *opus reticulatum*, most likely in an attempt to protect the concrete from erosion. Several frescoes from these areas show how popular *pilae* were in Roman ports around the Mediterranean (Brandon et al. 2008:375-376). Unfortunately, and oddly for my project, researching Puteoli's port has uncovered more questions than answers. Puteoli was once one of the most prosperous and favored ports of the Romans due to its ease of access. It was the primary docking station for the early grain trade coming into Italy. Obviously, its facilities were large enough to cater to this trade. The city hosted a large population who celebrated every spring when the large ships came into sight. Over time it lost its most valuable trade in grain and slaves, but traces of the port have been preserved. Little more than its ancient arcaded mole and a few walls that made up its docks have survived. These docks and numerous warehouses stretched north up the *Ripa Hortensiana* all the way to Portus Iulius and then around to Misenum (Rickman 2008:18).

Cosa

140km north of Rome, Cosa is now considered the earliest site for hydraulic concrete. It also possesses the earliest fishery in the Roman world (McCann 1979:391-393). Cosa had five concrete *pilae* dating to the late second or early first century B.C. The pozzolana used came from the Puteoli region, and ROMACONS surmises this use may be a case of experimental innovation

before becoming more widespread (Oleson et al. 2004:208). If so, Cosa was a well-chosen site. It was the best anchorage en route to the west between Gaeta and La Spezia while also providing different services like the aforementioned fishery and fresh water from its springs (McCann 1979:393). After the ROMACONS testing Elaine Gazda proposed that the site needed a revised chronology for its architecture because of its later dating and the timespan of its pottery. Earlier scholars date the site to the second century B.C., but Gazda believes it was built after the 70's B.C.. Still, others believe the site to be early Augustan, no doubt because of the monumental concrete structures being built elsewhere in the empire at that time. The second century date reflects the start of Sestii trade with the Will 1D amphorae, while Gazda's argues the site's strong economic presence between 125-75 B.C. (Gazda 2008:265-270), which suggests that the harbor was built after the Sestii were already successful. Perhaps the Sestii used their own funds to build the harbor instead of it being the bedrock of their economic success.

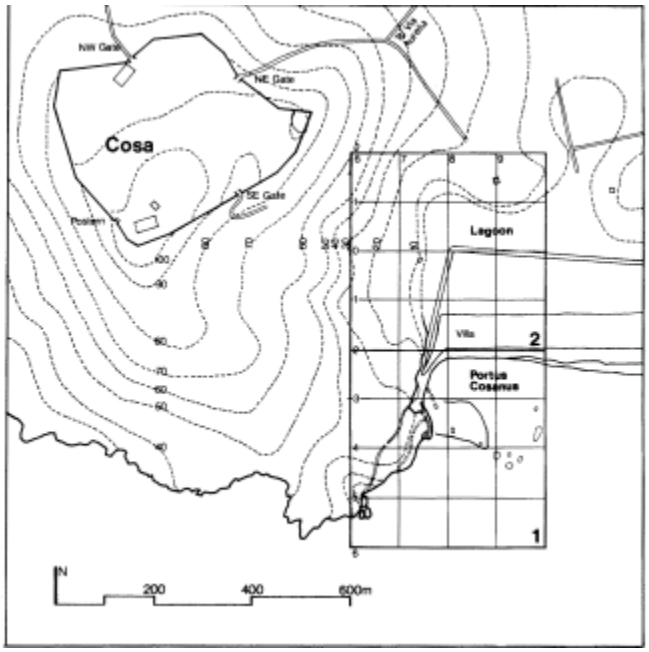


Figure 11. Map of Cosa, including the harbor and lagoon (McCann 1979:392).

In antiquity Cosa was a landlocked port with an artificial ship-channel protected by a large breakwater (McCann and Lewis 1970:201). The entire site was carefully coordinated and most likely built at once (Gazda 2008:271). It was protected by a promontory, which was eventually enhanced with a breakwater of limestone rocks from the cliffs overlooking the harbor to create a 100m long and 70m wide projection meant to break incoming waves but to allow the circulation of currents (McCann 1988:103). The concrete used was made of volcanic tuff and pozzolana applied to areas that needed extra strength, such as in walls and submerged piers, because it set quickly underwater and could withstand the weight of superstructures and the force of the current (Gazda 2008:271). Of the port proper there were two separate parts: the harbor and lagoon, which was a kilometer east. The former was meant to serve the hilltop town and the surrounding territory in imports and exports while the latter supported the site's fisheries and conveyed excess produce for export. The breakwater and the moles were built at the same time, since the site's piers and walls were made of the same tuff and pozzolana mix. There is evidence of refurbishing with the use of different building materials in some junctions between sections (McCann 1987b:81).

The remains of the breakwater lie underwater and extend 1000m from the promontory. The south face was placed in a straight line, and on the north eastern face a similar line was traced 70m from the eastern tip towards the shore. A clear line of rocks was spread north of the breakwater to create a curving contour ending 23m from the third of the remaining five piers. The largest of the rocks measured 2m by 1.5m by 1m and weighed up to 2,000kg facing the sea while the smaller ones lined the inside of the breakwater towards the shore. The enclosed space was 25,000m over the longest space of the modern shoreline to the north eastern remains, giving the entire area a diameter of 190m (McCann 1987b:75). There are five remaining concrete piers,

labeled accordingly in the projects of the 1970s, though piers four and five were badly eroded. These two were also located further out than the others, pier four 40m east of the cliffs and nearly centered on the breakwater, and pier five 15m from the tip of the breakwater. The first three are better preserved and closer to the cliffs as well as closer to one another at about 6.5m, while 36m from between three and four and 55m between the latter and five. Within their structures are indents indicating the use of a wooden cofferdam. Broken parts of the piers have revealed aggregate rocks layered with the concrete mortar and "yellow-brown tuff" on the lower parts and a mix of Dressel 1 amphorae sherds (second or first centuries B.C.) and other aggregates for the top (McCann and Lewis 1970:204). The parts were made of different mixtures needed for the additional strength below the waterline (Gazda 2008:279). The piers could be reached by an entrance channel at the eastern tip of the breakwater. It was six meters deep, allowing mid-size merchantmen access to the basin. Smaller vessels were usually moored to the piers and perhaps even to floating docks from the breakwater or beach while the loading and unloading was handled by barges and other small vessels (McCann 1988:103). The dock took on a roughly rectangular shape "with wings projecting to the east" (McCann 1970:209).

The remains of several walls within the harbor area still stand, the most substantial being Wall M, about five meters north of pier one. It was made of concrete and aligned parallel to piers one through three and like these piers its lower section also showed signs of yellow tuff. Indentations indicated it was made in similar formwork to the piers, and like much of the harbor, it underwent reconstruction with limestone rubble, sherds, and lime mortar. Other walls included A and B which defined one of the many channels created in the harbor just to the east of Wall M. They used limestone boulders and were laid horizontally without mortar. Wall B may have connected to a wall in the nearby lagoon due to similar build and direction (McCann 1987b:77-

79). Several walls served important purposes in the channels that connected the lagoon to the sea. Two of the channels, Spacco della Regina (southwest to northeast) and the Piccolo Spacco (to the southeast), were natural while the Tagliata was an artificial 17m tunnel. They emptied in the trapezoidal basin. Behind these a collecting basin was cut into the cliff. On the seaward entrance to the channels cuts for sluice gates remain, suggesting stringent water control. Water exiting from the lagoon flowing east of the harbor and extending into the sea also bypassed triple sluice gates (McCann 1970:201-202; Brown 1980:50-59).

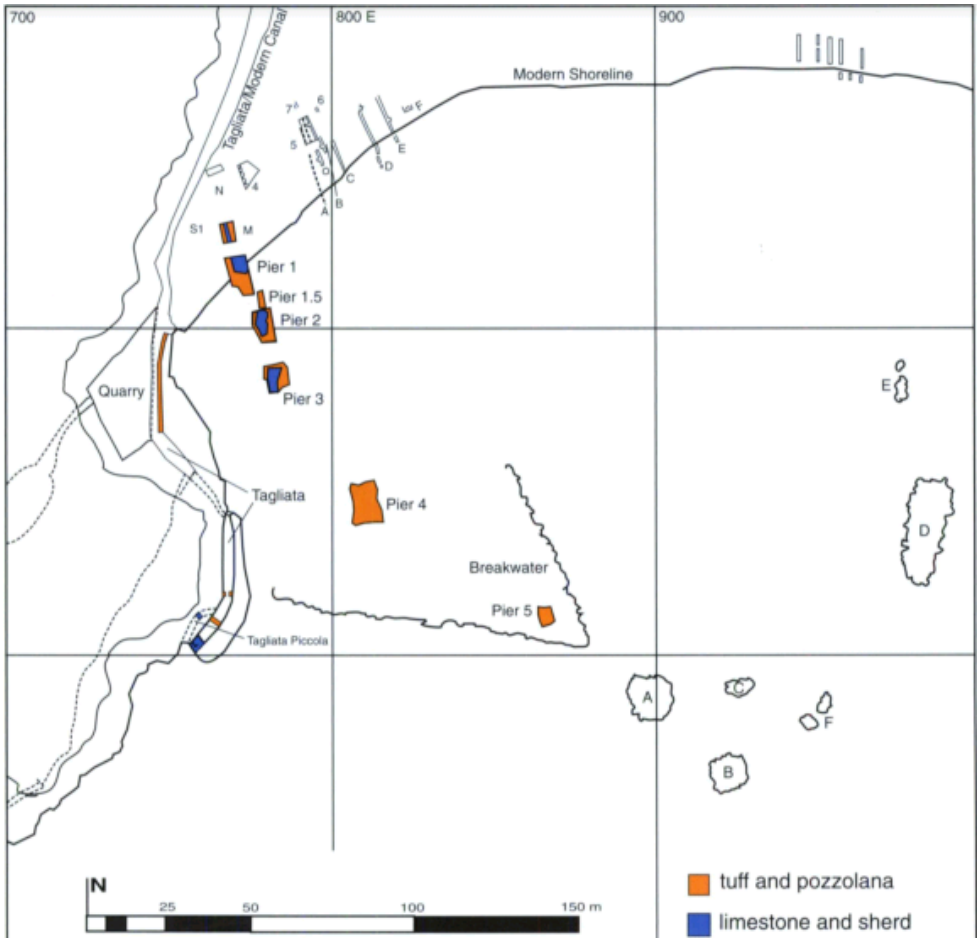


Figure 12. Types of concretes used at Cosa (Gazda 2008: 370).

The lagoon had retaining walls X and U to the north and east, walls for its fish tank (V, W, L, N), and a retaining wall (P). The fishery appears to have been built at one time with walls as evidenced by the methods of using wooden forms to bond U and X and then X P with tuff and

concrete (Gazda 2008:275). The fishery contained several tanks for varying types of fish for the production of different types of food and sauces. The lagoon was also the site of another feature that marked Cosa as a pertinent anchorage: its springhouse. Its platform and basin were made using hydraulic concrete, as were the nearby aqueducts because of the sheer amount of water handled by both. (Gazda 2008:274). The springhouse basin was divided by a drain with two pedestals placed on either side. In antiquity water came from the west side of the basin as evidenced by a series of drain holes, leading to the calculation that it was piped from a large wooden-lined structure from the bedrock at a rate of about 400 gallons a minute (McCann 1970:210; Brown 1980:59). Segments of its walls were the same as those found elsewhere in the harbor, and the finds of several pottery sherds of the Will type amphorae 4a and 4b placed the lagoon complex to 70 B.C. at the earliest (Gazda 2008:277).

Though no inscriptions specify who built, controlled, or profited from Cosa's port its size indicates that it was intended for commercial purposes. At its peak a mid-size merchant ship would approach the port, perhaps guided by the site's lighthouse which may have been 30m tall with a square base according to a model from the late second or mid-first century B.C. at Vulci. In all probability it sat atop pier five since it was the furthest from the others and at the very tip of the eastern edge of the breakwater (McCann 1988:104). The entrance channel was 33m wide with a deeper channel at about six meters in antiquity. It was oriented on the east-southeast by a west-northwest clearance and a summer wind would let ships enter on the port tack and leave on starboard broad reach. Vessels could moor by floating extensions, along the breakwater, at the piers, and at floating docks to be serviced by barges, cranes, or small crafts in shallower waters. Like other Roman sites this peak declined as a result of economic slumps and the nature of silting within the Mediterranean.

Villas and Other Small Harbors

Katia Schörle performed surveys at several harbors along the Tyrrhenian coast which have paved the way for future studies. Her research began south of Vada Volaterrana, but the relevance in size and similarity of sites has proven important in providing examples to which Vada can be compared. These harbors served cities and private villas. Anzio, which was created by Nero, was larger than previously believed, measuring between 25 and 30 hectares making it the third largest along the Tyrrhenian coast. It must have had both an as of yet unspecified impact on Roman trade and a stable relationship with its own hinterland. Civitavecchia, north of Rome, has well preserved remains. This port retained its importance through the Renaissance due to the silting at Portus. In fact, it is still a port of importance to the city of Rome. Its main basin and the trapezoidal darsena (inner enclosure) were protected; they measured 300 by 350m for loading and unloading. Its design came after Portus had been built and so the techniques used there no doubt had a role to play in its resistance to silting (Schörle 2011:97-98).

Centumcellae contained facilities for Trajan's villa as well as for naval vessels. It also helped to boost the local economy which was known for wine production. Terracina to the south of Rome was another large harbor, though obviously not of the Tyrrhenian coast. The expanse of its harbor covered 11 hectares and offered 1,200m of docking space. It most likely dealt with wine shipments, earning enough revenue to warrant repairs under Antoninus Pius. In Miturnae Schörle came across the same dilemma faced by Vada Volaterrana. It had a coastal port near Puteoli, but its size is hard to determine since only its inland river port has been excavated. The facilities at the mouth of the river, however, are covered by a cement factory. Of what has been excavated fifteen ship sheds were found, and there was mention of the *architectus navalis*

(shipbuilder), as well as guilds for caulking ships and sealing containers with pitch (Schörle 2011:98-99).

Smaller harbors and private villas get less notoriety. These landing places were key ports of call along the coast, providing lodging, fresh water, and even their own goods. One example is Giannutri, a little over 2km wide and the southernmost island in a chain found in the Tyrrhenian. It was abandoned primarily due to its lack of fresh water, but in the first century A.D. a villa was built there with later additions. The site had been examined in 1927 by Edouardo Galli who noted cut rocks surrounding the cove Cala degli Spalmatoi and mapped a breakwater going north at right angles to the south shore of the cove. It was not until 1972 that student divers explored the site and found a rock shelf along the water's edge on the south side of the cove. Fragments that had once rested on a submerged foundation had fallen. They could have been an embankment stretching across the southern side of the cove for over 66m. Most of the fragments were rubble limestone, but some were from limestone blocks. The stems of granite columns were discovered; they were most likely meant to fit into a foundation or platform. One piece of foundation showed evidence of mooring-rings on the side facing the embankment. Thus the island's primary anchorage was at Cala degli Spalmatoi, which served its villa beginning in the first century A.D., though another harbor at Cala Maestra was later discovered to be in service (Bruno 1973:365-368; Schörle 2011:100).

The problem with villa ports is the lack of information, not only because of the lack of research but also because these sites had been private ports at the best and small docks or jetties at the least. It was cheapest to trade along the sea, and necessary for island sites, and sea trade was safer than roadways. But large-scale public sites are easier to track through their economic receipts. In contrast, a villa site's enterprise could have easily catered only to the whim of the

elite who owned it rather than to the needs of a larger, dependent group. After all, Schörle found that the largest of her surveyed villas was seven hectares while the smallest was .7 hectares. These villas were not sending out large ships; in fact they were limited to 200-300 amphorae by the *lex Claudia*. However, the seven hectare port, Torre Astura, was twice the size of Cosa, but it may be an exceptional case where a villa developed its port control and eventually catered to its own needs and those of its hinterland and of the empire. The smallest sites had adequate space for a wooden pier or jetty mainly for boats loading up on fish or landing supplies for the villa (Schörle 2011:102). Conversely, it is very likely that villas dating to the first and second centuries A.D. were more advanced than some towns of the second century B.C. due to the development of technology and trade (Wilson et al. 2012:379). Although the relative area of harbors can aid us in understanding the size of ships and their goods, the port must be analyzed in relation to its associated city. Thus, analyzing a site's public buildings, inscriptions, and possible production centers in a port's surrounding areas may help to explain sites which have lost all or virtually all of their archaeological evidence.

