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Ancient harbours in the Mediterranean. Part 1

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Literary and pictorial evidence

The bulk of the evidence now available to the archaeologist consists of the remains themselves. But in his search for remains and interpretation of them, surviving ancient texts may help. Unfortunately, no ancient technical handbooks on harbour construction survive, though we know that they were written, for example by the engineer Philon in the late 3rd century BC. By this date there were flourishing schools of engineering, notably at Alexandria and Rhodes. Vitruvius, writing his work on architecture in the 1st century BC, was clearly able to draw on a body of technical literature for his one chapter on harbour construction.[1]

The compilations entitled *Harbours* are almost entirely lost, too, though we know the names of some authors.[2] These were geographical rather than engineering handbooks. What have survived are a number of *Periploi* or 'Coastal Pilots', very similar in essence to their modern equivalents: practical handbooks of sailing directions, compiled from travellers' reports and systematized for the use of navigators. They provided details about harbours, anchorages, landmarks, watering-points, and some gave the distances between. The most valuable examples we have are that of the Mediterranean and Black Sea, attributed to the geographer Scylax (*c.* 500 BC) but dating in its surviving form to the late 4th century BC; that of the 'Erythraean Sea' (late 1st century AD) describing for traders the coastal routes from Egypt to India; and the *Stadiasmus Maris Magni*, probably of the 3rd century AD. The last gave watering-points, water supply being one of the greatest problems for voyagers in antiquity, and the distances in *stades* (furlongs) from place to place right round the Mediterranean. One uncertain point is whether there were complementary coastal maps, like modern Admiralty Charts, to go with these sailing directions. A number of interesting late medieval *portolani* also survive.[3]

We also have some of the raw material on which these works were based, the original reports of voyages of exploration or survey, some of which fulfilled official commissions: for example, we are fortunate to have the report by Hanno of Carthage on his voyage down the west coast of Africa, by Alexander's admiral Nearchus on his voyage from the Indus to the Euphrates, reproduced by the historian Arrian, and by Arrian himself on his voyage round the Black Sea. Other reports, for example Pytheas', are referred to or quoted by geographers.[4] Like their 19th-century equivalents, the reports of hydrographers and surveyors like Beaufort (1817), Spratt (1865) and the brothers Beechey (1828), these first-hand accounts are much more readable than the prosaic digests.

The *Periploi* give for each site only the basic information needed by the navigator. This information, and particularly the distances and locations, may help the archaeologist to find and identify ancient harbour sites.[5] But it will not help him to reconstruct the detailed layout, beyond telling him the number of harbour basins available. For some harbour sites more detailed ancient descriptions exist, mainly in the geographers such as Strabo whose description of Alexandria is famous, and occasionally in historians and other writers, who describe the scenes of famous battles and sieges or famous feats of engineering. For example, Appian includes this description in his account of the final siege and destruction of Carthage by the Romans:

> 'The harbours communicated with each other, and there was an entrance to them from the sea, 70 ft wide, which they closed with iron chains. The first harbour was given

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up to merchants, and contained all kinds of mooring-cables; in the middle of the inner harbour was an island, and both island and harbour were lined at intervals with large quays. The quays were full of slipways built for 220 ships and storerooms over the slipways for the triremes' gear. In front of every shipshed stood two Ionic columns, so that both harbour and island appeared to be lined with a colonnade. On the island had been built the Admiral's Headquarters; from here the trumpeter had to signal and the herald proclaim orders and the admiral supervise. The island lay opposite the entrance, and rose to a great height, so that the admiral could observe everything going on at sea, while approaching voyagers could not clearly see what was going on inside. The docks were not immediately visible even to merchants who had sailed in, for they were surrounded by a double wall, and there were gates which gave merchants access to the city directly from the first harbour without their going through the docks.'

Other descriptions include that by Herodotus of the great mole in Samos harbour; by Josephus of Caesarea; by Suetonius of the building of the breakwater at Ostia, also described by Pliny the Elder; and by Pliny the Younger of similar work under Trajan at Centumcellae.[6] Vivid, specific details are sometimes provided by inscriptions which, unlike historians, are often concerned with mundane matters of regular routine, the ordinary and the humble; from them we get glimpses of routine harbour regulations, dredging work, titles of officials, and the ordinary working people and trades connected with seaports.

The remains of harbour installations are often preserved only at foundation level. The archaeologist may be able to reconstruct a ground-plan from them, but the third dimension is difficult to recreate. What did the harbour actually look like? For help in answering this question he can turn to another type of ancient evidence: an (unfortunately small) number of ancient depictions of harbours.

There are a number of problems in using the evidence of ancient harbour scenes. They are almost entirely of Roman date; the size and shape of the field available, and the medium employed, are significant restricting factors; and the reliability of the artist on points of detail is always open to question.

Few harbour scenes of pre-Roman date are known, except for some Egyptian reliefs and wall-paintings. A number of these depict ships, in some cases clearly in a port: for example, a painting in the 14th century BC tomb of Kenamon at Thebes shows Syrian ships in an Egyptian port, with stevedores unloading and merchants setting up shop on the beach by the ships, but no harbourworks are visible. Then and later, small craft no doubt unloaded directly on to the beach without the help of any harbourworks (as is shown on a mosaic from a 3rd century AD tomb from North Africa), but this is less likely for large merchantmen; only one Egyptian tomb-painting, from Amarna, shows a quay, with ships moored to bollards on it, but the rarity of harbourworks in pictures does not prove that they were rare in Egypt in the late 2nd millennium. As we shall see (p. 92), some actual remains have now been found.[7]

In 1972 miniature frescoes, including a marine scene, were found in a house on the Aegean island of Thera (Santorini), destroyed in about 1500 BC. But there is no sign of built harbourworks.[8]