Caesarea Maritima

Flavius Josephus extensively catalogued the creation of the Herodian harbor at Caesarea Maritima. He claimed that the site was originally Strato's Tower upon which Herod made a "great city" with "white stone [and] palaces" as a "haven to keep free of the waves of the sea" (*Antiquities of the Jews* XV.9.6). Herod calculated and created a circular harbor so that fleets could remain closer to the shore. He reportedly let down 15.23m long blocks, 2.7m high and 3.05m wide into water 20 fathoms deep, though this depth has been considered an exaggeration and estimated more probably as 20m. After these foundations were set he placed moles above sea level 61m across, 30m of which made up the *prokomia* (breakwater) to break waves while

the rest supported the stonewall blocking the harbor. At intervals towers were placed, the tallest of which was named the Drusion after Drusus, the stepson of Augustus. Reportedly there were vaulted chambers for sailors on the promenade with wide curving quays in front of them. The entrance channel faced north and had six colossal statues, three on either side, standing on columns. The Drusion stood on the port side of the boats entering while the starboard side held two blocks of stone yoked together supposedly higher than the tower. All along the quays were buildings, including temples to Augustus and Rome as well as subterranean warehouses and storage (Antiquities of the Jews XV.9.6; Jewish Wars 1.411-13).

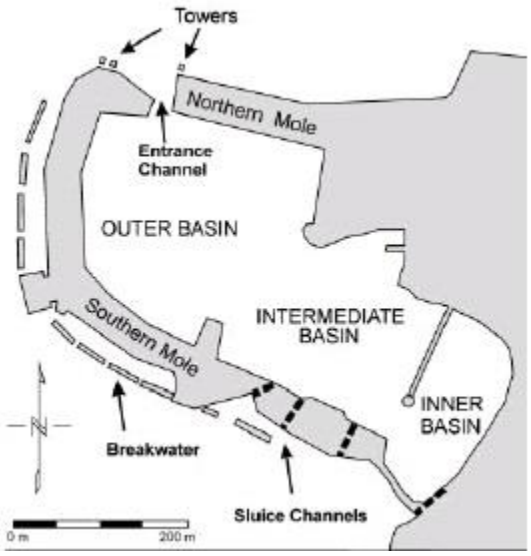


Figure 13. Plan view layout of Herod's harbor according to archaeological evidence (Boyce and Reinhardt 2004:124).

Overall, Josephus' figures were correct for the width and outlines of the moles. The site was built on the former Straton's Tower which had supported two harbors: (1) a Hellenistic, rock-cut basin and stone quay north of the town with long headers of Phoenician style at the southern side of the cove and (2) another basin which had been a bay, widened and deepened in the second century B.C. and eventually covered by a following sea wall of 13m (Oleson 1989:25-28; Raban 1995:6; Friedman 2002). Herod wanted a harbor built there because the site

had always been a transit port, but the difficulty came in creating a facility to support larger vessels on a relatively straight coastline upon a sea bed of shifting sand. These structures would have to withstand winter, the logistics of shipping and storage along moles, and the need to keep the basin silt-free (Raban 1989:286-287; Raban 1995:6). The solution was the Roman invention of hydraulic concrete. Herod had been interested in these hydraulics since meeting with Agrippa in 33 B.C. and while he drew inspiration for the grandeur of the harbor from Alexandria he relied on Roman technology to achieve it. In fact, he relied on Vitruvius' instructions to create baths, begin a sewer system, and create aqueducts in the Roman style (Roller 1998:46-47;98-100). Presently, it has proven difficult to reconstruct the harbor foundations because while several moles are exposed at different locations most of the harbor is buried beneath two meters of costal sediments and a rubble layer caused by collapsed buildings, erosion, and bioencrustation (Boyce and Reinhardt 2004:122).

The idea of a "grand plan" concocted by Rome for the entirety of the Mediterranean gains much of its impetus from Herod's artificial harbor. In 10/9 B.C. when construction was complete Herod named the harbor Sebastos after the Greek word for Augustus, for whom he also built a temple. He utilized techniques seen in Rome in planning his city, some temples, and even a theater and amphitheater. This connection may have been an interest of either party or one that was mutual. There is also the suggestion that the harbor was meant to support troops against the Parthians, though no ship sheds have been found and ships are usually supplied by nearby allies in the region. In fact, legions were only stationed in the southern Levant in A.D. 70 after the Jewish revolt, and then not in Caesarea Maritima itself even when it was later Vespasian's base (Gambash 2013:54-56).

Nevertheless, Herod followed Vitruvius' principles and imported Italian engineers to help build his harbor. The difficulty comes, once again, with pouring concrete blocks in the open sea. Different methods may have been used throughout Caesarea Maritima instead of one primary method. Some remains carry marks reflecting box-like forms with horizontal tie beams like the ones discussed at Cosa. There were remains of different wooden forms which had horizontal tie beams and vertical interior supports for the huge block (15m by 12m and 2m thick) placed at the tip of the northern breakwater. Giant sleeper beams and upright walls were preserved beneath layers of rubble and sand. There were also double-walled forms made for mortar that did not have the pozzolana additive and instead were packed with clay. There also seems to be a hybrid of formwork types at work as well. While the concrete was made with pozzolana the wall compartments were made with puddled mortar which allowed water to slip through until it hardened. This meant the interior could not be pumped dry because of the heavy beams resting at the base atop the sand which would be constantly bubbling up to replace any drained water. In order to combat this effect the beams would have needed to be pounded deep into the sand. These were signs of doubled-walled forms made in wood upon the shore and then floated into place (Oleson 1985:165).

Once the bottom was cleared and leveled the mortar would be poured into the hollow sections of the wall, which were balanced carefully until they sank into place. While it was being filled, rubble was placed around it to prevent the formwork from shifting and disturbing the concrete. This meant beams passing through could not be salvaged in one piece and the formwork would have to be rebuilt on shore (Yorke and Davidson 1985:158; Oleson 1988:153-155). Therefore, the majority of the evidence followed the Vitruvian design of driving boards into the seabed, building another double-walled form that could be filled with concrete beneath

the water after its surrounding area was secure, and using formwork that reflected enclosures that allowed concrete to dry in the air and then be sunk into place (Brandon 2008:251).

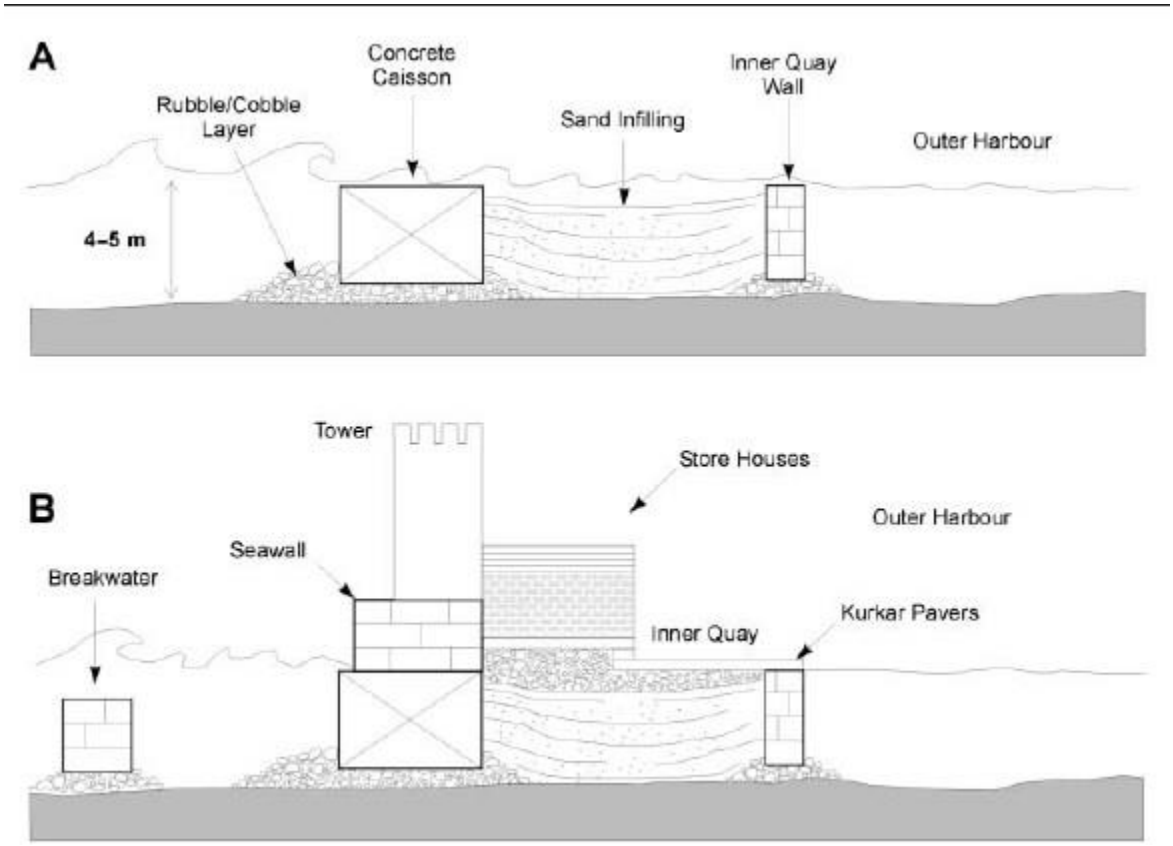


Figure 14. Method of Construction at Herod's Harbor. A. Mole Formation using large concrete-filled wooden caissons on the sea bed. B. Kurkar pavers and ashlars laid over concrete to form quays, in turn supporting buildings (Boyce and Reinhardt 2004: 125).

Most likely, construction began with an artificial island where the breakwater was to be placed, ultimately spread over 500m, and built with caissons that had been created on shore and towed into place (Friedman 2002). These caissons were created by towing the forms into place, mooring them with iron chains at their corners, and then loading rubble and pozzolana into the caisson until it sank into place. This process was repeated with another caisson being placed as close as possible to the previous. The caisson's sides were supported with piles of rubble and the gaps were filled with pozzolana packed in sacks to create a platform 21 by 42m, which was eventually covered with paving slabs. These ends would host large towers, one of which was

most likely the Drusion. After this "wall" was created a second one was laid inside of the first, parallel along a designated line of the quay. It was made of kurkar blocks and rubble which stood above sea level and possessed three hollow spaces parallel along the curved line of the main mole. When waves overran this *prokomion*, sand and silt would fill these hollows in a process that took between two and three years to be completed. They were then covered by rubble and paving slabs to create a promenade and floors for storage vaults. To complete the harbor protection the *prokomion* was confined as a line of the subsidiary breakwater, putting it just a little over sea level in order to break the surge and prevent intensive silting. With the harbor closed the prevention of silting was an important factor. To avoid silting a series of shallow channels were cut diagonally across the main mole at the south side. They opened to the surge with their base above the sea level, which meant they only took in the waves (Raban 1995:6-9; Friedman 2002).

The inner basin was rock-cut and over 40m wide on its north-south side and over 100m long. A quay was placed on the eastern side, carved out of Eolian sandstone bedrock, the west of which was excavated and hollowed out for a basin deeper than two meters. This bottom was covered with sandstone chips, sand, and fine mud (Raban 1992:116). Ultimately, the outer basin contained 200,000m^2 of protected water, giving about 600m of mooring space along the inner quay of both moles (Raban 1989:288). The quays were decorated with porticoes in order to protect sailors (Roller 1998:135). The intermediate basin measured 5,000m^2 with 250m of quay, and there was most likely a series of flushing channels across the mole on the south side with the docking facilities and shipyards on the north side (Raban 1989:288). The quay changed direction over its course and eventually met with a solid retaining wall and ended in a nearby sandy beach (Friedman 2002). There were also kurkar blocks on the inner face of the southern breakwater to

increase docking space. The small basin was separated from the intermediate one by a sea wall ending at its southern edge and was marked by a round tower 50m from the south promontory entrance (Raban 1989:276). Spread throughout the harbor, as already mentioned, were reinforced bases for statues or concrete towers usually along the outer face of the breakwater and notable for their "peppery gray-green mortar with irregular limestone and kurkar ruble aggregate" put into place by a wooden formwork (Oleson et al. 1984:289-293).

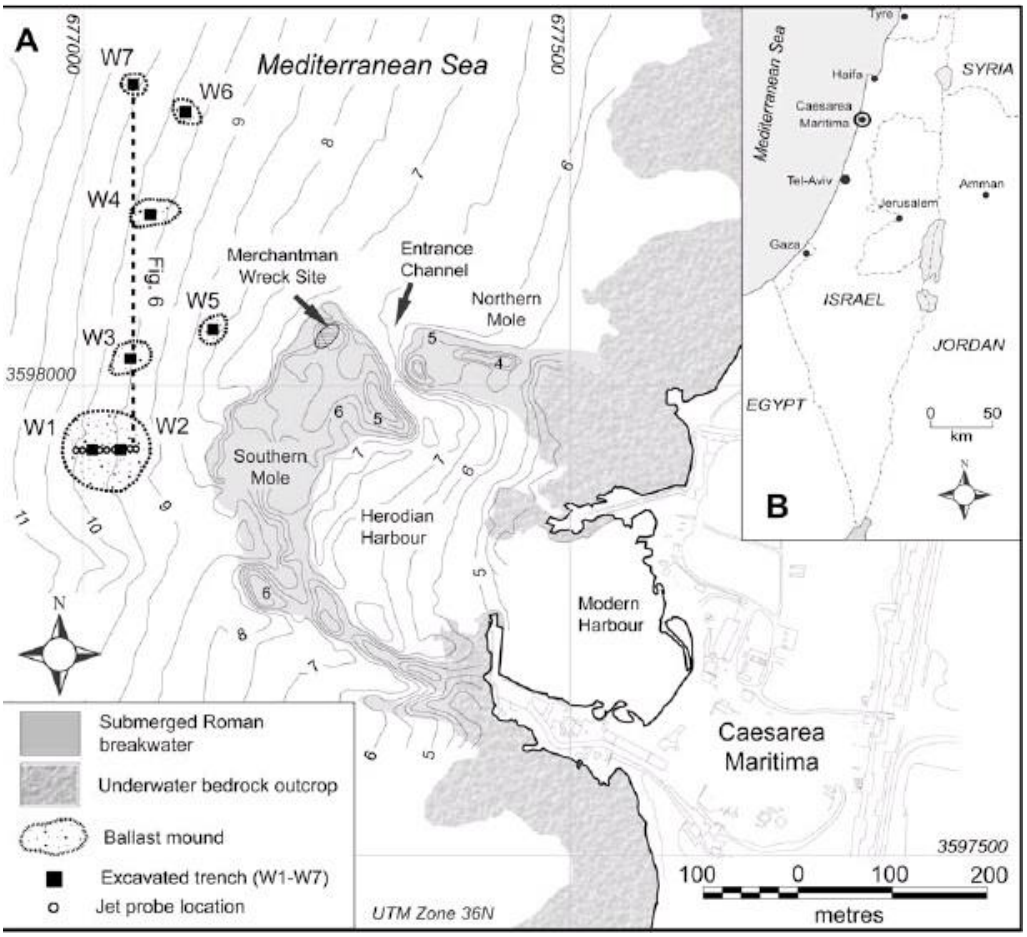


Figure 15. Sebastos study area with submerged Roman harbor ruins, ballast mounds, and locations of excavated trenches and sediment probes (Boyce et al. 2009: 1518).

In addition to the *horrea* along its main streets, several were built along Caesarea Maritima's sea front for storage. Many of these *horrea* were buried beneath present day sand dunes and have yet to be fully excavated (Bull et al. 1993:63;68). Most likely, the majority of

horrea were created soon after the Herodian harbor, which corresponded with the harbor's trading peak; several of them were maintained until the Byzantine period (Oleson 1989:29). These warehouses were vaulted and had a courtyard and a corridor, or else were composite types with vaulted or gabled roofs made of beams; some were flat and composed of beams and mortar. Some examples of the vaulted type were the Mithraeum *horreum* (named so for its later reconstruction) and the inner harbor *horreum*. The former (second or third century A.D.) had four parallel vaults that measured 30m long, 5m wide, and five meters high facing towards the west with arched openings in the front and a secondary opening in the back. The latter (A.D. 300) had two series of six parallel vaults alongside a staircase. They were 21m long, about 5m wide, and 6m high. It also opened to the west and had openings in the rear upper section for light and ventilation. Other warehouses had storerooms that were between 3-6m and were paved with flagstones; they had plastered or beaten earth floors sometimes covered with mosaics. The walls between rooms were 20-30cm thick. Some had *dolia* halls with tiled roofs and flat ceilings held up by arches. The *dolia* would have stood upright, and beneath that floor would have been another grouping of *dolia* to catch any spilled contents. By the Byzantine period there were underground granaries, though it is unclear as of yet whether they are earlier (Patrich 2011:227-232).

Again, as with our other sites, Caesarea Maritima faced economic degeneration and the hazards of silting. The main quay had begun declining towards the end of the first century A.D. due to silting, and by the end of the second century there are signs that silting was affecting the inner harbor basins. Focus shifted to the eastern sections by extending the quay 21m. Unfortunately, attempts to deepen the eastern part of the basin blocked the southeastern flushing channel. Dredging seems to have failed, and between the third and fifth centuries larger parts of

the basins became clogged with sand as shown by archaeological evidence (Hohlfelder 1993:106). By the middle Byzantine period (A.D. 550-560) the emperor Anastasius attempted to repair the site by using draining channels, raising and widening the eastern quay, and putting a column there to act as a mooring stone. Even so, by A.D. 640 the inner harbor was entirely filled with sand (Friedman 2002; Patrich 2011:99). Several archaeological projects have been undertaken at Caesarea Maritima such as CAHEPS (Caesarea Ancient Harbor Expeditions Project) in the 1980's and there is continued research today. In the 1990's the site was turned into an archaeological park (Raban 1992:27). It allows visitors to explore the remains on fixed cable guidelines, showcasing the submerged evidence of a once great harbor system.

North Africa

The limited sources detailing the building techniques of North Africa (not including Alexandria), are divided by scholars in terms of wharf space, and only selected specifics come into the discussion when they are relevant. In Roman times the North African provinces of *Africa Proconsularis* contained about twenty cities along 1,900km of coastline and had the most developed infrastructure. It possessed 81% of North Africa's total wharf length despite having only 48% of the total coastline. The second largest was *Mauretania Caesariensis* with 10% of North African wharf length on 22% of the coast, then *Cyrenaica* with 8% on 16% of the coast, and finally *Mauretania Tingitana* with only 1% over 14% of the coastline (Stone 2014:572;583). The clustering of ports in more agreeable areas probably explains this distribution, rather than deliberately having one large harbor system in each area.

The ports were of the enclosure type, normally rectangular or circular, and the early ones often used Punic techniques which included digging out a basin behind the shoreline resulting in a cothon (basin). Later, ashlar masonry was used to create basins, which would have possessed

one or more quays for docking at the shoreline and probably possessed additional space at timber, stone, or concrete jetties jutting from the shore. These jetties were necessary due to the notoriously shallow waters of many of the harbors, which necessitated jetties to be built with platforms for extra mooring in deeper water. Many of these platforms were made with hydraulic concrete and rubble. Likewise, these sites used artificially enhanced breakwaters built atop reefs filled with ashlar blocks or rubble and mortar (Stone 2014:572-573).

The smaller regions in North Africa had fewer examples of advanced artificial technology. *Mauretania Caesariensis*'s largest harbor was at Iol Caesarea which had artificial structures linking the coast with its two offshore islands. It had an inner and outer basin, which may have served both military and commercial purposes. The remains of a sanctuary and lighthouse from the reign of Juba II place the site between 25 B.C. and A.D.23. There were three other ports near Iol Caesarea built with similar plans and layout, including offshore islands linked to the shore by jetties. Tipasa offered extra docking space with three jetties to islands and its breakwater. Thalefsa and Ras el Meskouta were rural and very likely villa harbors. Though it ranks third in size, *Cyrenaica* had one of the largest and most complex harbors in North Africa at Appollonia. It had two natural bays framed by promontories already sheltered by two offshore islands. Ship sheds were built there in the fourth century B.C., and then further expansion occurred in the second century B.C. when a lighthouse, a fortification wall, and a channel connecting two bays were added. Quays, breakwaters, jetties, and storage facilities followed shortly thereafter (Stone 2014:575-576).

The largest of the Roman North African harbors are the most well-known. Carthage lies within *Africa Proconsularis* and boasted several enclosures, jetties, and quays resulting in 4,730m of docking space, the largest outside of Alexandria. Before the Romans the site

originally had been occupied by the Phoenicians and then inherited by their descendants, the Carthaginians. After its wars with the Romans, Carthage was levelled and subsequently reimagined as a Roman colony. Construction had begun before Roman intervention. Two man-made harbors were excavated; one was closer to the end of Carthaginian independence in 146 B.C. while the inner circular harbor was used as a naval arsenal during the third Punic War (149-146 B.C.). Presumably, the outer rectangular harbor was meant for commerce. The quays in this period were between the city wall on the seaward side to the east and a sanctuary in the west, connecting to the inner harbor on the north and south sides. Under Roman rule an island was placed in the middle of the circular harbor, but it was turned into a colonnaded public space in the later second century A.D., outfitted with a temple and then office-like rooms where several *ostraka* detailing olive oil shipping in A.D. 372-373 were found. The harbor quayside likewise hosted several buildings associated with harbor control, planning, and perhaps even manufacturing which indicated a possible harbor marketplace. The rectangular harbor was extended and modified with a new Roman entrance, and extra moles offered extended mooring possibilities. Roman warehouses built along the coast contained cells to accommodate cargo from the grain fleets. Archaeological evidence identifies activity at the warehouses and in the supposed marketplace until well into the seventh century A.D. (Hurst 2008:50-56).

Lepcis Magna, the home of Septimius Severus, had another famous harbor system. It is located 130km southeast of Tripoli and was used by the Phoenicians as far back as the twelfth century B.C. The Roman harbor was built under Nero at the end of a wadi (seasonal river) east of the city proper; Hadrian later had a dam built there. Nero originally built the harbor, but it was enhanced by Severus. He developed a circular basin with channels that had a circumference, and, therefore, docking space, of 1,200m, and overall it covered a total space of 102,000m^2. The

1,200m of docking space included jetties, colonnades, and quays. At the northwest end of the harbor pier there was a square-based lighthouse, estimated to have three floors. In the east there was another small tower, and south of that were temples and more docks. Most of it was made of concrete with facings of square blocks. Much like Carthage, Lepcis Magna survived well into the late Roman and middle Byzantine periods. Unfortunately, Hadrian's dam broke sometime in the fourth century A.D. and left the basin to silt and become unusable between A.D. 550-650 (Beltrame 2012:321-322).

Vada Volaterrana

Rutilius Namatianus describes landing at Vada Volaterrana in *A Voyage Home to Gaul*. He claims that in order to dock at the harbor the boat needed to go through the deepest part of a treacherous channel. Supposedly this channel had boundaries of hammered piles, or timber, on each side to indicate its sandbars. Atop these piles they attached laurels so that they were visible through the shifting bank of seaweed (I.95). Unfortunately for my research, the ancient port is most likely buried beneath the present-day Solvay company's jetty, which takes advantage of the area's good anchorage and protective sand bars (Pasquinucci 2014:20). As of today, the actual port facilities cannot be examined directly and so we must make inferences from available comparative material. The eight buildings and structures that remain within the harbor quarter of Vada Volaterrana are also of importance because their size and the techniques used to create them may offer direct insight into the lost harbor structures.

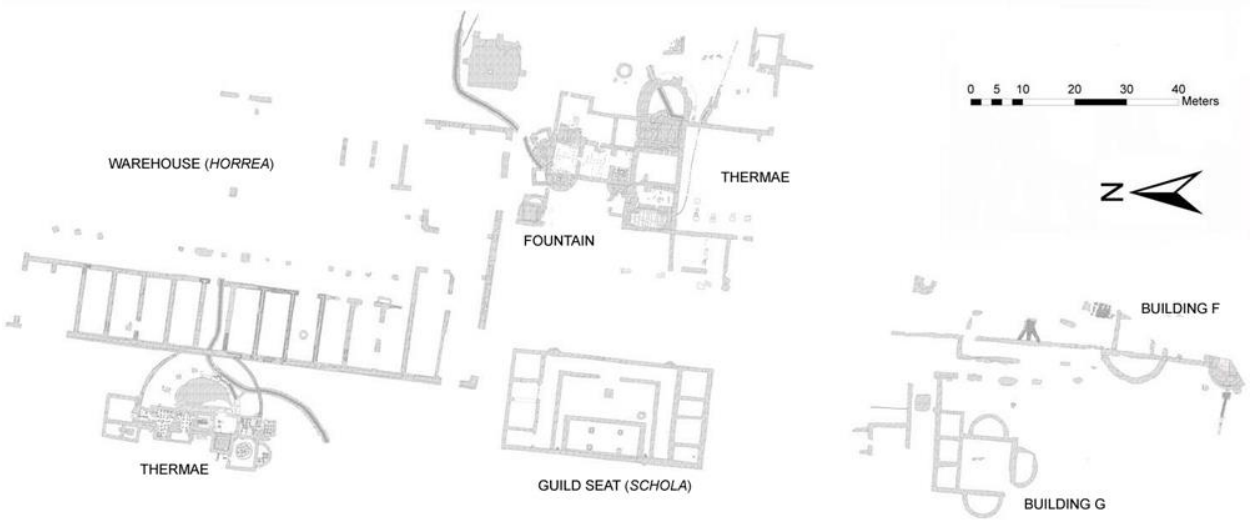


Figure 16. The Archaeological Area of San Gaetano di Vada (Courtesy of Digging Vada Volaterrana Website http://www.diggingvada.com/wp-content/uploads/2014/01/HARBOUR2.jpg).

Bath buildings were important to the Romans. Not only did they allow for bathing, but often business was conducted within their walls. It is relevant to know what building materials were used to create waterworks in Vada Volaterrana. Two baths were located in the harbor sector. The Large Bath dwarfed the Small Bath in a ratio of 3:1. It was intended for public use and was oriented towards the Via Aurelia. It contained a praefurnia, tepidarium, caldarium, laconicum/sudation, frigidarium, a gym, and a service room. The southern wall had a porch with square pillars that overlooked the entrance and enclosed the space for a gym. The caldarium was embellished with exedras that held benches. The building also had pilae to support decking of brick bessales, though without archaeological remains of its upper parts there is no way of telling if it was heated through tegular mammatae or tubules as in the frigidarium. The floor was made of *opus sectile*, that is, geometric patterned tiles sometimes made of marble, and there is evidence that imported mosaics covered the walls. The remains of a statue of Attis dating from the second half of the second century A.D. were also discovered (Pasquinucci and Menchelli 2005:397; Pasquinucci et al. 2008:379-380). A well connected to the Large Bath, was built upon

pebbles with a brick structure that was packed with mortar before it was plastered (Pasquinucci et al. 2008:380). The Small Bath probably was intended for those who worked in the *horreum*; its eastern wall was shared with the warehouse. Its eastern, semi-circular side was an open area surrounded by a portico marked by the remains of the pillars. Like the Large Bath, some floors were made of mosaic and marble coatings, though later they were replaced by brickwork that had predominated in buildings at Ostia. The final waterworks is the monumental fountain northwest of the Large Bath. It was built on a quadrangular block facing the warehouse. In its second phase its former shape had either been destroyed or raised higher. Both times it was made of concrete with terracotta piping (Pasquinucci and Menchelli 2005:396).

Opus caementicium, ordinary Roman concrete, was used in Vada primarily for building foundations. Early walls in the area were replaced at one point with *opus vittatum* faced with local limestone blocks. The floors were made of semicotti (clay) bricks and often covered with stylistic tiles. Many gabled roofs had wooden beams with roof tiles (Pasquinucci et al. 2002:94). This was the case with the warehouse which was rectangular and ran around a central colonnaded courtyard. Its cells were symmetrical from the east to the west. The eight largest cells, four at the southern and four at the northern ends, were 18 by 5.5m while the remainder were 11.40 by 4.4m. The entrance was not on the coastline though it did face it. Its entrance was about 1.80m, which allowed a moderate flow of goods in and out of the cells. The goods were brought by cart. It has been surmised that the size of the cells, the building materials used, along with the lack of grain minerals and charring means that the warehouse primarily held amphorae, which contained wine, oil, garum, foodstuffs, or other goods that have left no record (Pasquinucci and Menchelli 2005:395-396). Nevertheless it is still possible that grain brought into Vada Volaterrana could have been stored in the cells or elsewhere, perhaps even in the city

proper. Vada Volaterrana acted as a harbor for the city of Volterrae, so the fact that there is no evidence yet for any grain trade in the harbor context may just imply that grain was either not held there for very long or was stored elsewhere.

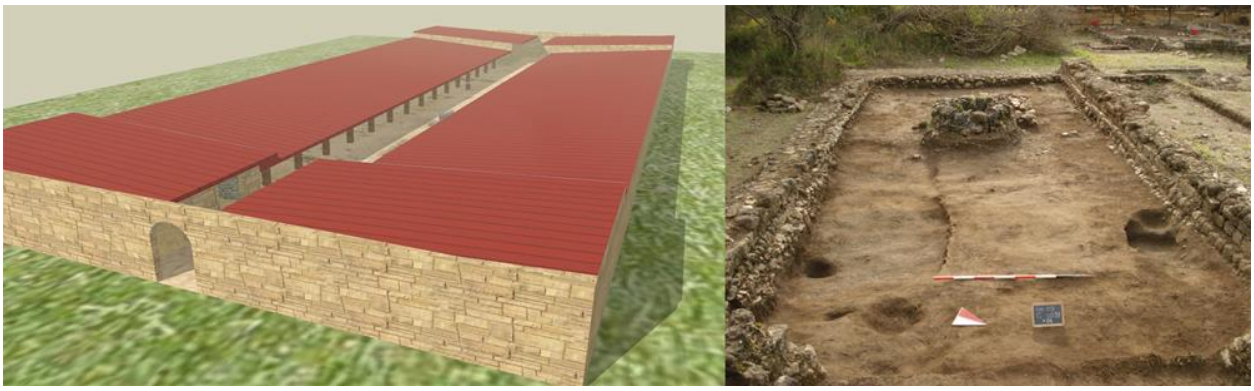


Figure 17. Three Dimensional Reconstruction of the Warehouse at San Gaetano di Vada (Courtesy of Digging Vada Volaterrana Website http://www.diggingvada.com/wp-content/uploads/2014/01/HARBOUR.jpg.)

The remaining buildings used similar materials in a similar manner. One has been identified as the home to the guild (*collegium*) that helped run the harbor facilities. This building was 36 by 18m with an entrance on its eastern wall beside a stone and brick base that once held a statue or votive. Its main room had three walls which left a large, decorated open area. A porch-corridor with paved tiles led into four rectangular rooms from the north to the south. Against the western wall there was a 15 by 6m rectangular room with four pillars of *opus vittatum*. In the southwest corner two wells had been dug and filled with animal bones, and there were two exedras on the eastern side of the portico. University of Pisa archaeologists believe the many religious aspects, the overall design, and the building's open area reflect preferences of guilds seen elsewhere in the Roman world during the empire. An *aula* (open courtyard) southeast of the warehouse has been attributed to the *collegium* as well. It is 8.80 by 8.60m with foundations of cement, strong walls, and five pillars that may have once held up a vaulted ceiling (Pasquinucci and Menchelli 2005:397).

Buildings G and H have been discussed and studied repeatedly through the University of Pisa's long archaeological project in order to determine their original functions. At first, Building G was thought to have been related to the *collegium*. Its strange plan contained a hallway, a central area with three apses, and larger rooms measuring 4x1m which, in addition to rich wall paintings, made it one of the wealthier-looking buildings (Genovesi and Bulzomì 2013:1; Pasquinucci and Sangriso 2010:363). At one point its northern wall collapsed, forcing it and other buildings to be replaced; however, remains of the original style date the building to the first century A.D. and make it the earliest of the buildings (Pasquinucci and Menchelli 2005:397).

Building H may have more to offer. Outside of it, and included in what is called Complex H, is a courtyard containing a basin and a kiln. The building was analyzed through GPR. It measured 4 by 5.3m with 90cm thick walls and two large apsidal rooms. Certain readings indicated a water tank or the ruined remains of a stairwell; if there was a stairwell it obviously indicates a second floor. Both marble slabs and pottery fragments were found inside, as well as a trash pit dating between the fifth and sixth centuries A.D. (Genovesi and Bulzomì 2013:1-3). Later discoveries suggested that Complex H, and thus the building, were somehow involved with the terracotta piping to the fountain. During excavation it was discovered that the piping was broken in order to get to the water supply late in the site's life. The upper mouthpieces were found not to have male or female joints but a smaller opening. There was also evidence that cracks in the pipe were fixed, one of which had a lead pipe inserted, though it was presumably taken when dug up in the late Roman period (Pasquinucci et al. 2007:596).

There was evidence of renovations throughout both the imperial period and later antiquity. For example, one of the earlier burials found on the site was dated between A.D. 27-37. Starting in the fifth century A.D., the site was built over with temporary buildings, and the

land was used as a cemetery for amphorae burials. This practice continued until the seventh century A.D. when the site was abandoned (Pasquinucci and Menchelli 2005:396; Genovesi 2014:2-4). Ultimately, we have a site that had a moderate flow of goods from the harbor and substantial buildings to entertain and house those who oversaw that flow. The building materials and overall structure is reflected throughout the empire. The wealth evidenced in the co*llegium* and baths attests to the guild's rise due to the harbor's prosperity.