No harbour depictions of Classical Greek date have been found, except for the coins of Zankle which show the sickle-shaped encircling structure (the distinctive feature which gave the city its name); the simple, regular form of the harbour may well be accurate, but may also reflect contemporary artistic taste (Fig. 1A).[9] Some Greek harbours are portrayed in works of the Roman period, and from these one can form an impression of what some individual harbours may have looked like in earlier times, when many already had impressive complexes of buildings. However, such imaginative reconstructions are uncertainly founded, for though the basic geography cannot change, many of the buildings may have been altered or added. Furthermore, for the early period when pictorial evidence is not available, the evidence provided by actual remains is more scrappy. The remains surviving from the Greek world give us a clear idea of many particular harbourworks as they were in their final form in the Roman Imperial period, but only fragmentary details, or less, of the original layout; this fact puts a veil between

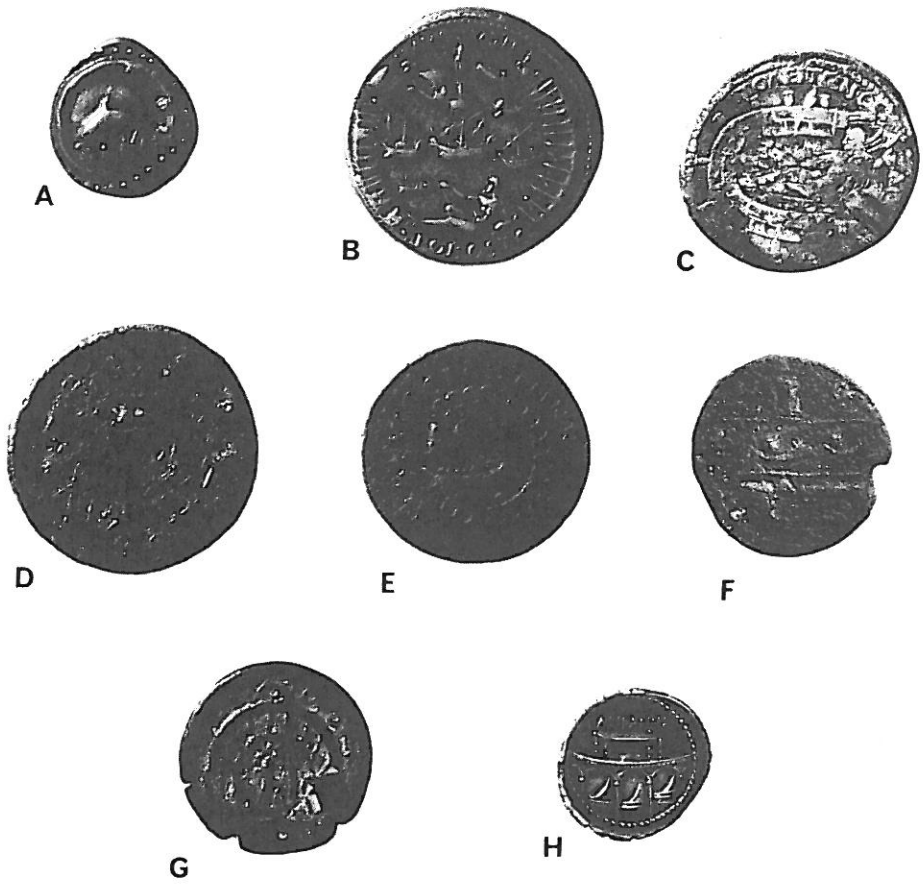


Figure 1. **Coin depictions of harbours** (all reproduced at actual size). A. Silver coin of Zankle (the later Messina): a leaping dolphin within a sickle. This was the city's emblem, for Zankle means 'sickle' and the city clearly derived its name from the sickle-shaped natural harbour. The four small squares may represent quays, or possibly towers. (British Museum *Sicily* no. 2.) B. Bronze sestertius of Nero, issued in AD 63/64 or 64/65, portraying the newly constructed harbour basin at Portus, near Ostia; within it lie seven ships and a harbour deity. The right-hand mole appears to be arched, but this is probably not accurate. (British Museum *Nero* no. 132.) C. Bronze coin of Pompeiopolis in Cilicia, portraying the newly built or improved harbour at the site; within it reclines a harbour deity (reign of Antoninus Pius, *c.* AD 144). (American Numismatic Society, Newell Collection.) D. Bronze sestertius of Trajan (AD 104–111), portraying the newly constructed inner harbour at Portus, surrounded by buildings with colonnades; three ships appear to lie within. Though the artist has clearly attempted accuracy of detail, he gives the harbour seven sides (plus the entrance) instead of six sides (including the entrance). (British Museum *Trajan* no. 770A.) E. Coin of Gallienus, portraying the harbour of Side as a perfect circle, concentric with the coin, when in fact the main harbour was roughly triangular. The arcade surrounding the basin probably represents porticos rather than slipway entrances. (British Museum *Lycia* no. 112.) F. Coin of Septimius Severus, portraying the harbour of Patrae, with apparently a breakwater (background) parallel to the shore (foreground). This may accurately represent the actual port layout. On the shore are depicted temples, and on the breakwater a round building (tower?) and equestrian statue. (Fitzwilliam Museum, Cambridge, Leake 8438.) G. Coin of Antoninus Pius, portraying the harbour of Cenchreae, with a statue (of an unidentified deity) shown in mid-harbour, though it probably stood on the north mole; in the foreground, three ships. (British Museum 1899, 4-1-26.) H. Denarius of Palikanus (a mint official), 47 BC, showing three warships in shipsheds; above is a 'bisellium' or double seat of honour, the interpretation of which is uncertain. (British Museum *Republic* no. 4011.) Photographs of British Museum coins by R. A. Gardner. Reproduced by permission of the institutions concerned.

us and the early days of Greek harbour engineering which is difficult to penetrate.

In the Roman period harbour scenes appear on coins, gems, lamps, bottles, reliefs, mosaics and wall-paintings. A number of Roman coins depict entire harbours. For example, some famous bronze sestertii of Nero, issued probably in AD 64, and perhaps celebrating the tenth anniversary of its dedication, show the new harbour at Portus near Ostia. Curving breakwaters enclose seven ships and a marine deity, perhaps the harbour god, reclining holding a rudder (Fig. 1B). A coin of Pompeiopolis in Cilicia, dating from about AD 144, gives a similar impression (Fig. 1C). An element of imitation is likely; indeed, the latter coin could commemorate the centenary of an early stage of work on the harbour at Portus, as well as work on the harbour of Pompeiopolis. A similar reclining deity almost fills the area within the horseshoe-shaped structure, which is apparently two storeys high. The 'jars' on its roof may be beacons, and the object between the first two 'jars' may be a sail acting as a weather-vane or signal. At the upper end of the structure is a statue holding a sceptre—the emperor perhaps, or a marine deity; at the other end is a base, probably of a lighthouse, but the coin is damaged.[10]

It is dangerous to rely too closely on such depictions to provide 'photographic' realism. In fact, we know that in these two cases the portrait conveys fairly accurately the shape of the actual harbour, but we could not assume this without the evidence of remains at the sites concerned. Many harbours are depicted on coins as circular when their actual shape was somewhat or very different. Coins celebrating the new harbour built by Trajan at Ostia seem to give it seven sides instead of the six it is known to have had, and later coins of Side show its harbour as circular when in fact it was an irregular triangle (Fig. 1D and E). Coins of Patrae provide an apparent exception (Fig. 1F).[11]

The field available to the artist on a coin was small and restricting, and he was forced into schematic shapes and rendering of the scene even if—hazardous assumption—he wanted to be accurate. An elaborate appearance is probably accurate for the major harbours of the Roman Empire, and the plethora of statues is confirmed by the other pictorial evidence, limited, it is true, to a few sites; the contrast with the Zankle coin is striking, but the latter picture (Fig. 1A), even if accurate for contemporary Zankle, may not be representative of the major harbours of the Classical period.

What one *may* be able to deduce from 'harbour coins' are historical conclusions about harbour constructions at the sites depicted. One advantage of Roman Imperial coins is that they can often be closely dated. The emperors of the early 2nd century did much to encourage harbour construction and improvements in Italy and the Empire, and the coins reflect this and confirm the literary evidence. Furthermore, recent study of 'harbour coins' has shed new light on the symbolism of architectural and other links between major harbours of the Roman Empire, notably Ostia and Alexandria, the two ends of the corn route vital to Rome's survival.[12]

However, for architectural rather than historical information coins depicting smaller subjects are more useful. On the coins showing entire harbours it is, for example, often difficult to know whether quayside colonnades, arched moles or roofed slipways are represented (Fig. 1E and G: compare Appian's description, above p. 80);[13] but with coins showing detailed views on a larger scale the identification as roofed slipways is clear (Fig. 1H), and confirmed by similar scenes in a larger context in mosaics and wall-paintings.[14] Lighthouses, like ships, provided a satisfying subject for the limited field: particularly common are Roman coins of Alexandria portraying the Pharos.[15] But even here, the picture is often too stylized to be reliable. A few gems survive which have various maritime scenes, inevitably schematic, rather crowded in a very restricted field.[16] Roman lamps offered a somewhat larger but similarly restrictive field of decoration, again more suitable for a limited subject like a ship or lighthouse. On some the artist attempted a more complex subject: for example, an arched causeway or bridge in the foreground and a town in the background, with water between; the causeway called the Heptastadion at Alexandria may be intended on some, but the type seems to have been conventional.[17]

No harbour scenes are found on pottery

other than lamps. There is, however, a curious series of Roman engraved glass flasks, tourist souvenirs which give a vivid, if impressionistic, picture of the waterfront at Baiae and Puteoli—the Roman equivalent of Regency Brighton, and a good deal wilder. The arched breakwater is shown, surmounted by columns and a triumphal arch, but with only 3–5 arches to the breakwater instead of the 15 which it is known to have possessed.[18]

Other media provided a larger and easier field for large and complex subjects like harbour scenes. A number of Roman reliefs, mainly from sarcophagi, depict maritime scenes—usually just a ship or ships, but sometimes with harbour installations in the background.[19] Attention is normally centred on the ships and the activity on and around them, but a lighthouse often appears and sometimes a quay or breakwater. Most of these reliefs were found at Ostia, and it appears that most of them portray the nearby harbour of Portus.

A few larger reliefs pay more attention to the background detail. The most famous example is the 'Torlonia relief', showing two ships (Fig. 2): one is just entering the harbour, with the master and perhaps his family sacrificing to celebrate their safe arrival, one of the crew in the ship's boat astern, apparently making fast the steering oar, and another hauling a fender into position forward; the second ship, perhaps the same ship at a later stage, with its sails furled, is tied up to a mooring-stone, stem to, and a man carries an amphora across the horizontal gangway. In the background stands a reproduction of Claudius' lighthouse at Portus, but with five stories instead of a probable four. Neptune figures large in mid-scene, and a number of other figures, clearly statues, and a monumental arch fill the background.[20] A clutter of monumental figures (some holding lighthouses may perhaps be personifications of harbours) obscures even more another large and detailed relief, the 'Vatican relief', in which little can be made of the harbour scene except for two ships, one bearing Odysseus(!), and a number of smaller harbour craft, apparently in two bays lined with arched quays.[21] This is no specific harbour but probably an evocation of life at sea on a mariner's tomb-relief.