However, it is important to realize that such prosperity was relative. The harbor adequately served its hinterland, which was full of agriculture and manufacturers. There were wealthy elite, but their wealth does not even match that of Cosa nor that of the larger cities of the Roman world. This is why it is important to compare Vada Volaterrana to these larger sites: juxtaposing the drastic differences between large and small harbor sites indicates what smaller sites were not. Vada did not require the size or opulence seen at Ostia, Portus, or Caesarea Maritima because of its smaller hinterland. Part of the issue is that large harbor sites are anomalies: they served emperors and kings and thus capture the imagination of researcher and the public. It is almost necessary that this project compare them to Vada due to the numerous studies done at these sites. However, Ostia, Portus, Caesarea Maritima, or even Cosa were not average. Average harbors, like Vada or those in North Africa, are harder to find in the archaeological record, but not impossible. These are the sites that will give us a better understanding of Mediterranean Connectivity and how it affected the lives of smaller populations and manufacturers throughout the Roman world.

There is a good chance that Vada's wealth was spent on maintaining its baths and buildings and keeping them decorated and fitted out with religious statues. Judging by Rutilius Namatianus' description of Vada's harbor and comparing it with the materials and styles of its

buildings, it is safe to assume that hydraulic concrete was not used. The sandbars apparently protected the channel and basin, and if further protection was needed an artificial breakwater, or more likely moles, could be made out of cheap, local rock rather than by hiring the more costly concrete workers and their technology. Likewise, its jetties and quays could also have also been made of rock or even timber, which would have been more than adequate at such a site. There are no underwater remains, but little within the harbor sector's buildings suggests the need for expensive artificial facilities. The evidence provided by the warehouse suggests that cargoes were brought to the quays and then wheeled some distance to the storage cells, and may imply small to moderate cargoes were carried in equally-sized vessels. Vada Volaterrana had a harbor system that catered to the hinterland around it, containing a small town, villas, and farms. Volterrae was a distance away and landlocked, but its roads gave access to several ports, and show that Volterrae was not entirely dependent on Vada. Comparative economic evidence from other harbors in the Roman world fit with Vada's own evidence to support this interpretation.

Chapter Four: Economy of Roman Harbors

"[F]ocusing on the supply of Rome as the main stimulus of Mediterranean trade […] greatly underestimates the need created by the development through the Roman empire of an urban and civic culture and way of life based on social inequalities and personal patronage" (Arnaud 2016:118). Roman trade peaked between 200 B.C.-A.D. 200 which is reflected in shipwrecks and archaeological sites throughout the Mediterranean. After A.D. 200 decline set in and continued into the fifth century (Hopkins 1980:105; Wilson et al. 2012:34). Trading patterns on the sea began with cabotage, which meant smaller cargoes and more opportunistic trading at emporia. Traders and sailors, therefore, needed to know what ports and markets awaited them. Many shipwrecks have been found with specific items for specific ports. However, over time ships carried mixed cargoes relevant to the trading patterns of their period (Wilson 2011:53-54). Demand increased, which forced shipbuilders to build ships capable of holding bigger cargoes. Harbors had to provide sufficient space for moored ships, which in turn reflected of the needs of the harbor's hinterland. Those that served needs beyond those of their hinterland were the grandest of the Roman world: Ostia and Portus and Carthage among them. These were built around political and administrative requirement rather than the city's own economic factors (Rickman 1988:265). That is why the present study views harbors and their hinterland as separate entities serving themselves rather than being subservient to Rome's economy. Comparing economic and cultural trends experienced in Rome to the harbors within its sphere of influence allows us to infer the relative wealth and activity of a site.

According to John Opdebeeck there are three mechanisms to Roman trade: reciprocity, *Annona* or redistribution, and marketing (2005:17). If these were the outlets of the driving forces of supply and demand the question arises as to who was involved and to what extent and what

overarching standards were set as guidelines. Trading for essentials such as grain created the framework of shipping, credit, and harbor facilities, which in turn also benefited those trading in other goods (Rickman 1988:260). There are two different theories as to how trading was managed: economic formalism and economic substantivism. The former claims that the empire is governed by a market-based economy that integrated local economies on an empire-wide scale. The latter says that the role of government was in price-setting, requisitioning, and distributing goods. Hopkins offered his own model of tax and trade, whereby the government and elite call for taxes and rent, thereby driving market forces and creating reciprocal flows of taxable resources (Cioffi 2015:11). In 218 B.C. the *Lex Claudia* forbade the senatorial class to possess ships that could carry more than 15 tons, and denied them extra income from large trade ventures (Houston 1988:559). Inscriptions indicate that traders and merchants were usually of low status, but became locally important because of their dealings. Rickman believes that as *societas, familia,* and *amici* these merchants and traders came to work with the wealthier classes in order to finance larger ventures and earn higher rewards. Senators may have used slaves or freedmen to act on their behalf commercially (Rickman 2008:12; Pascal 2015:72).

The wealth that moved through harbors benefitted those working in them and those living in their hinterland. It is, therefore, difficult to pinpoint who "controlled" them. Several suggestions have been made about control of larger facilities such as Portus, but these suggestions do not reflect the conditions of smaller harbors around the Mediterranean since they typically did not have direct imperial contact but were instead dependent on specific local factors. Archaeology has yet to reveal specific answers as to the exact administration of ports. At Ostia and Portus inscriptions reveal titles of state officials who oversaw aspects of harbor life but not their actual activities. It is presumed they were responsible for security, maintaining

entrances, overseeing anchorages, depositing goods in warehouses, and much more. Undoubtedly at Rome there were several officials acting in some capacity. As the Roman Empire expanded it included maritime colonies as defensive posts, and these posts were under the direct authority of Rome. However, as these areas became independent, legally-recognized cities, direct Roman interference ceased (Pascal 2015:63). There are several records of cities acting as port authorities and even cases of a governor getting involved in port authority in the east (Pascal 2016:120). Without imperial support public and private financing was essential and common for harbors. These funds went to creating and maintaining the harbor facilities that in turn bolstered their community (Rickman 1988:264).

As Rome's needs grew so did their ships and likewise their influence over the Mediterranean basin. In the western Mediterranean the south-north route from Africa to Italy served ships coming from Carthage to Rome with the *Annona* supply, but other vessels could stop at harbors along the way up to Puteoli or Rome. Puteoli was the first stop for grain until the middle first century A.D. when the carriers sailed directly for Ostia and Portus. Ships from as far away as Portugal traveled along the southern Spanish coast and over to Ostia and Rome. From Iberia the great west-east route ran from Cadiz to Sardinia via the Balearic Islands and then onward through the strait of Bonifacio. Ships traveled down from Gaul along the coast to Corsica, then by Elba or through the strait of Bonifacio. In the Adriatic the path led from Brindisi to the north. Aegean imports usually came in through eastern Sicily to Ravenna via southern Italy. In the eastern Mediterranean there were three east-west routes: (a) the northern one along the coast of the Aegean, passing through the Corinthian isthmus and gulf of Corinth either to Brindisi or to Messina, with the possibility of diverting into the Adriatic or around to Sicily (b) the central route along the coast of Cilicia and Lycia to Rhodes and the Carpathos Islands, then

to Crete and Sicily; (c) the southern route from Alexandria along the coast of Africa to Paraetonium or Cyrene, and then on to Sicily and further north (Opdebeeck 2005:28-31).

By the early second century B.C. grain became the most important commodity for Rome. By the time of Nero, the annual figure of imported grain reached nearly half a million tons. The carriers had a capacity of 50,000 *modii* (340 tons) and if the grain was packed in sacks so that they could be carried by one man, as many as 7,500 sacks per ship would have to be taken up the Tiber. Rather than face a shortened supply Claudius granted civil rights to individuals who built ships of at least 10,000 *modii* (70 tons) to transport grain for six years. Owning large ships was costly, and grain seemed the only product that could fill a ship's entire hold; thus another product, such as oil, would not bring the owner the same payout. As such, a century after Claudius exemptions from the liturgies (financially supporting the Roman public) were offered to anyone who built a ship of 50,000 *modii* (350 tons) or several that could hold 10,000 *modii* each and put them in service of the *Annona*. The empire continued to have a hard time raising larger ships because those with holds of 70 tons capacity or less were more versatile and did not confine their owners to long-term service (Houston 1988:558-560). Wine and oil were exceedingly popular, especially those from Campania and exotic types from abroad. Large amphorae could hold 20-30 liters (upward of 100 pounds). Carriers usually transported between 2,000 and 3,000 amphorae in their holds. Timber and building stone were also important in the late Republic and the empire as a result of expansion and luxury works throughout the Mediterranean (Casson 1965:31).

The majority of merchants originally owned smaller vessels, and larger merchantmen do not come into play until after 100 B.C and start to drop off after the fifth century with the decline in Roman trade (Wilson 2011:39). The ebb and flow of trade is best exemplified by pottery

sherds. From the Augustan period to the mid-first century Italian terra sigillata pottery was distributed throughout the Mediterranean and even as far as India. Pottery from the east, especially the Aegean, was popular but usually as luxury items. Gaulish Samian ware then became the staple in the central and western Mediterranean. By A.D. 90 African Red Slip ware from Tunisia became the dominant ware throughout the western and central Mediterranean. North African pottery, oil, and garum continued to be imported from the third to the seventh centuries, and thus survived both the sharp decrease in other pottery centers and the split of the empire. This trade was cut off by the Arabic invasion of North Africa in the 640s, which caused the Italian peninsula to turn to local production once again by the eighth century (Whittaker and Garnsey 1997:285-286; Wilson 2011:38-39).

The Italian Peninsula

Ostia and Portus

Before its growth, the area around the city of Rome supported various agricultural pursuits. On its eastern side there had once stood a lagoon, to the north and against the Tiber was an overlay of alluvium, and in the south there was marshland. Although marshland could be dangerous it provided Rome with salt beds which were accessed early in its history and then again during the Middle Ages. The northern end of its plain had good soil, though it needed drainage in the winter and irrigation in the summer for healthy grain to grow. Farms and villas appeared in those areas, though their extent is uncertain. The soil could also support vegetables and a few fruits. Workers of these fields may have had large farms or a small patch of land that yielded harvests to be sold at a market in town. There was also demand for cattle and poultry. Ostia and the Tiber River provided lupus, eels, gray mullet, sturgeon, and shad as well as prawns. Early on, the area most likely had timber for building construction, which was later

replaced with concrete, tufa, and brick. There still may have been some sources of timber when shipbuilding became more widespread. In total, early Rome was most likely able to support itself until just before the first Punic War (Meiggs 1973:263-268).

In the third and second centuries B.C., Italian black-glazed pottery dominated the Roman market. By the end of the Republican period it changed to red-glazed decorated ware from Italian manufacturers. By the Flavian period Gallic pottery and imported glass had become popular. As mentioned, oil and wine were coveted commodities. In Ostia, beneath the present-day museum, large earthenware jars (pithoi) stood over four feet tall and held the contents of about 40 amphorae (230 gallons). The largest found contained 100 jars (20,000 gallons) worth of wine or oil meant for Ostia alone (Meiggs 1973:270-275). Between 1998 and 2001 the DAI-AAR project excavated 37 sondages of roughly the same size in order to track the trends of importation of amphorae-borne foodstuffs to Ostia. They gave special attention to fabric groups, total sherd count and weight, vessels represented by rim sherds, and a maximum representation of diagnostic sherds minus joints.

The vessels spanned a gap between the first and fifth centuries A.D. Their first group of sherds comprised 3,367 pieces dated A.D. 50-100. More than half of the wine amphorae was Italian with a mix of Campanian and Etruscan. A fair amount also came from southern Gaul, then Iberia, and the eastern Mediterranean or Black Sea area, with next to nothing representing wine from North Africa. Amphorae that carried oil or fish sauce were predominantly from Iberia (75%) while the remainder had been shipped from North Africa. The second group of 7,991 pieces dated from the first half of the second century. Wine imports seem to have declined and came instead from both Iberia and the eastern Mediterranean. Campanian containers were rarer after the eruption of Vesuvius in A.D. 79. Oil and fish containers seemed to be imported in much

the same way. The third horizon contained 2,610 sherds dated A.D. 280-350. The rise of North African amphorae is clearly seen in these remains as North Africa was responsible for half of all the sherds. Oil and fish sauce represented two thirds of the sample, dominated by North Africa but with minor imports from Iberia. The wine mostly came from the eastern Mediterranean. The last horizon of 2,165 sherds dated A.D. 350-475 and was characterized by its oil and fish sauce imports. 91% of these imports came from North Africa, while 55% of the sherds for wine amphorae originated in the eastern Mediterranean, but Italian ware seems to have made a comeback, representing 44% of the mixture (Martin 2008:105-109). The change in trends at Ostia reflects trends seen elsewhere in the Roman world, including Vada Volaterrana. Rome had once manufactured its own goods before imports became more frequent. As the wealth within the Italian peninsula dwindled, so too did goods from the east. The most direct partner was just to the south in North Africa where hydraulic concrete had allowed cities and production centers to create and reconstruct strong, lasting port facilities that could cater to the needs of the Italian peninsula quicker than other areas of the Mediterranean.

During the late Republican period the rural population around Rome declined. In the late first and early second centuries small farms gave way to *latifundia*, large agricultural estates managed by absentee owners who lived in Rome proper. Slaves were brought in to work these lands, which Giovanna Vitelli believes may have played a role in lower grain output as slave labor proved more fruitful in other ventures such as pastoral ranching or vine and olive cultivation. The importation of slaves into Italy swelled Rome's population forcing a grain distribution in 53 B.C., which granted free grain to 320,000 citizens. In order to supply just one person in the city with grain it would take as many as nineteen working out in the fields, which caused the lands around Rome to be used for animal husbandry and cereal output purely for local

consumption in smaller communities (Vitelli 1980:56). By then sea trade had become a much cheaper and more expansive option, which forced *latifundia* to turn to luxury products because of the massive amounts of grain coming from Egypt, North Africa, and Sicily (Vitelli 1980:56). Unfortunately, as previously stated, there is no direct evidence in the warehouses at Vada for the storage of grain. There may yet be an undiscovered area for grain storage, but it appears that the agricultural hinterland around Vada was either self-sufficient or received grain in another way. Therefore, the importance of the grain trade for this research is that it led elsewhere to the creation of grand warehouses as well as numerous jobs and guilds that can be compared to the evidence from Vada.

The numerous large warehouses in Ostia and Portus were created to store grain and other foodstuffs for Rome and their own populations. The majority of these warehouses had quadrangular plans with individual storage cells along the sides of a courtyard like the Horrea of Hortensius and the Horrea Galbana at the banks of the Tiber (Vitelli 1980:58). The House of the Lararium, for example, contained ten to twelve rooms situated around an open court (Meiggs 1973:277). With some exceptions, they were usually only a single story with buttressed walls to prevent collapse. The cells were usually structured the same as one another, but with differences in placement of air gaps. They were often covered by stone barrel vaults ranging anywhere between 7 and 17.5m in height dependent on how high goods were stacked and the placement of the warehouses in Ostia or Portus. The floors were made of travertine and were about 30cm above ground level in order to keep grain dry. There are remains of pins that allowed doors to open towards the outside. The walls were 90cm thick, as at Vada, to prevent moisture and temperature changes. As mentioned, some warehouses had small air gaps while others had channels in the floor to create insulating air gaps to protect the interior of a cell (Hermansen

1981: 228-232; Pagliaro et al. 2015:561-565). Those with second stories often had homes or offices above their cells such as the Horrea Epagathiana et Epaphroditiana, which had been owned by two freedmen.