Among smaller reliefs from Ostia and Portus one vividly portrays a harbour tugboat; another shows stevedores unloading wine-amphorae down a steep gangway and collecting a tally from shipping-clerks sitting in a booth on the quay; a third shows a ship arriving and men drinking in a tavern.[22] One set of reliefs on a public monument, Trajan's Column, includes a few harbour scenes, though the harbourworks mainly provide a background to the ships.[23]

In maritime scenes on mosaics, too, ships usually hold the central place. One mosaic shows cargo being unloaded directly on to a beach (see p. 80). In a number of the 'shop signs' on the pavement before the shippers' offices at Ostia freighters and a lighthouse appear and in one, amphorae are being off-loaded from a freighter into a barge.[24] However, in one mosaic, from Rome, a harbour wall, apparently arched and bearing a lighthouse, occupies the foreground, and another, from Praeneste, seems to portray an arched quay. A little-known mosaic from a Roman villa in Spain has a number of maritime motifs including a port and a lighthouse. Mosaics portraying ships in shipsheds have already been mentioned: a striking example is the arcaded border of a mosaic from a Roman villa in Gaul.[25]

Several of a group of glass mosaic panels recently discovered at Cenchreae show harbour scenes.[26] One has a mole curving out into the foreground, and ships and fish on either side, but some of the detail is difficult to make out because the panel is not completely preserved. At the end of the mole there seems to be a monumental building, perhaps a small temple such as stood on the east mole at Leptis Magna (Figs 3 and 4).

Maritime scenes on wall-paintings, almost all from Campania, mostly show ships by seaside villas or engaged in mock battles (*naumachiae*), and clear details of harbourworks and related buildings, even in the background, are rare. Exceptions include the painting from the Temple of Isis at Pompeii, before AD 79, on which two- and three-storey arcaded piers can be made out; and the famous painting from Stabiae, also pre-79, with a hill in the foreground topped by a lighthouse or mark, a high arched breakwater beyond, and in the background a jetty which could be of timber—this

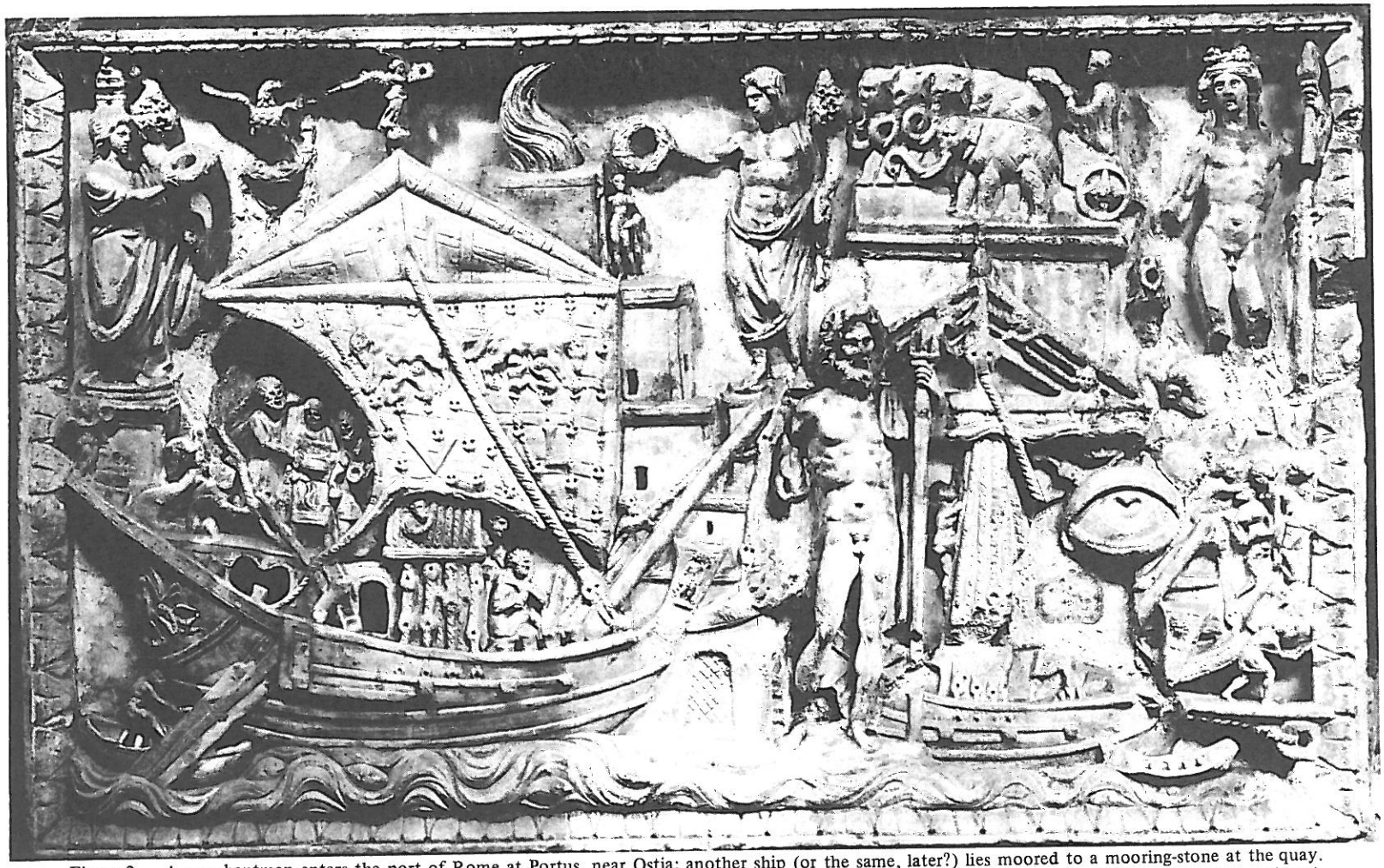


Figure 2. A merchantman enters the port of Rome at Portus, near Ostia; another ship (or the same, later?) lies moored to a mooring-stone at the quay. The figures embroidered on the sail probably indicate the ship's home port. The lighthouse with beacon portrays the lighthouse at Portus (though with five storeys instead of four). Of the figures, clearly statues, the female (top left) is probably a personification of Ostia. About AD 200. (*Torlonia Museum, Rome.*) Photograph by Gabinetto Fotografico Nazionale, Roma, Neg. series E 368 h 1.

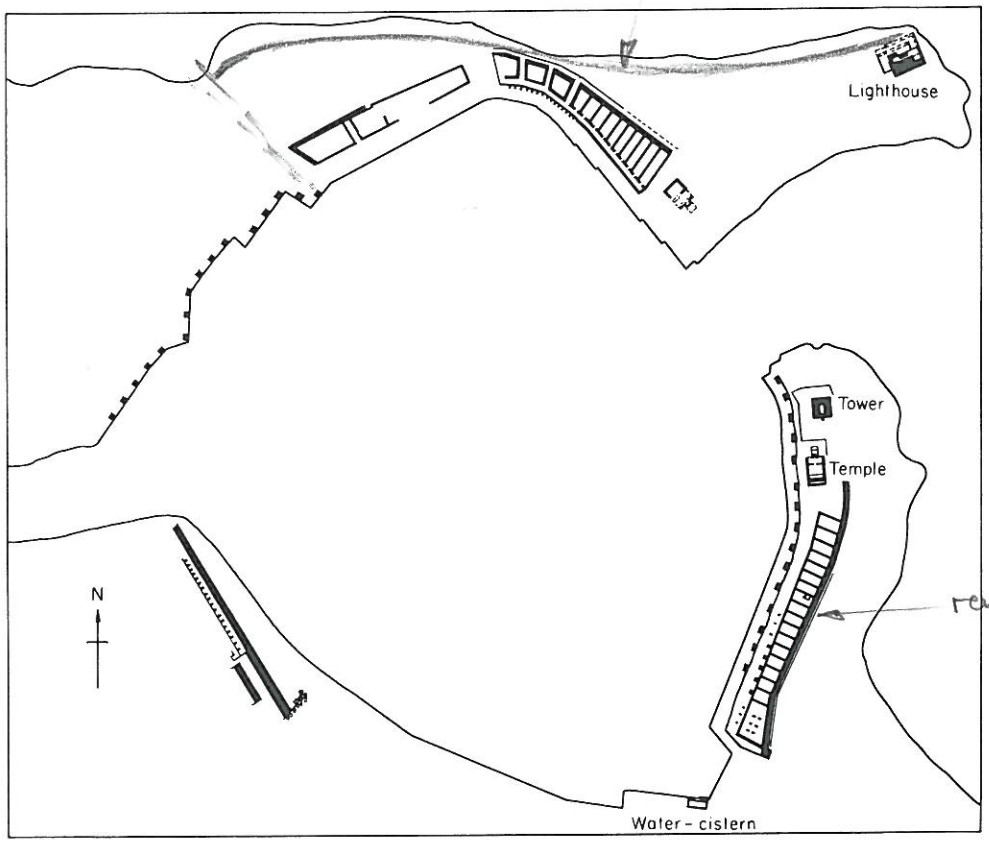


Figure 3. Leptis Magna harbour, after Bartoccini (1958), pl. III.

is a lively and detailed scene which bears some resemblances to Puteoli (Fig. 5). A painting newly discovered seems to show the lighthouse at Portus and one picture has ships in shipsheds, a motif also found on coins and mosaics.[27]

Modern research

In the 19th century little systematic work was done except on the pictorial evidence discussed above. A few studies of individual harbours were published;[28] and the topography of Rome and particularly Piraeus, where some excavation took place, was much debated. Many plans and descriptions of harbours were made by hydrographers, but their work was not fully utilized by archaeologists.

A new interest in the actual remains of ancient harbours and submerged coastal sites was sparked off by the study of evidence for changes in sea level in historical times: for example, an English geologist, Günther, studied the evidence for earth movements in the Bay of Naples, and Negris, a Greek engineer working for a French company involved in drainage works, harbour dredging and canal excavation in Greece, noted a number of submerged harbour installations.[29] Another such Greek engineer, Georgiades, produced in 1907 the first specific study of a group of ancient harbours (six harbours in Greece); but his knowledge of ancient history was inadequate, and some of his plans have since been proved to be very inaccurate.

In 1912–16 Jondet, as Chief Port Engineer of Egypt, surveyed the 'prehistoric harbour' at Alexandria, west of the Pharos, before a new harbour was built; he made limited use of divers to plan the breakwaters and quays, which are still not certainly dated, and published his work fully. Two harbours in Greece were also studied in some detail at this time: Lechaeum and Delos.[30]

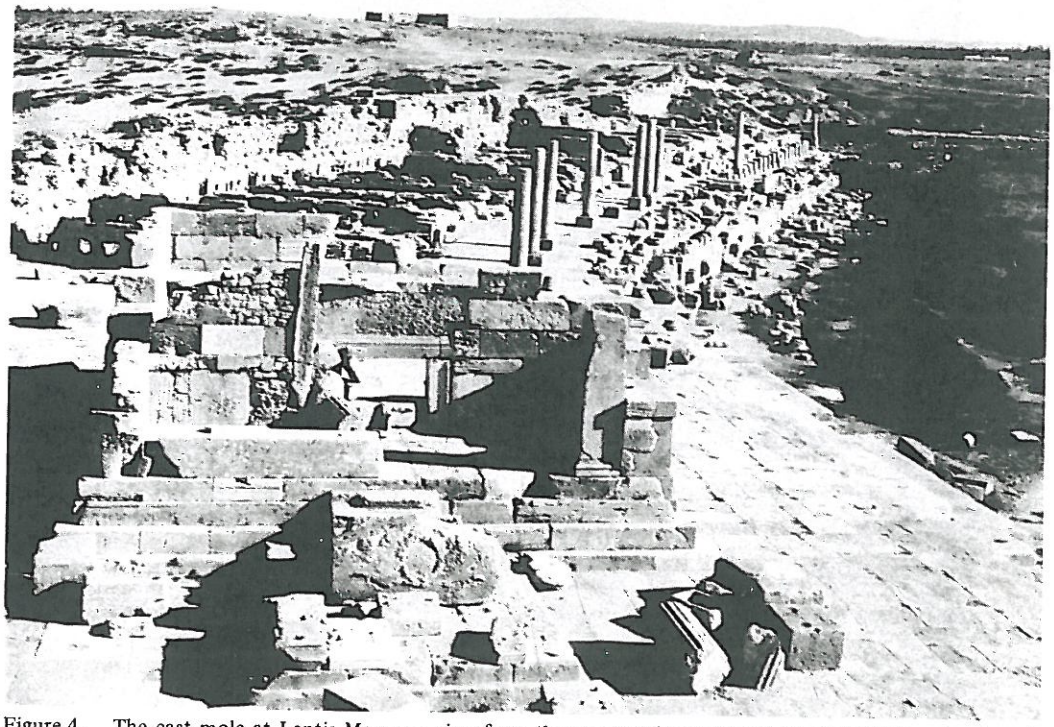


Figure 4. The east mole at Leptis Magna: a view from the tower at its north end. In the foreground, a temple; beyond, warehouses line the quay. Photograph by D. J. Blackman.