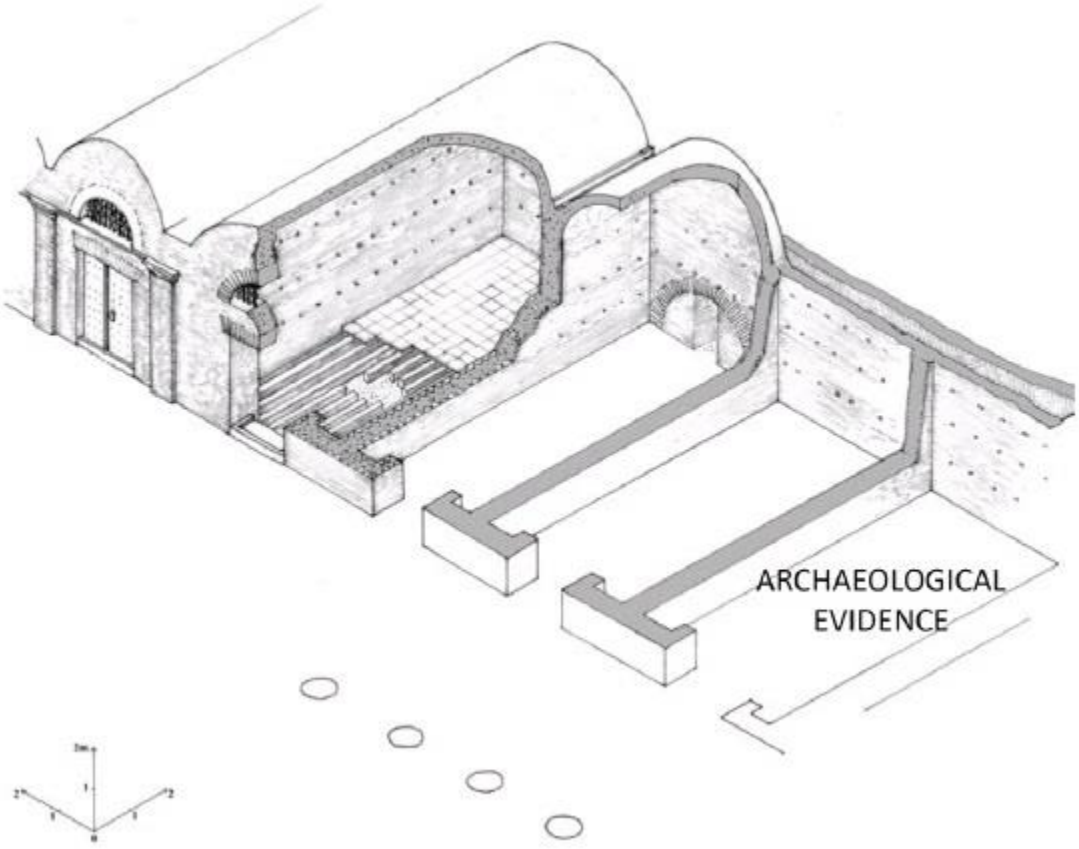


Figure 18. Axonometric reconstruction of a warehouse cell at Portus (Pagliaro et al. 2015:562).

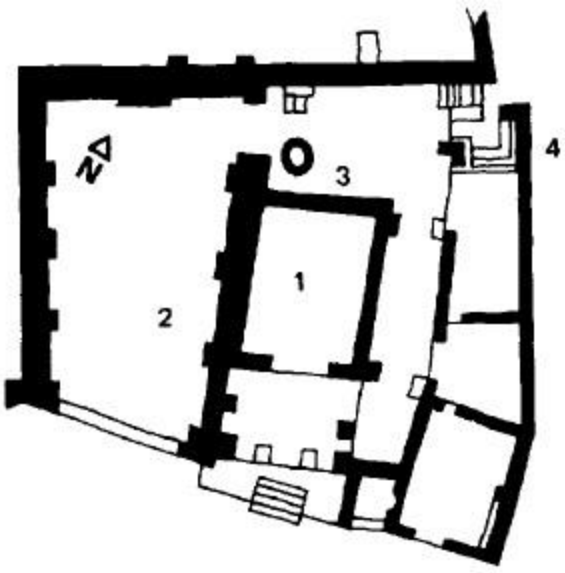
Over time the decrease in size and function of warehouses in Ostia reflected the levels of prosperity or decline throughout the empire. During the Claudian era *horreum* courtyards occupied almost half the available space of the building, while in the Flavian period these areas were reconfigured to contain even bigger storage facilities, with rooms arranged in rows along corridor-like spaces. In the former period the warehouses were along major city roads or along the Tiber with their entrances facing their main modes of transportation. At Portus more warehouses were built, making up almost all of the buildings around Trajan's basin. It is around

this time that warehouses became more directly linked to the government. With imperial influence they could continue to function and, therefore, support the city even when it began to decline in the third century (Vitelli 1980:58-65; Boetto 2002). Not all warehouse space was meant for grain, of course. Wine, oil, and other foodstuffs were brought in by ship and were stored there before going to Rome. Regardless, the warehouses of Ostia and Portus were some of the largest in the world during the Roman period. While the techniques used are similar to what we see at Vada, these structures not only outnumber Vada's but completely dwarf them which lends credence to the idea of self-sufficiency at Vada and the presence there of a warehouse for wine, oil, garum, and luxury goods.

The administration of major ports is still a bit of a mystery for archaeologists. Likewise, at Vada no detailed administrative inscriptions survive. Instead, it is more useful to look at the evidence of who benefits from the harbor economy at Ostia and Portus and compare that information to what is known for Vada. Generally, these individuals were merchants or traders in addition to guild members. An influx of people from different backgrounds moved to Ostia after it was established as a major harbor for Rome. This number swelled further when Portus was created. When trade shifted from Puteoli to Ostia merchants were granted several boons such as exemption from the penalties of the *Lex Papia Poppaea* of AD 9 for those unmarried and without children, and then under Claudius they were offered insurance against losses at sea. Latins were offered citizenship if they engaged in the grain trade for six years, and later merchants were given exemptions on harbor taxes and municipal tolls in order to keep the imperial capital in good supply. From Augustus to the Flavians these tactics were successful in bringing workers to the docks and wharves. Numbers only began to dwindle in correlation to the empire's prosperity (Vitelli 1980:57). Early on economic enterprise was based on a system of

friendship and patronage, but when merchants were deemed necessary to fulfill demand Ostia and Portus turned into a free market with occasional government intervention. Merchants who worked in Rome or Ostia would send agents (knights or freedmen) abroad to purchase and sell goods or to oversee shipping. Merchants often had companies with investors. A system of checks was put in place to monitor wealthy traders: courts settled disputes and contracts bound involved parties (Kessler and Temin 2007:316-325).

Another system of checks against moral hazard were the *collegia*, or guilds. These men worked as unskilled labor within the harbor for unloading, storing, or transshipping. Thus they moved goods to make sure merchants did not tamper with them in order to save money. They acted as "self-enforcing cartels" who could deny membership to outsiders or punish members who had stolen or otherwise proven themselves untrustworthy (Kessler and Temin 2007:326). *Collegia* held elections for membership, required fees and oaths, and elected their own officers for five year terms to manage the business operations. Often these were lower class men, including freedmen, who followed in their father's footsteps (Kessler and Temin 2007:326). The inscriptions and evidence for guilds at Ostia and Portus is almost overwhelming. There guilds could focus on one specific good or aspect of Ostia or Portus as compared to smaller sites where one guild would run the entire operation. At Ostia and Portus numerous guilds were dedicated to specific parts of grain shipping and its related services, such as those for *lenunculi, codicariae, lintres* and the *scaphae* which were all types of lighters or barges shipping goods from one place to another within the harbor or up to Rome; the *sacomarii* were weight controllers; and the *mensores* measured cargoes. Similar guilds were dedicated to other areas of commerce, transport, trades, or civil services as well (Casson 1965:34-35; Hermansen 1981:56-58).



14.
Seat of the grain measurers' guild. 1. Temple of Ceres Augusta.
2. *Schola* of the guild.
3. Yard with well.
4. Latrine.
Scale 1:500.

Figure 19. Example of the seat of a guild (Hermansen 1981).

Guilds could number over two hundred men or involve barely twenty, but all guilds had to have formal sanction of the Roman senate or the emperor. Under Marcus Aurelius they were allowed to hold property and inherit legacies, own, and free slaves before the later empire apparently conscripted the guilds into working directly for it (Hermansen 1981:311-312). Slaves most likely handled harder labor or maintained the guild halls. If they were freed they sometimes took the name of the guild and continued to work within it, as did their sons. They could even rise up to office within their respective guilds. While men were confined to one guild most remains of *scholae* indicate that they were fairly wealthy.

Scholae were headquarters for the *collegia* where they held meetings, various festivities, and also performed religious functions. These buildings were often embellished with decorations such as mosaics that reflected the guild's wealth. For example, a mosaic of *mensores frumentarii* depicted a grain measurer with helpers and controllers as well as a statue base with an inscription to honor their patron. Wealthy guilds could even build their own temples. Religion was a constant for every guild, and they often had their own *genius* or patron gods or goddesses. The

schola del Traiano had one of the largest temples dedicated to Fortuna with an expansive vestibule and marble columns. Other important deities for the guilds were Bona Dea, Hercules, various eastern cults, including Mithraism, and Cybele with her lover Attis who were the chosen deities of the guild at Vada Volaterrana (Meiggs 1973:324-332; Hermansen 1981:59-74). By the third century guild halls and their temples stopped expanding and were either repurposed, abandoned, or harvested for marble as the volume of trade began to decline. With crises befalling the empire, its eventual split, and the silting of important harbor facilities there was less money, if any, to be made by guilds whose members over time were forced to find work elsewhere.

Cosa

The complex at Cosa is large enough for us to infer that it was meant for commercial use although inscriptions as to who built it, controlled it, or benefited from its enterprise have yet to be discovered (McCann 1988:104). Maguerite McCann believes that the equestrian class rose as businessmen under the Gracchi since in that era they were allowed to handle government contracts, engage in banking, collect taxes and port dues, and even engage in private enterprise. It was also acceptable and popular for the wealthy at this time to have both urban and rural homes, the latter of which could have been involved in different forms of trade. At the end of the Republic Rome expanded by land and sea, and eventually it opened ports to free trade. Pompey's command against piracy in 67 B.C. also made the waters a safer, cheaper, and quicker means of transportation. At Cosa the earliest trading ventures occurred early in the third century B.C., though its enterprise would peak in the late Republic (McCann 1987a:31-32).

Cosa was most likely the home port of the Sestii family in the late second and early first centuries B.C.; they were famous for their wine throughout the Mediterranean to judge by their amphorae so far found at thirty different archaeological sites stretching as far as the agora in

Athens. In all likelihood the family owned not only a villa but a vineyard (McCann 1988:104). The Sestii family can be traced back to the late third and first half of the second centuries B.C., and Lucius Sestius served as a tribune in 91 B.C. They were a wealthy family who benefitted from shipping pottery, wine and *garum*. Most likely their financial status also reflected the port's. As previously mentioned, the port may also have been a test site chosen for an early hydraulic concrete formula. While citizens of a town were known to support their harbors, most likely the Sestii family invested a large sum into the facilities at Cosa in order to pursue their economic success (McCann 1987a:34;41).

Amphorae of the Sestii are notable for their distinct shape as well as the family's stamps and the symbols placed upon them. The family is attributed with creating the first Roman amphora of the Greco-Italic type. The sherds from this early pottery makes up 9% of the total material found at the site. The clay used was made from volcanic materials surrounding the site. Later the amphorae developed into Will Type 4, which predominated at the peak of the harbor. They were tall (over 1m high) and slender with long necks, a flaring lip, vertical handles, a narrow belly, and a solid toe dating to the end of the second century and into the first century B.C. 86% of the sherds of Will Type 4a were branded with the 'SEST' stamp although they make up only 70% of the total amphorae found onsite (McCann 1985:118-121). In total over 2,300 sherds were found at the harbor including Will 4a, 4b, 5, Dressel 1a, 1b, 1c and Greco-Italic 215. The sheer number of them that carried stamps or symbols of the Sestii including the letters of their abbreviated name, the Cosan lighthouse, a trident, an anchor, and other maritime imagery indicates that Cosa was a port made for exports (Will 1979:341; McCann 1988:107).

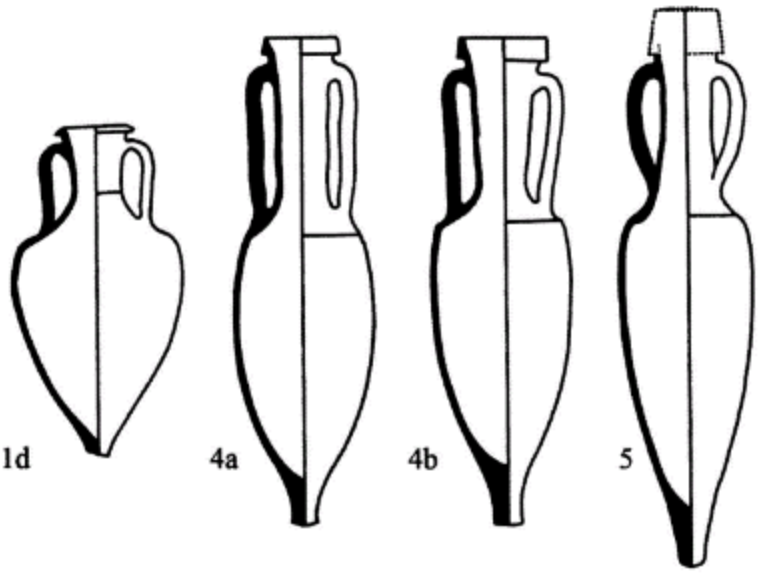


Figure 20. Dressel-type amphorae from Cosa (Gazda 2008: 288).

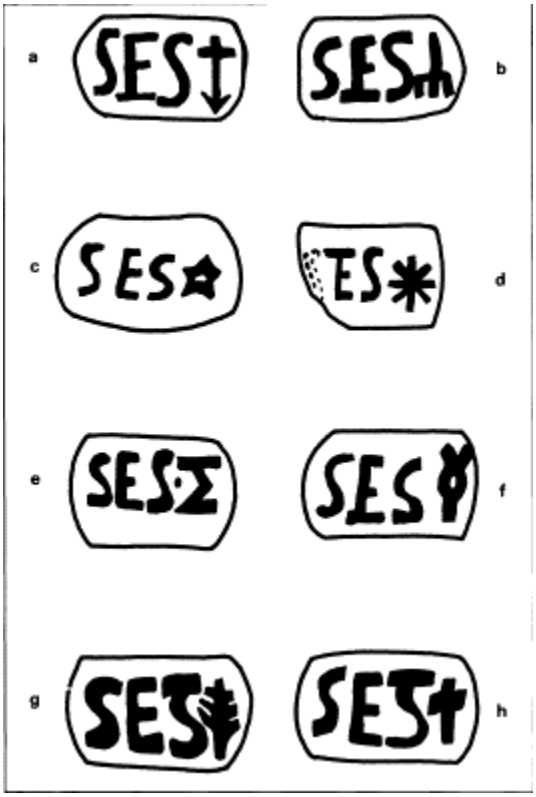


Figure 21. Sestii family amphorae stamp examples (Will 1979: 343).

As previously mentioned, Sestii exports extended eastward as far as Greece and evidence of their exports was also discovered at a wreck off Grand Congloué, an island near Marseilles. Two Roman merchant ships were wrecked at the site, but the uppermost one, excavated by

Jacques-Yves Cousteau, dated to around 100 B.C. at the time Cosa was beginning to reach its peak. There were over 1,200 amphorae stamped with ‘SES’ on their rims. They were Will Type 4a and held 26 liters of wine (Will 1979:339; McCann 1988:105). Cosa was also known for its nearby fishery and its export of *garum*. Its fish farm was located in a nearby lagoon containing concrete fish tanks over 100m long, and it occupied over a hectare of space. Today they are silted, but in antiquity they were connected to the sea by a series of channels now known as the Tagliata and the Spacco della Regina. These channels, cut in part from the bedrock, allowed the circulation of water to control the temperature, oxygen levels, and salinity of the brackish lagoon. The Tagliatta sluice gates were fitted on the seaward section to both control the flow of water and to catch fish. For instance, at high tides it carried seawater and fish into the lagoon, but when the lagoon’s level was high it carried the overflow to the sea. Overall, it is estimated that the tanks could contain about 15,000 kilograms of fish every year. These fish included eels, gray mullet, sea bass, glitead, and sole, which were either enjoyed locally, shipped in boats with wells for holding live fish, salted or dried, or else turned into *garum* (McCann 1985:115; McCann 1988:106).

Figure 22. Sestius-type Dressel 4a amphorae found at the wrecksite of the Congloué (Will 1979: 339).

It is not clear what types of vessels were used to carry goods from Cosa. Cargoes from the port included amphorae of substantial size carrying wine and *garum*. The size of these amphorae led to the use of large, flat-bottomed hulls for maximum room. Some of the wrecks along Cosa's shipping lanes at Provence or Liguria are 20-30m in length and 6-10m at their beams, which suggests that they could hold 100-150 tons of cargo. These hulls are the larger examples built, as indicated in the Ostia and Portus section, such vessels were not the norm for Roman merchants. Perhaps the goods of the Sestii were carried out to ships like these, but the port could not handle such large sizes. Smaller harbor crafts like barges, tugboats, or other crafts propelled by oars were needed to service such large vessels anchored outside the harbor. Goods were most likely carried from the ships by stevedores over the course of long hours (Casson 1987:160-162). The hard work is evidenced by human remains found in the lagoon. The remains belonged to a middle-aged male, who was larger than average but healthy and strong. The indentations and stress on his remains indicated that there had been substantial weight on his shoulders, as if he had been worn down by carrying heavy freight for hours on end (Angel 1987:315). Evidence attests to a guild supporting the temples to Mater Matuta and Portunus in the town, and so perhaps this man had been a member. The guild would most likely have worked under the Sestii as unskilled labor since the port fell into relative dormancy in the first century A.D. There was a time of activity in the second and third centuries when a seaside villa was built on the site, but the port did not see another expansive enterprise like that of the Sestii again (McCann 1987a:33).