The first, and so far the only, large-scale survey of ancient harbours by Karl Lehmann-Hartleben was a monumental piece of work and remains an important reference book. It was, however, largely a compilation based on literary evidence rather than personal observation, and it does assume too easily an even and universal advance in methods of harbour construction. 'Primitive' does not necessarily mean 'early'; rough work could be the result of a city's poverty or an emergency.

Rather surprisingly, this book did not revive interest in ancient harbours and little was done for a decade, until the work of Father Poidebard at Tyre in 1934–36 and at Sidon in 1946–50. He was the first to appreciate the value of air photographs in studying sites submerged in shallow water, having used them in tracking the Roman frontier line in the Syrian desert. At Tyre he used local sponge-divers and French naval divers to carry out underwater survey and photography and check the air photographs; and he produced with remarkable speed in 1939 a full survey of the outer roadstead, protected by remains of the coastal reef, and the inner harbour. By similar methods he traced a similar pattern in the remains at Sidon and found and explained a remarkable de-silting

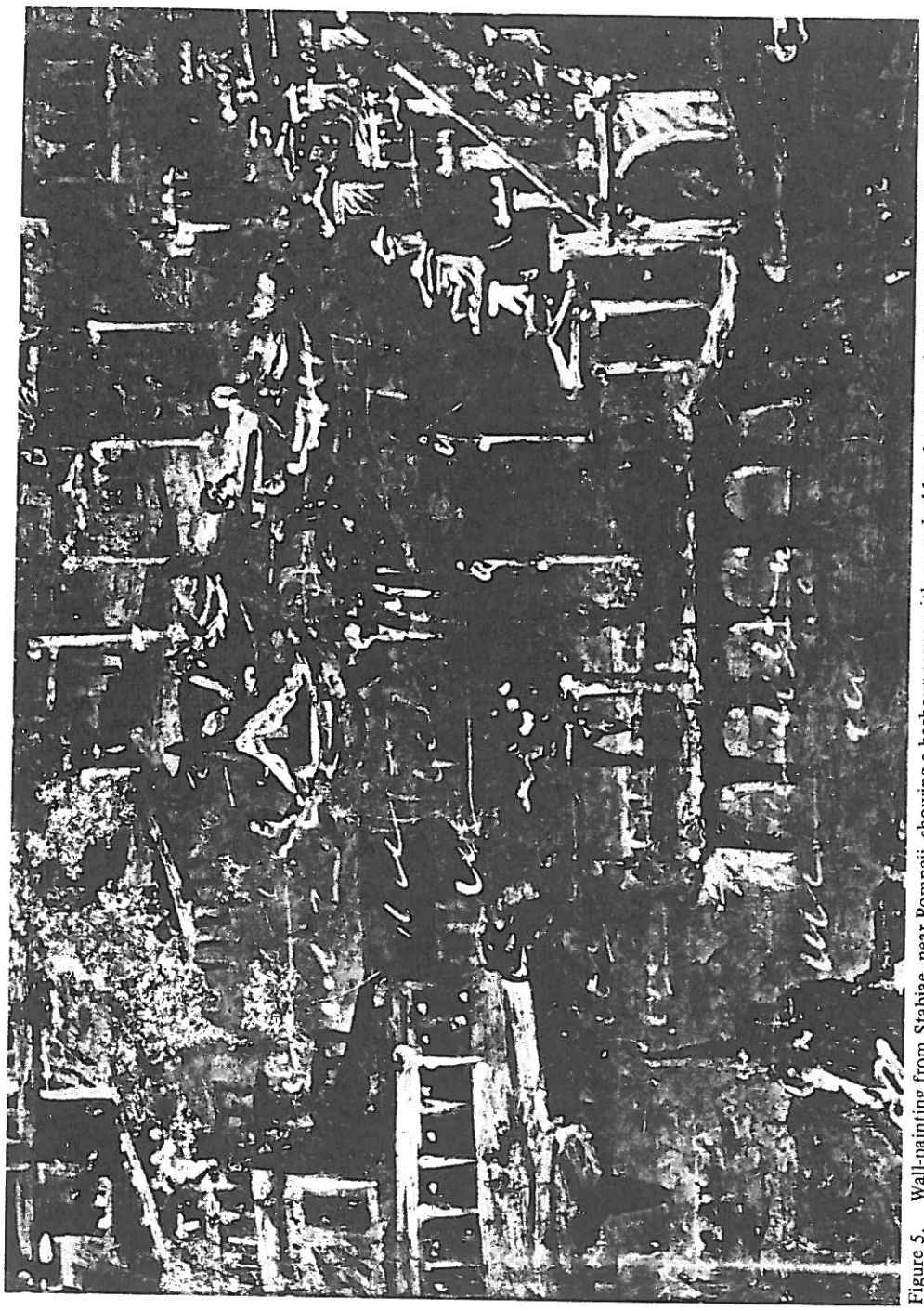


Figure 5. Wall-painting from Stabiae, near Pompeii, showing a harbour scene with an arched breakwater and a jetty. Courtesy Mansell Collection.

system (see Part 2, 'Siltation problems'). The importance of his pioneer work has only recently been fully appreciated.[31]

Since the Second World War several harbour sites now completely silted up have been studied and partially excavated: notably the Claudian harbour at Portus, now under Fiumicino airport; the Roman harbour at Leptis Magna, Tripolitania; parts of the ancient port of Massilia (Marseilles); and the entrance-channel and part of the inner basin on Motya island on the west coast of Sicily. In recent excavations at the harbour town of Sarepta, Lebanon, part of a quay has been uncovered, and remains of slipways have been found at the deeply buried site of Sybaris/Thurii in southern Italy. Excavation of the harbour areas at Carthage commenced in 1974 and has provided valuable new information.[32]

At some important sites like Miletus, Ephesus and Cnidus, the harbour areas have been defined but hardly excavated. At others which lie under modern cities, like Corcyra and Rhodes, much has been learnt about the ancient sites, including the harbours, from careful scrutiny of modern excavations carried out for high-rise buildings which need deep foundation trenches that disturb earlier and deeper layers previously untouched. In Rhodes this accumulating evidence has proved the existence of a west harbour, silted up and previously unknown, though brilliantly deduced from a study of air photographs,[33] and has defined the shoreline of the main harbour. At far too many sites in the Mediterranean, however, the story is a grim one: during the construction of new hotels, harbourworks, and roads, ancient remains have been built over or demolished for their building-stone, with little or no study or recording.

Others have followed Bradford and Poidebard in using air photographs in studying coastal sites, notably Schmiedt (Fig. 6); and recent experiments have shown the value of remote-control photography from tethered balloons.[34] Air photographs can save much time in surveying land and shallow-water sites, as can underwater photographs taken above deep water sites. Since many more sites are threatened by development of coastlines for tourism, survey of surviving harbour sites is a major priority. A large number of surveys is probably more desirable than one or two excavations, and no more expensive.

The development of the aqualung opened up new possibilities for the survey of harbours and submerged land sites. Little was done until the later 1950s, but in recent years the pace of work has quickened. The port of Narbonne was studied from the air and the water, and British divers surveyed some sites on the coast of Crete. A Cambridge student team surveyed in 1958–59 the Graeco–Roman harbour works at Apollonia, port of Cyrene, and demonstrated the feasibility of shallow-water survey, operating where possible above the surface; their successors have surveyed a large number of harbour sites in Libya, Tunisia and Algeria. British teams have surveyed three harbour sites in Sardinia, and German divers a river-mouth port in Majorca. Sites in Sicily have been studied, notably Syracuse, and recently some sites on the Italian coast, including Cosa (see below), Pyrgi and Populonia and, on the east coast, Sipontum, Egnatia (Gnathia) and Portus Uxentinus. On Giannutri Island, south of Elba, American divers have found remains of a Roman villa harbour. The submerged shoreline of the Bay of Naples has continued to be the subject of investigation. In the west, almost nothing is known of ancient harbourworks in Spain—a notable gap in our knowledge.[35]

In the last 15 years a number of harbour sites in the Aegean area have been surveyed, notably Cenchreae (see below), Anthedon, Larymna, Aegina, Gythion and Cyme, and in Southern Turkey Phaselis and Side.[36] Search in this area for evidence of sea level changes in historical times has added a number of sites, and has also highlighted the importance for any harbour study of establishing the evidence for relative change of sea level and of considering the processes which may have affected sea level at the site. The archaeologist can often provide helpful information to the marine geologist and biologist which should eventually make possible more precise dating of many harbourworks and other coastal installations. Attention has been drawn to the possibility of dating earlier sea levels by Carbon-14 dating of dead marine fauna which could only have lived at sea level. Honor Frost has tentatively drawn on this evidence in her continuing study of the harbourworks of the great Levantine ports: Tyre, Sidon