Caesarea Maritima

Like many ancient sites, Caesarea Maritima was reused, harvested, and covered over in the periods following the Roman era. Though there were many warehouses along the quays the

remains in them were often of later date. Though some research has been focused on the amphorae of Caesarea Maritima, much of the effort has gone into the monumental structure of the site. Jeffrey Blakely examined one of the vaults used for storage at the harbor's peak under the Romans. Most of the contents were bag-shaped Palestinian amphorae that spanned the early Roman period through to the Umayyad period (beginning in 661 AD). Of the imported amphorae discovered there were Iberian and Portuguese from the first century B.C. One came from southern Iberia and contained fish products, and two were from the Guadalquivir river and carried defrutum and olive oil. A Dressel 1B amphorae filled with blank sand (augite) temper was discovered; originally it likely carried wine from Campania from the first centuries B.C. and A.D. A Dressel 6 from Apulia or the Istrian peninsula contained olive oil, wine, or possibly *garum*. The last piece studied was a Rhodian amphorae from the first century, once filled with wine. These finds suggested that the vault was originally either part of a warehouse or used as one in the first century A.D. and catered to imported amphorae, though the vault was not defined by a single class of goods or a single origin. The local Palestinian amphorae suggest either that foreign imports were substituted for local ones or that the vault changed functions (Blakely 1988:33-43).

The other source for pottery and additional archaeological finds are harbor wrecks. Unfortunately, most of these wrecks seem be later than the harbor's peak. One site on the inner edge of the northern breakwater, for example, contained Byzantine pottery. Another site halfway along the western part of the breakwater contained late Roman amphorae dated to the end of the second century and into the third. Another wreck site from the same time, as dated by bronze coins, was preserved by crumbling bits of the breakwater elsewhere (Raban 1992:113-115). Most recently divers in the Caesarea National Park discovered a ship covered by the seabed; the site

included iron anchors, remains of wooden anchors, as well as other defining features of a sailing vessel. The artifacts turned over to the Israel Antiquities Authorities included a bronze lamp depicting Sol the sun god, a figure of Luna the moon goddess, a lamp made in the image of an African slave, fragments of three life-size bronze statues, and some bronze objects resembling animals. There were large jars that had held drinking water for the vessel's crews as well as thousands of coins compressed into the form of the pottery vessel in which they had obviously been carried. The coins dated to Constantine when it was less safe to use the harbor. It has been suggested that a storm hit the ship at the entrance of the harbor, and when its anchors failed it crashed upon the seawall (Heritage Daily 2016).

North Africa

As previously stated, the harbors in North Africa are in need of further archaeological fieldwork. The evidence compiled for this project showcase North Africa's domination of *garum* and pottery exports in the late Roman period. Unfortunately, early Roman involvement in North African trade has yielded fewer studies than the earlier dominance of the Phoenicians and Carthaginians. Much of the early trade at these harbors appears to be minimal and was undertaken without artificial facilities, which means that beaching or mooring off an unimproved beach were necessary to engage in trade (Stone 2014:579). Gradually after the Second Punic War ended in 201 B.C. North African agriculture and trade increased, creating new markets and corresponding settlements, which were dominated by rich coastal villas, farms, and wine or oil-pressing manufacturing sites (Schörle and Leitch 2012:152). This growth led to artificial port structures, which in turn strengthened the North African economy.

The largest North African export was fish, followed by olive oil and wine, three staples of the Roman world. In the hinterlands of the harbors the villas were closely related to nearby

production facilities including vineyards, fisheries, and kilns. These villas were positioned in highly advantageous places, often close to their maritime outlets and manufacturing centers. A slight decline in amphorae production and the abandonment of some villas seems to have occurred in the third century A.D., which remains unexplained as for the most part North Africa avoided the crises that impacted the rest of the empire (Schörle and Leitch 2012:152; Stone 2014:590). True decline did not come until the Arab invasions in the seventh century as amphorae and tableware remains from North Africa are found at numerous sites on the Italian Peninsula, including at Vada Volaterrana.

Vada Volaterrana

Over the years Vada Volaterrana has yielded extensive evidence of pottery, which allows for exact dating of the site and provides the ability to track specific trends through the changing styles. The main harbor was at the mouth of the Cecina, since covered by the Solvay Company's jetty, and was in use as far back as the eighth century B.C. Roman influence on the site began in the Republican period, and then during the Augustan age a harbor complex was created and continued to function into the sixth or seventh centuries A.D. (Menchelli and Pasquinucci 2006:230-231; Genovesi et al. 2010:93). Goods from throughout the Mediterranean were shipped to Vada Volaterrana in order to be redistributed to the hinterland as well as to Volterrae. The harbor also exported goods with special attention paid to wine and amphorae as attributed to local manufacturing centers.

Vada Volaterrana's main trade route led into the south of Gaul and even up the Rhine river to provide for legionnaires stationed along the empire's borders (Menchelli 2013:250). The harbor presumably was not large, based on the description by Rutilius Namatianus who detailed passing into the main facilities through a channel flanked by sandbanks into lagoon-like shallows

to a mooring station (Genovesi et al. 2010:94; Genovesi et al. 2014:96). The hinterlands were connected to the nearby Via Aurelia and Via Aemilia. They were also abundant in natural resources including cereals, vineyards, timber, and salt. Wine was produced locally and usually stored in Greek-Italic amphorae of Dressel 1a and 1b types that were also locally manufactured. Workshops also indicate metallurgy (Menchelli 2013:250-251).

The pottery analyzed came from excavations at the landlocked harbor site as well as from surveys along the coast. The rural settlements were also examined and dated as early as the second century B.C. by Campanian Graeco-Italian amphorae, cooking wares, and black glazed vessels in the area. Romanization was plainly seen in the painted plasters, elaborate mosaics, marble slabs, and areas for bathing, which helped distinguish simple farming sites from villas (Pasquinucci and Menchelli 2012:1008). Local pottery was probably created at four or five different production sites defined by ancient kiln spacers and the terracotta rings on which pottery was heated to prevent sticking. These kilns dated to the imperial age and were used well into the sixth century (Genovesi and Bulzomì 2013:6; Genovesi 2014:6). The items made in the hinterland contained ophiolite sediment and had to be heated at a very high temperature since they were calcareous (Menchelli et al. 2012:96). Also found in the rural areas outside the harbor, and most likely manufactured there, were 83 fragmentary pieces of brick, roofing material, tiles, fragments of terra sigillata, including the rim of a cup and pieces of a decorated wall, and a fragment of thin walled pottery (Sangriso and Marini 2010:346).

The survey along the coast uncovered a significant number of amphorae and other commodities with varied origins, which most likely represent imports for Vada that had come to rest between the Solvay company and the current mouth of the Cecina (Genovesi and Bulzomì 2013:5). Two wrecks were discovered *in situ* and labeled Wreck A and Wreck B. Wreck A

contained cups and black-glazed ceramics dating to the second century B.C. as well as black painted pottery. There were a total of 39 cups 10-11.3 cm in diameter, with loops and splayed bases. They boasted white decorations and had horizontal bands below their rims; this design became popular in the second half of the first century B.C. in the western Mediterranean and especially around Etruria. There were conical cups between 14-16 cm in diameter, with white decoration and bands below the rims, lobed style, and with a disc acting as a base. Plates of balsam and Greco-Italian amphorae dated from the first half of the second century B.C. The loaded vessel most likely originated in Campania and travelled up the coast headed for a harbor on the French coast where these cups were popular (Genovesi et al. 2010:72-74).

Wreck B was closer to the Fine River mouth and lay at nine meters; it was first discovered in 1971 and then was revisited in 1978. The second visit revealed twenty Dressel 1B amphorae closed with opercula pozzolana and stamps with crescents to form the name M'ani Rufi M'ani. The clay used was red and black, volcanic in origin and probably from the area around Cosa, which dates it to the first quarter of the first century B.C. Over the years other artifacts were recovered from both rivers, including Dressel 1B and 1C amphorae of uncertain production, plating, and millstones. There is also a third wreck at Secche Vada that was discovered in 2000 revealing 6 intact Dressel 1 amphorae and fragments of another four containers (Genovesi et al. 2010:75;93). Looted artifacts were given to the archaeological museum of Cecina in 2010; these included ceramics, bronze, and ingots. Unfortunately, because of this looting they have no clear context, but archaeological dating seems to indicate that the artifacts were not from any known wreck. The ceramics were of Massilot production from the second half of the sixth century or the early fifth centuries B.C., far earlier than Wreck B. This

indicates a fourth shipwreck that may have been lost to archaeologists because of treasure hunting (Genovesi et al. 2010:69-70; Genovesi et al. 2014:69).

The ceramics discovered at the harbor site, notably in the warehouse and surrounding areas, originate from different regions and different periods. The majority of pottery (55%) came from North Africa, followed by Volterrae and Pisa (15%), the eastern Mediterranean (14%), Iberia (12%), and Calabria/Sicily (4%). There were 1,800 fragments of terra sigillata, 417 of which were late-Italic originating at Pisa. Ten intact Sealed Gallic drinking vessels were discovered in the warehouse along with a further 161 fragments of other types of thin-walled drinking vessels, the majority of which had been made in northern Etruria. There were 1,292 pieces of North African sealed earth fineware, which would have been shipped into the hinterland where another high percentage of finds were discovered. Also, 1,550 examples of African kitchenware dating between the first and seventh centuries A.D., were discovered within the harbor. These included 850 pans, 700 dishes, and the remains of various lids.

Figure 23. Pottery discovered at Vada Volaterrana (Courtesty of Digging Vada Volaterrana Website https://s-media-cache-ak0.pinimg.com/originals/87/06/7c/87067cb36e27ba26f6d3513203b903a8.jpg).

The amphorae discovered within the warehouse were either local productions of Dressel types, Spello, or Forlimpopoli intended for northward export. The imports were in Iberian types from the early empire. After the third century A.D., the majority of these amphorae were

replaced by North Africa Keay type amphorae (Sangriso and Marini 2010:346-347). Most common-use pottery was of local manufacture since it was cheaper and not intended as a luxury. Lastly, there were a few oil lamps all imported from the Tyrrhenian coast (Menchelli and Pasquinucci 2006:233-236; Menchelli et al. 2012:98-101). The later imports from North Africa included Lucerne lamps in the "African classical" shape popular in the Mediterranean between the fifth and seventh centuries A.D. (Sangriso and Marini 2010:346).

Figure 24. Pottery at one of Vada Volaterrana's hinterland manufacturing sites (Courtesy of Digging Vada Volaterrana Website http://www.diggingvada.com/wp-content/uploads/2014/01/ACT_SURVEY_2.jpg).

Vada Volaterrana's warehouse has a rectangular plan situated around a central colonnaded courtyard (see Figure 17). Its cells were mostly symmetrical save for four larger ones at both the southern and northern ends, which were 18 by 5.5m, while the smaller cells were 11.40 by 4.4m. The entrance was 1.80m and goods were brought by cart. As we have seen throughout its effective lifetime the warehouse stored impressive amounts of amphorae from different areas. There is no direct indication such as charring or any remains, but it is very possible that grain was stored within the warehouse as well. Because Vada Volaterrana acted as a harbor for the city of Volterrae there is a good possibility that it received grain through its maritime trade. It may be that it was either not stored in the warehouse for very long or else was

stored somewhere else entirely. Air gaps have not yet been discovered, but their discovery would shed light on the situation.

Like many ports, it was not clear who controlled Vada and its harbor. As the Imperial government did not intervene in smaller port installations it is likely that the site was overseen by Volterrae when necessary, but otherwise was largely under the management of the local guild. The guild appears to have been small but wealthy. Its building was fairly large at 36 by 18m, and its entrance had once opened onto a statue or votive of some kind. Its main room had a decorated, open area and another room was decorated with four pillars of *opus vittatum*. The southwest corner may have been a cooking area, and there were two exedras on the eastern side of the portico. The nearby *aula* most likely served the *collegium* (Pasquinucci and Menchelli 2005:397). The embellishment of its office indicates surplus wealth earned from the multitude of duties at Vada Volaterrana.

Unlike Ostia and Portus, there were not numerous guilds for different tasks at Vada. With only one guild, members would pilot the lighters used to bring goods in from larger merchantmen offshore, act as divers if anything fell overboard, measured and catalogued grain or amphorae, managed storage, and oversaw distribution among other tasks. During the 2015 field school the body of a male in his early twenties was discovered dating from the early empire. His bones showed no evidence of disease, but they did display the effects of extreme stress from physical activity. These effects were most evident on the femurs due to the contraction of the glutes during squats or rowing motions. The joint in his femur was also larger than normal from prolonged wear and stress. The strength of his deltoid muscles was apparent in the bones of his shoulders, and the wear on his radius and ulna showed signs of the abnormal arm movement used in rowing. His clavicle was likewise more robust than average (Fulvio Bartoli 2015, pers.

comm.). As a result, there is a distinct possibility that this young man was a member of the guild and involved with more than one task as part of his job. Lastly, like the guilds seen at Ostia and Portus, the one at Vada Volaterrana had its own patron gods in Cybele and Attis as indicated by spaces intended for their statues. Though one of Cybele was not found, the remains of a statue of Attis were found within the *schola*.

Figure 25. Possible *lars familiaris* found in trash pit (Courtesy of Digging Vada Volaterrana Website http://www.diggingvada.com/wp-content/uploads/2014/01/DV-trittico_1000px.jpg).

Periods of crisis occurred throughout Vada Volaterrana's long life. As elsewhere in the Roman world, it most likely peaked during the early empire. There seems to have been a period of crisis in the third or early fourth centuries as indicated by the larger baths being repurposed as a cemetery, specifically for children buried in both amphorae and pit tombs. Vada apparently recovered, however, as new buildings arose in the fourth century, and it still exported and imported goods into the following century. Its farms and several villas were still active and its manufacturing centers continued to produce wine amphorae, common pottery, bricks, and large dolia. During the sixth century buildings started to decay and were repurposed or abandoned. Still, the site welcomed Byzantine commerce in the early seventh century, though this trade

dropped off after A.D. 643 and the conquest of Liguria by Longobardo Rotari of Lombard until the site was only used as a necropolis before ultimately being completely abandoned (Sangriso and Marini 2010:345).

Economy is a function and result of Mediterranean Connectivity in the Roman period. By comparing trends throughout the Roman world to those seen at Vada, we can discuss the relative wealth and activity of the site. Much like Rome, Vada had numerous imports that originated locally in the Italian peninsula which were gradually replaced by foreign products towards late antiquity. At that time, North Africa became a major exporter for the western Mediterranean after the imperial capital had been changed to Constantinople. Still, there is a frustrating lack of evidence on the harbors, small or large, contributing to North African exports in late antiquity. Schörle attempted a study to understand North Africa's place within Mediterranean Connectivity but was cut short. This is not only a problem at smaller sites; Caesarea Maritima's warehouses and vaults have been repurposed several times throughout history. Minimal finds have indicated the trend of imports back to local ware during times of crises occurred at Caesarea Maritima.

The most important features of Vada that indicate its wealth and local significance are its warehouse, its guild, and its surrounding production centers. Though it had a single *horrea*, the method and materials of its construction were like those used in Portus. It had 90cm thick walls to prevent moisture and temperature changes and a second floor for offices above its cells. At Ostia and Portus, guilds were numerous. At Vada, there was one guild that saw to all the aspects of the harbor which is reflected in the luxury of their *schola*. Most likely, the *collegia* and the harbor benefitted from rural production and manufacturing sites. Like Cosa, Vada exported pottery which traveled as far as the Rhine to provide for soldiers, which indicates that Vada

Volaterrana's role in the context of Mediterranean Connectivity extended further than local demand.

Chapter Five: Discussion

The research presented here has diachronically compared the architecture and technology, the economy, and social aspects of Roman harbors to make inferences about the function and life of Vada Volaterrana. This project showcases how Vada Volaterrana both served and benefitted its hinterland, as the majority of Roman harbors did in their respective regions. This is the primary relationship for a harbor and also a component of Mediterranean connectivity. Those harbors that grew beyond the capacity of their hinterlands, such as at Rome or Caesarea Maritima, were exceptions. Although Vada Volaterrana grew from the prosperity of rising Roman power, the harbor governed itself. Not even Volterrae, to which Vada paid tribute, controlled the workings of its facilities, which were meant to serve those living and working in its hinterland. This project has attempted to correlate the similarities between Vada Volaterrana and the other ports discussed to indicate that they were also servants of their hinterland. Though a harbor first serves it hinterlands, its secondary importance is its involvement with other harbors as clusters and nodes of Mediterranean connectivity.

Large harbor sites should be considered anomalies. They are sparse throughout the Roman world, but because of their long-lasting material construction and grandiose size they have become the most recognized. The majority of harbors within the ancient Mediterranean were natural harbors or beaching sites. These sites were opportunistic and familiar to those living in the surrounding areas who then shared their knowledge with people in search of ports and trading centers. Most traders preferred smaller vessels in order to avoid conscription, and because they could easily sustain themselves with simple cabotage to smaller, coastal communities. Small and mid-sized vessels were the most common on the ancient Mediterranean Sea because they were easier to repair and local trade was safer than extended voyages. These

are the types of vessels most likely to have docked at Vada Volaterrana which was an average-sized harbor within the ancient Roman world. Larger vessels would have anchored offshore and used lighters or barges to transship goods.

Vada Volaterrana, as well as the other sites, were known and in use before the Roman presence. Archaeological evidence at Vada goes back to the eighth century B.C. before the harbor was covered by lagoon waters. When those receded, it fell under Etruscan control by way of Volterrae, and its natural anchorage was used to move goods. In the first half of the third century B.C., Volterrae was conquered by the Romans. The city's hinterland swelled with veterans settling down to create farms and villas. Even in the late Republic Vada was still an important landing place according to Pliny, and this importance was most likely enhanced under Augustus. Vada and its hinterland benefitted from the prosperity of the rising empire, and its own growing wealth allowed for the creation of a harbor complex which was then lavishly decorated.

As elsewhere in the empire, a minor crisis in the third century is evidenced by the slight crumbling of buildings and by burials in the larger baths. Half of the villas and farms were no longer maintained, but the remainder continued to function normally. During the following century, many of the harbor's buildings were renovated, and there is evidence that the facilities as well as the manufacturing centers in the hinterland continued working into the seventh century. Like the rest of the Italian peninsula, Vada imported goods from North Africa during this period. Eventually the number of working villas dwindled to two, and only four small settlements nearby were inhabited, reflecting the loss of power and wealth to the eastern Mediterranean. Its trade with North Africa ended only because invasions severed the ties between them. Comparatively, Vada Volaterrana fared much better than other Roman harbor

sites and most likely lasted on a local scale well into the Middle Ages because the natural state of the landing site did not require dredging or renovation. Similarly, Rome used the Tiber in the Middle Ages for smaller vessels with smaller cargoes and for its ease of access.

This project has advocated for considering ports differently. Architecture and technology should be incorporated into broader archaeological studies rather than being the sole focus of them. The spread of technology throughout the Roman Mediterranean was a product of connectivity. Landing sites were dependent on local factors, but Roman adaptation to them led to innovation. Roman harbors were either natural or artificial. Natural sites included beaches and rivers with no manmade interference. Most Roman harbor sites were natural because they were easy to maintain and inexpensive. They were often shallow, which limited both the draft of incoming vessels and the size of their cargoes. Unfortunately, they also left relatively little, if any, evidence for further study. Artificial harbors were mostly natural sites enhanced by manmade facilities. Early on these enhancements were made with local rock and rubble and could include cutting new channels or widening a natural basin. Later, larger sites were enhanced with hydraulic concrete made from the pozzolana mixture originating in the Bay of Naples.

The largest harbors were those of Rome, Puteoli, and Caesarea Maritima, to which comparisons of construction do little for understanding Vada or other small harbors. This is another aspect of harbor archaeology that needs to change. The warehouses at these sites, however, are important for comparison because of their similar construction and use. Because of its smaller population, Vada's warehouses were not nearly as large as those in Ostia and Portus. Still, cell size in the warehouses can be used to estimate the relative size of cargoes stored at Vada, from which we may surmise the size of incoming vessels and thus, also, the size of Vada's harbor facilities. It is difficult to compare the size of Rome's huge *horrea* because they increased

from 17,677 m^2 to 31,882 km^2 by the second century and eventually encompassed 46,118 km^2 by the end of the Empire (Keay 2005:43). The single *horreum* at Vada had eight large cells measuring 18 by 5.5m and smaller ones measuring 11.40 by 4.4m. Clearly, Vada took in much smaller cargoes than Rome, but it still had the capacity to hold cargoes from both small and mid-sized vessels.

Cosa is the only smaller settlement that had a port with concrete. Vada did not have the prestige that Cosa experienced, nor its wealth. It has been estimated that Cosa was either an experiment in hydraulic concrete due to its wine trade, or that because of its trade it was able to procure the funds to have enhancements made to the port. Most likely no hydraulic concrete was used at Vada. Rutilius Namatianus claimed he came through a deep-cut channel protected by sandbars into the shallows which have been accepted as the shallows of a lagoon. In all likelihood, Vada's outer basin on the sea was protected by an artificial breakwater of local rock and rubble, which likewise would have been used for any docking facilities directly on the sea. For vessels within the shallows, rock or timber jetties were used as mooring places.

The economy of Vada Volaterrana reflected ancient Roman trends. While no evidence remains as to whether grain came into Vada by sea or land, it was probably not stored in the warehouse for long before being shipped into the hinterland. The warehouse held a moderate supply of goods that were sufficient for the local people dependent upon the harbor. Most evidence from the warehouse and throughout the site were pottery sherds. There were different types of fineware, common ware, and amphorae which suggest that Vada imported items for different social groups. The findings of the DAI-AAR project at Ostia mirror the sherds found in this project. The finds begin with wine and oil amphorae from the Italian peninsula at the start of the Empire, though amphorae for fish came from Iberia. Towards the end of the Empire Ostia

had switched to importing goods from elsewhere, namely North Africa. The goods from North Africa were far more abundant in small, coastal sites such as Vada after the split of the Empire in the fourth century.

One of the most interesting aspects of Vada Volaterrana was the inclusion of a guild hall (*schola*) placed so prominently within the harbor context. *Collegia* are expansive and numerous at Ostia and Portus, but places such as Cosa and Vada Volaterrana indicate that smaller harbors had a single guild overseeing the harbor. At Vada the *collegium* certainly ran the harbor complex and was made wealthy for it. Their *schola* was finely decorated, though not too elaborately, and they had enough money to fund their own bath house separate from the one used by the public. As in Rome and elsewhere, religious aspects were evidenced by the remains of a statue of Attis, Cybele's lover. Attis and Cybele were patron deities adopted from the eastern Mediterranean. Such borrowing was a staple within Roman culture and prime evidence of Roman social connectivity bolstered by technology and economy.

Ultimately, this project has discussed and compared Vada Volaterrana's timeline, architecture and technology, and its economy, which are components of connectivity, to other Roman harbors in order to establish its place within the context of Mediterranean connectivity. Like other sites in the Italian peninsula, Vada has an extensive history, both prior to Roman occupation and long after the fall of the Empire. Its smaller size, natural landing spot, and fertile hinterland contributed to its survival, which is reflected in other Italian settlements through the Middle Ages. The architecture and technology used in Vada's buildings were like those elsewhere, particularly the warehouses in Rome. The only remaining evidence of concrete, however, was used in the harbor complex's fountain. It is safe to assume that hydraulic concrete was not used in its docking facilities because of ancient descriptions as well as the site's

longevity. The former paints an image of a natural site, probably augmented only by rock and timber. Vada's long life shows how little renovation a natural site would have required. Its longevity is exemplified also by Vada's economy, which parallels other sites throughout Italy.

As a production center, Vada Volaterrana continually exported pottery and wine as far as the Rhine, but its imports were predominantly local before items from the east and North Africa came to be coveted. Vada benefitted from its hinterland and production centers for most of its life until the seventh century A.D. With all comparisons considered, Vada Volaterrana was a place of local and coastal importance within the context of Mediterranean connectivity. The surrounding population, as well as the people of Volterrae, made strong demands on the harbor complex, which the harbor clearly fulfilled. Its mention in ancient literature indicates that it was also an important stop on the route to Gaul. It is the assumption of this project that Vada Volaterrana was an example of an average-sized system vital to its hinterland. Although Vada and its surroundings have been researched for several years, there are still gaps in our knowledge which have limited this thesis. As at other sites, archaeological projects focused on the buildings and artifacts of Vada rather than the extent of its influence. We understand how the harbor served its hinterland, but Vada's influence extended beyond its local sphere. There are remains of pottery from its surrounding production centers at Pisa as well as up the Rhine, but to truly understand its connectivity we need to look further. If imports are one example of connectivity, so too are exports. A project to track the extent of Vada's northward exports is vital to truly understand its place within Mediterranean connectivity. In the future, similar studies should be made on average harbor sites throughout the Mediterranean to recognize their individual importance at the local level which would lead to an understanding of their place within the wider Roman world.

References Cited

Angel, Lawrence J.
1987 "Human and Faunel Remains: Human Bones," In *The Roman Port and Fishery of Cosa: A Center of Ancient Trade*, Princeton University Press, New Jersey: 315.

Arnaud, Pascal
2016 "Cities and Maritime Trade under the Roman Empire." *Connecting the Ancient World. Mediterranean Shipping, Maritime Networks and their Impact*, Christoph Schäfer, ed. Rahden/Westf: Verlag Marie Leidorf, pp. 117-174.

Bartoli, Fulvio
2015 Personal Communication. University of Pisa 22 July, Pisa, Italy.

Beebe, H. Keith.
1983 Caesarea Maritima: Its Stratetic and Political Significance to Rome. *Journal of Near Eastern Studies* 42 (1983): 195-207.

Beltrame, Carlo
2012 New Evidence for the Submerged Ancient Harbour Structures at Tolmetha and Leptis Magna, Libya. *The International Journal of Nautical Archaeology* 41.2:315-326.

Benefiel, Rebecca Ruth
2004 Pompeii, Puteoli, and the status of a colonia in the mid-first century AD. *Pompei, Capri e la Penisola Sorrentina*, Oebalus, Capri: 349-367.

Blackman, D.J.
1982 Ancient Harbours in the Mediterranean, Part 2. *The International Journal of Nautical Archaeology and Underwater Exploration* 11.3:185-211.

Blakely, Jeffrey A.
1988 Ceramics and Commerce: Amphorae from Caesarea Maritima. *Bulletin of the American Schools of Oriental Research* 271:31-50.

Boetto, Giulia
2002 Il porto fluviale a Ostia. *The NAVIS II Project*, European Commission Directorate General X, Brussels.
<www2.rgzm.de/Navis2/Home/HarbourFullTextOutput.cfm?HarbourNR=Ostia-Fluviale>. Accessed 05 December 2015.

Boyce, Joseph I. and Eduard G. Reinhardt
2004 Marine Magnetic Survey of a Submerged Roman Harbour, Caesarea Maritima, Israel. *The International Journal of Nautical Archaeology* 33.1: 122-136.

Boyce, Joseph I., Eduard Reinhardt, and Beverly N. Goodman
2009 Magnetic detection of ship ballast deposits and anchorage sites in King Herod's Roman harbor, Caesarea Maritima, Israel. *Journal of Archaeological Science* 36: 1516-1526.

Brandon, Christopher J.
2014 "Maritime Concrete in the Mediterranean World." *Building for Eternity: the History and Technology of Roman Concrete Engineering in the Sea*, C.J. Brandon, R.L. Hohlfelder, and M.D. Jackson, eds. Oxbow Books, Havertown, PA.
2008 Roman Structures in the Sea: Sebastos, The Herodian Harbor of Caesarea. *Memoirs of the American Academy in Rome, Supplementary Volumes* 6: 245-254.

Brandon, Christopher J., Robert J. Hohlfelder, and John Peter Oleson
2008 The Concrete Construction of the Roman Harbours of Baiae and Portus Iulius, Italy: The ROMACONS 2006 Field Season. *The International Journal of Nautical Archaeology* 37.2: 374-392.

Brown, Frank
1980 *Cosa: The Making of a Roman Town*, University of Michigan Press, Ann Arbor.

Bruno, Vincent J.
1973 An Ancient Roman port in the Archipelago Toscano. *The International Journal of Nautical Archaeology and Underwater Exploration* 2.2, 365-369.

Bull, Robert J., Olin J. Storvick, Edgar M. Krentz, and Marie Spiro
1993 The Joint Expedition to Caesarea Maritima Eleventh Season, 1984. *Annual of the American Schools of Oriental Research* 51: 63-86.

Cassius Dio
1927 *Epitome of Book LXVIII*. Earnest Cary, trans. Harvard University Press. <www.penelope.uchicago.edu/Thayer/E/Roman/Texts/Cassius_Dio/68*.html>. Accessed 12 Jan 2015.

Casson, Lionel
1987 Ancient Shipping in the Portus Cosanus. *The Roman Port and Fishery of Cosa: A Center of Ancient Trade*, Princeton University Press, New Jersey: 160-163.
1965 Harbour and River Boats of Ancient Rome. *The Journal of Roman Studies* 55.1/2:31-39.

Cioffi, Robert L.
2015 Travel in the Roman World *Oxford Handbooks Online*. Oxford University Press, Oxford. DOI: 10.1093/oxfordhb/9780199935390.013.110

Comfort, H.
1976 Puteoli (Pozzuoli) Campania, Italy. *The Princeton Encyclopedia of Classical Sites*, Stillwell, Richard, William L. MacDonald, Marian Holland McAllister, eds., Princeton University Press, New Jersey. <http://www.perseus.tufts.edu/hopper/text?doc=Perseus:text:1999.04.0006:entry=puteoli>. Accessed 25 February 2015.

Comune di Rosignano Marittimo
2015 "Il porto di Vada Volaterrana e l'area archeologica di San Gaetano," Comune di Rosignano Marittimo. <http://www.comune.rosignano.livorno.it/site4/pages/home.php?tipop=vis_pagina&visualizza=left&id=16772&idpadre=16652#.V6ACNfkrLIW>. Accessed 12 May 2015.

Digging Vada Volaterrana
2015 Digging Vada. Digging Vada Volaterrana: Summer School in Classical Archaeology, ArcheoData Società Cooperativa, Pisa, Italy. <http://www.diggingvada.com/digging-vada/>. Accessed 27 February 2015.

Dionysius of Halicarnassus
1939 *The Roman Antiquities*. Earnest Cary, trans. Harvard University Press. <www.penelope.uchicago.edu/Thayer/E/Roman/Texts/Dionysius_of_Halicarnassus/3C*.html>. Accessed 12 Jan 2015.

Eutropius
1886 *Abridgment of Roman History.* John Selby Watson, trans. George Bell and Sons: London. <www.tertullian.org/fathers/eutropius_breviarium_2_text.htm>. Accessed 12 Jan 2015.

Flavius Josephus
2003 Antiquities of the Jews. William Whiston, trans. *The Works of Flavius Josephus*. www.ncbible.info/MoodRes/History/WorksofFlaviusJosephus.pdf Accessed 12 Jan 2016.

Friedman, Zaraza
2002 Caesarea Maritima. *The NAVIS II Project*, European Commission Directorate General X, Brussels. <www2.rgzm.de/Navis2/Home/HarbourFullTextOutput.cfm?HarbourNR=Caesarea>. Accessed 05 December 2015.

Gambash, Gil
2013 Caesarea Maritima and the Grand Strategy. *Skyllis Zeitschriff für unterwasserarchäologie* 1:55-58.

Gazda, Elaine K.
2008 Cosa's Hydraulic Concrete: Towards a Revised Chronology. *Memoirs of the American Academy in Rome, Supplementary Volumes* 6: 265-290.

Genovesi, S.
2014 Vada Volaterrana Harbour Project, Discovering a Roman Harbour in Tuscany 2014 Report. ArcheoData Società Cooperativa, Pisa.

Genovesi, S., M. Giorgio, V. Palleschi, and C. Rizzitelli
2014 *Rotte e commerce lungo la costa volterrana tra II e I sec. a.C. Materiali inediti da relitti e rinvenimenti sporadici del tratto costiero tra il Fine e il Cecina.* Notiziario della Soprintendenza per i Beni Archeologici della Toscana.

Genovesi, S. and F. Bulzomì
2013 Vada Volaterrana Harbour Project, 2013 excavation and survey report. ArcheoData Società Cooperativa, Pisa University. <http://www.diggingvada.com/wp-content/uploads/2014/11/Summer_School_2013_Report.pdf>. Accessed 27 February 2015.

Genovesi, Stefano, Marcella Giorgio, Vincenzo Palleschi, and Claudia Rizzitelli
2010 Rotte e commerce lungo la costa volterana tra II e I sec. a.C. Materiali inediti da relitti e rinvenimenti sporadici del tratto costiero tra il Fine e il Cecina, University of Pisa, Pisa: 69-106.

Goiran, Jean-Phillipe, Ferreol Salomon, Ilaria Mazzini, Jean-Paul Bravard, Elisa Pleuger, Cecile Vittori, Giulia Boetto, Jonatan Christiansen, Pascal Arnaud, Angelo Pellegrino, Caterina Pepe, and Laura Sadori
2014 Geoarchaeology confirms location of the ancient harbour basin of Ostia (Italy). *Journal of Archaeological Science* 41: 389-398.

Heritage Daily
2016 "Spectacular cargo of ancient shipwreck found in Caesarea," *Heritage Daily*. <http://www.heritagedaily.com/2016/05/spectacular-cargo-of-ancient-shipwreck-found-in-caesarea/111268>. Accessed 29 May 2016.

Hermansen, Gustav
1981 *Ostia: Aspects of Roman City Life.* University of Alberta Press, Edmonton.

Hohlfelder, Robert L.
1993 An Experiment in Controlled Excavation Beneath Caesarea Maritima's Sea, 1990. *Bulletin of the American Schools of Oriental Research* 290/291: 95-107.
1988 The 1984 Explorations of the Ancient Harbors of Caesarea Maritima, Israel. *Bulletin of the American Schols of Oriental Research, Supplementary Studies*, American Schools of Oriental Research: 25: 1-12.

Hopkins, Keith
1980 Taxes and Trade in the Roman Empire (200 B.C.-A.D. 400). *The Journal of Roman Studies* 70:101-125.

Houston, George W.
1988 Ports in Perspective: Some Comparative Materials on Roman Merchant Ships and Ports. *American Journal of Archaeology* 92.4: 553-564

Hurst, Henry
2008 Understanding Carthage as a Roman Port. In *2008 – International Congress of Classical Archaeology Meetings Between Cultures in the Ancient Mediterranean,* Ministero per i Beni e le Attivita Culturali, IT: 49-68.

Iacophini, E., A. Del Rio, L. Cherubini, S. Menchelli, and M. Pasquinucci
2012 Il Sistema Informativo Territoriale dell'ager Volaterranus: Metodologia e Metaditi. *Quaderno: Laboratorio universitario volterrano* 15: 55-64.

Karmon, Yehuda
1985 Caesarea Maritima. *Harbour Archaeology: Proceedings of the First International Workshop on Ancient Mediterranean Harbours Caesarea Maritima* 24-28.6.83 No. 1, Avner Raban ed., Haifa University BAR International Series 257:33-68.

Keay, Simon, Martin Millet, and Kristian Strutt
2014 The canal system and Tiber delta at Portus. Assessing the nature of man-made waterways and their relationship with the natural environment. *Water History* 6: 11-30.

Keay, Simon
2005 The Port System of Imperial Rome. *Portus: An Archaeological Survey of the Port of Imperial Rome,* Simon Keay, Martin Millett, Lidia Paroli, and Kristian Strutt eds., The British School at Rome, London: 33-68.

Kessler, David, and Peter Temin
2007 The organization of the grain trade in the early Roman Empire. *The Economic History Review* 60.2: 313-332.

Martin, Archer
2008 Imports at Ostia in the Imperial Period and Late Antiquity: The Amphora Evidence from the Dai-Aar Excavations. *Memoirs of the American Academy in Rome. Supplementary Volumes,* Vol. 6, The Maritime World of Ancient Rome, pp.105-118

McCann, Anna Marguerite
1988 The Roman Port of Cosa. *Scientific American*, 258.3: 102-109.
1987a History and Topography. *The Roman Port and Fishery of Cosa: A Center of Ancient Trade,* McCann, Anna Marguerite, Joanne Bourgeois, Elaine K. Gazda, John Peter Oleson, and Elizabeth Lyding Will eds., Princeton University Press, New Jersey: 15-43.
1987b The Port and Fishery: Description of the Extant Remains and Sequence of Construction. *The Roman Port and Fishery of Cosa: A Center of Ancient Trade,* McCann, Anna Marguerite, Joanne Bourgeois, Elaine K. Gazda, John Peter Oleson, and Elizabeth Lyding Will eds., Princeton University Press, New Jersey: 74-97.
1985 The Roman Port and Fishery of Cosa: A Center of Trade in the Late Roman Republic, *Harbour Archaeology: Proceedings of the First International Workshop on Ancient Mediterranean Harbours* 24-28.6.83 No. 1, Avner Raban, ed, Haifra University BAR International Series 257: 115-156

1979 The Harbor and Fishery Remains at Cosa, Italy. *Journal of Field Archaeology* 6(4): 391-411.

McCann, Anna Marguerite and Colonel John D. Lewis
1970 The Ancient Port of Cosa. *Archaeology* 23.3: 200-211.

Meiggs, Russell
1973 *Roman Ostia*, second ed. Oxford: Clarendon Press.

Menchelli, Simonetta
2013 "Produzioni di terra sigillata nella valle dell'Arno: evienze archeologiche di un'economia in espansione." In *Leben Auf Dem Lande: 'Il Monte' bei San Gimignano: Ein r*ömischer *Fundplatz und sein Kontext*, Günther Schörner, ed. Wien: 249-255.

Menchelli, Simonetta, Ninetta Leone, Aurora Maccari, Marinella Pasquinucci, and Giulia Picchi
2012 "Vasi Comuni Nell'Etruria Settentrionale Costiera." In *Les Céramiques Communes Comprises Dans Leur Contexte Régional: Faciès de Consommation et Mode d'Approvisionnement*, Lyon: 91-117.

Menchelli, Simonetta and Marinella Pasquinucci
2006 "Archeologia della redistribuzione nell'Etruria settentrionale: il caso di Vada Volaterrana." In *Old Pottery in a New Century: Innovating Perspectives on Roman Pottery Studies*, Catania: 229-239.
2000 Ceramiche Orientali Nell'Etruria Settentrionale Costiera (II Sec. a.C.-VI Sec. d.C.). *Rei Cretariae Romanae Fautorum Acta* 36, Roma: 371-378.

Morhange, C., N. Marriner, and Nicolas Carayon
2016 "Eco-history of ancient Mediterranean harbours." *The Inland Seas, Towards an Ecohistory of the Mediterranean and the Black Sea*, T. Bekker-Nielson and R. Gertwage, eds. Verlag: 85-106. <http:// www.ancientportsantiques.com/wp-content/uploads/Documents/AUTHORS/Morhange-PublGenerales/Morhange2016-HIstoryPorts.pdf>. Accessed 24 March 2016.
2015 "The geoarchaeology of ancient Mediterranean harbours." In *La géoarchéologie française au XXIe siècle*, G. Arnaud Fassetta and N. Carcaud, eds. CRNS: 245-253.

Morhange, Christophe and Nick Marriner
2008 Mind the (stratigraphic) gap: Roman dredging in ancient Mediterranean harbours. In *Roma 2008 – International Congress of Classical Archaeology Meetings Between Cultures in the Ancient Mediterranean*, Ministero per i Beni e le Attivita Culturali, IT, pp. 23-32.

Oleson, John Peter and Robert L. Hohlfelder
2011 Ancient Harbors in the Mediterranean. In *The Oxford Handbook of Maritime Archaeology*, Ben Ford, Donny L. Hamilton, and Alexis Catsambis, editors, pp. 809-833. Oxford University Press, New York.

Oleson, John Peter, Christopher Brandon, Steven M. Cramer, Roberto Cucitore, Emanuele Gotti, and Robert L. Hohlfelder
2004 The ROMACONS Project: a Contriution to the Historical and Engineering Analysis of Hydraulic Concrete in Roman Maritime Structures. *The International Journal of Nautical Archaeology* 33.2:199-229.

Oleson, John Peter
1989 The Site. *The Harbours of Caesarea Maritima: Results of the Caesarea Ancient Harbour Excavation Project, 1980-1985*, John Peter Oleson ed., Vol. 1 no 3 BAR International Series 491 Oxford, England: 1-53.
1988 The Technology of Roman Harbours. *The International Journal of Nautical Archaeology and Underwater Exploration* 17: 147-157.

Oleson, John Peter, Robert L. Hohlfelder, Avner Raban, and Robert L. Vann
1984 The Caesarea Ancient Harbor Excavation Project (C.A.H.E.P.): Preliminary Report on the 1980-1983 Seasons. *Journal of Field Archaeology* 11.3: 281-305.

Opdebeeck, John
2005 Shipwrecks and amphorae: Their relationship with trading routes and the Roman economy in the Mediterranean. Master's Thesis, Department of Archaeology, University of Southampton, Southampton, UK.

Pagliaro, Francesca, Evelyne Bukowiecki, Franco Gugliermetti, and Fabio Bisegna
2015 The architecture of warehouses: A multidisciplinary study on thermal performances of Portus' roman store buildings. *Journal of Cultural Heritage* 16: 560-566.

Pasquinucci, Marinella
2014 Costa Degli Etruschi: Archaeology and Historical Itineraries. San Gaetano Archaeological Area, Vada:20
http://www.costadeglietruschi.it/ARCHEOLOGIA_INGLESE.pdf 2014.

Pasquinucci, Marinella and Simonetta Menchelli
2013 Dinamiche tardo antiche nella fascio costiera livornese: I casi di *Portus Pisanus* (Livorno) e di *Vada Volaterrana*. In *Conoscenza E Tutela Del Patrimonio Sommersi: Atti Del Convegno Scuola Normale Superiore 11 Dicembre 2012, Pisa*, Lucia Botarelli and Denis La Monica, editors, pp. 139-152. Progetto Thesaurus, No. 1. Roma, Italia.
2012 Surveying the Complexity: A Global Approach to Italian Landscapes. *eTopoi Journal for Ancient Studies* Special Volume 3: 1007-1037.
2005 Rosignano Marittimo (LI). Località S. Gaetano di Vada: Scavi e Richerche a 'Vada Volaterrana.' *Concession di Scavo*, Università di Pisa: 394-398.

Pasquinucci, M., S. Ducci, S. Menchelli, A. Ribolini, A. Bianchi, M. Bini, and S. Sartini
2012 Ground Penetrating Radar Survey of Urban Sites in North Coastal Etruria: *Pisae, Portus Pisanus, Vada Volaterrana.* In *Urban Landscape Survey in Italy and the Mediterranean*, Frank Vermeulen, Gert-Jan Burgers, Simon Keay, and Cristina Corsi, editors, pp. 149-159. Oxbow Books.

Pasquinucci, Marinella and Paolo Sangriso
2010 Rosignano Marittimo (LI). S. Gaetano di Vada: la campagna 2010. *Concessione di Scavo,* Università di Pisa: 361-364.

Pasquinucci, Marinella, Simonetta Menchelli, and Paolo Sangriso
2008 Le terme di Vada Volaterrana venti anni dopo. *Trace dei luoghi, trace della storia*, Roma: 379-390.
2002 Vada porto di Volaterrae: la campagna di scavo 2002. *Quaderno: Laboratorio universitario volterrano* 6: 93-101.

Pasquinucci, Marinella, Simonetta Menchelli, Paolo Sangriso, Ninetta Leone, Alberto Cafaro, and Silvia Marini.
2007 Rosignano Marittimo (LI). Località S. Gaetano di Vada: campagna 2007 a Vada Volaterrana. *Concession di Scavo,* Università di Pisa: 596-599.

Pasquinucci, Marinella, Simonetta Menchelli, Renzo Mazzanti, Mario Marchisio, and Laurent D'onofrio
2001 Coastal Archaeology in Etruria, North Coastal Etruria: Geomorphologic, archaeological, archive, magnetometric and geoelectrical researches. *Revue d'Archéométrie* 25: 187-201.

Patrich, Joseph
2011 Studies in the Archaeology and History of Caesarea Maritima: Caput Judaeae, Metropolis Palaestinae, Brill, Boston.

Raban, Avner
1995 Sebastos, the Royal Harbour of Herod at Caesarea Maritima: 20 Years of Underwater Research. *Marinarkeologisk Tidskrift* 1.95: 1-11.
<marinarkeologi.nu/MT/1995/mt_1995_1__671.pdf>. Accessed 12 March 2016.
1992 Sebastos: The royal harbour at Caesarea Maritima—a short-lived giant. *The International Journal of Nautical Archaeology* 21.2:111-124.
1989 Summary Discussion. *The Harbours of Caesarea Maritima: Resuls of the Caesarea Ancient Harbour Excavation Project, 1980-1985,* John Peter Oleson ed., Vol. 1 no. 3 BAR International Series 491, Oxford England: 271-296.

Rickman, G.E.
2008 Ports, Ships, and Power in the Roman World. *Memoirs of the American Academy in Rome. Supplementary Volumes,* The Maritime World of Ancient Rome. 6: 5-20.
1988 "The archaeology and history of Roman ports," *The International Journal of Nautical Archaeology and Underwater Exploration* 17.3: 257-267.
1980 The Grain Trade under the Roman Empire. *Memoirs of the American Academy in Rome,* 36: 261-275.

Roller, Duane W.
1998 *The Building Program of Herod the Great,* University of California Press, Los Angeles.

Rutilius Namatianus
1935 A Voyage Home to Gaul. J. Wight Duff and Arnold M. Duff, trans. Harvard University Press: City. <Penelope.uchicago.edu/Thayer/E/Roman/Texts/Rutilius_Namatianus/text*.html>. Accessed 12 Jan 2015.

Sangriso, Paolo
2011 Il Sistema Portuale di Volterra: un Possible Modello Topografico. *Studi Classici e Orientali* 57, Pisa University Press, Pisa: 171-214.

Sangriso, Paolo and Silvia Marini
2010 Vada Volaterrana (Vada, Livorno). Materiali Tardo-Antichi dal Pozzo delle Grandi Terme. *Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean: Archaeology and archaeometry comparison between western and eastern Mediterranean,* Menchelli Simonetta, Sara Santoro, Marinella Pasquinuci, and Gabriella Guiducci, eds. Archaeopress, Oxford: 345-352.

Sear, Frank
1982 *Roman Architecture.* Ithaca: Cornell University Press.

Schörle, Katia and Victoria Leitch
2012 Report on the preliminary season of the Lepcis Magna Coastal Survey. *Libyan Studies* 43: 149-154.

Schörle, K.
2011 "Constructing Port Hierarchies: harbours of the central Tyrrhenian Coast." In Maritime Archaeology and Ancient Trade in the Med. D. Robinson and A. Wilson, eds. Oxford Centre for Maritime Archaeology, Oxford: 93-106.

Stone, David L.
2014 Africa in the Roman Empire: Connectivity, the Economy, and Artificial Port Structures. *American Journal of Archaeology* 118.4: 565-600.

Strabo
1932 *Geography*. H.L. Jones, trans. Harvard University Press. <www.penelope.uchicago.edu/Thayer/E/Roman/Texts/Strabo/5B*.html>. Accessed 12 Jan 2015.

Suetonius
1914 The Life of Claudius. *The Lives of the Twelve Caesars*, J.C. Rolfe, translator. Harvard University Press, Cambridge, MA. <http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Suetonius/12Caesars/Claudius*.html> Accessed 12 December 2014.

Vitelli, Giovanna
1980 Grain Storage and Urban Growth in Imperial Ostia: A Quantitative Study, *World Archaeology*, 12.1: 54-68

Vitruvius
1914 *The Ten Books on Architecture*, Morris Hicky Morgan, translator. Harvard University Press, Cambridge, MA.

Whittaker, C.R. and Peter Garnsey
1997 Rural Life in the Later Roman Empire. In *The Camridge Ancient History*, Averil Cameron and Peter Garnsey, eds. Cambridge University Press, MA: 277-311.

Will, Elizabeth Lyding
1979 The Sestius Amphoras: A Reappraisal. *Journal of Field Archaeology* 6.3: 339-350.

Wilson, Andrew, Katia Schörle, and Candace Rice
2012 "Roman Ports and Mediterranean Connectivity." In Portus and the Ports of the Roman Mediterranean, S. Keay, editor. Archaeological Monographs of the British School at Rome, London: 367-391.

Wilson, Andrew
2011 "Developments in Mediterranean shipping and maritime trade from the Hellenistic Period to AD 1000." In Maritime Archaeology and Ancient Trade in the Mediterranean, D. Robinson and A. Wilson, eds. Oxford Centre for Maritime Archaeology, Oxford: 33-59.

Yorke, R.A. and D.P. Davidson
1985 Survey of Building Technologies at Roman Harbours of Carthage and Some Other North Africa Ports. *Harbour Archaeology: Proceedings of the First International Workshop on Ancient Mediterranean Harbours* 24-28.6.83 No. 1 Haifa University BAR International Series 257: 157-164.