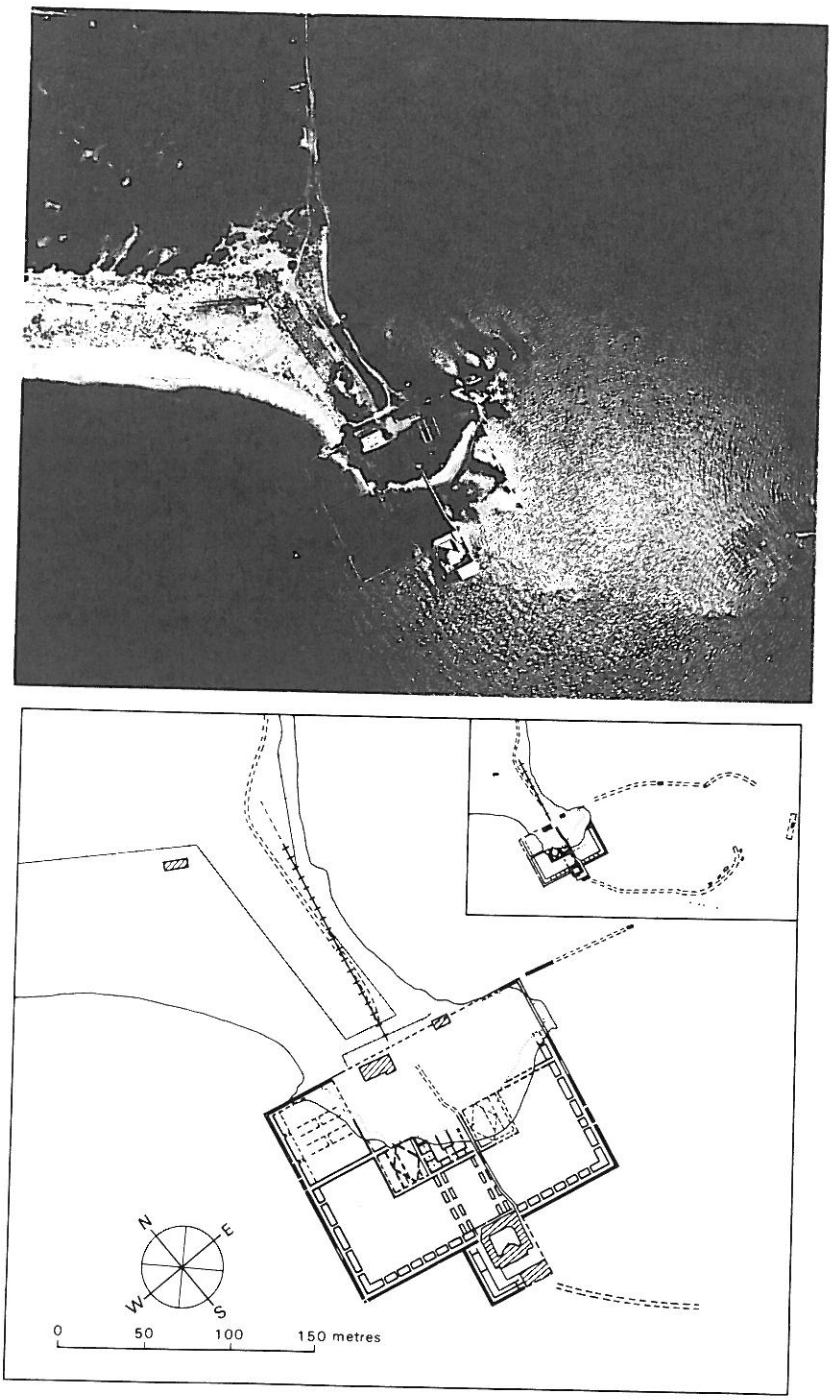


Figure 6. Air photograph and sketch plan of the port of Astura in Italy. The port was linked to a villa built on the island which was connected to the shore in the Roman period by a long bridge around which later formed a sandy isthmus. The two breakwaters of the port run out from the villa and the great fishery, which was subdivided into a great number of tanks for raising various types of fish. Courtesy G. Schmiedt and Gabinetto Fotografico Nazionale, Aerofototeca.

and Aradus.[37] In Israel the harbour of Caesarea has been investigated intermittently since 1960 and intensively since 1976, while early harbours at Dor, Akko and Athlit have been surveyed.[38] Russian archaeologists have explored a number of submerged land sites and harbour sites on the northern Black Sea coast, and carried out limited excavation under water; on the west coast a number of coastal sites are now being investigated in Romania and Bulgaria.[39]

Large-scale excavation under water has so far been undertaken on only three harbour sites: Cenchreae, the eastern port of ancient Corinth; Halieis, a small fishing-town in the southern Argolid (Fig. 7); and Cosa, a Roman foundation (287 BC) on the Etruscan coast.[40] At Cenchreae posts of a submerged pier were excavated with airlift, hose and dredge, and at Halieis the narrow harbour entrance and a number of submerged land structures with a dredge. At Cosa cuts were made through the breakwater and a pier, and the harbour basin and entrance investigated with a 'water-jet prober' and an air-lift used within a cylindrical steel caisson. Apart from the structures found, there is in underwater excavation always the possibility of spectacular finds of organic materials or valuable objects protected by their submersion. This was highlighted at Cenchreae, where two rooms of a temple on the pier were in use as storerooms, perhaps temporarily, when an earthquake submerged them: one contained large numbers of everyday wooden objects, rarely found in land excavations, and the other contained crates in which were found superb glass mosaic panels (see above p. 83.[41]

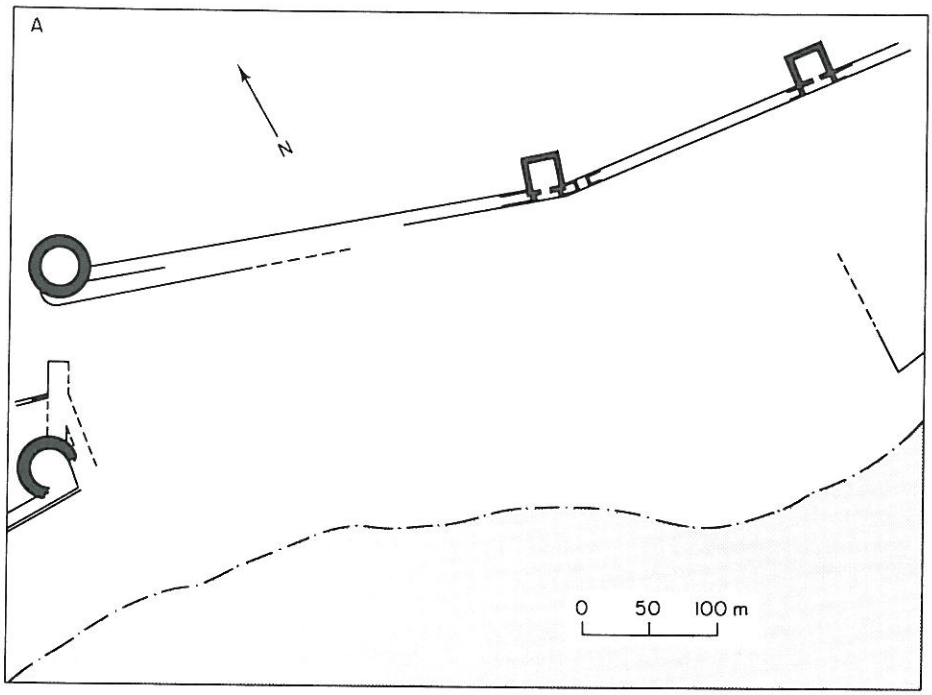
The chance of such finds makes excavation of submerged coastal sites attractive and desirable, but it is a good deal more expensive and in some ways more difficult than work on land, though less so than work in deep water. In the future, drainage and total excavation of a harbour basin may be possible, for example at Cnidus. But in the meantime the urgent task remains of surveying visible remains at as many sites as possible. Electronic prospection of ancient harbours, in order to detect remains buried in the seabed, has been carried out on a limited but increasing scale, for example at Gythion, Halieis, Akko and Caesarea; this possibility needs further exploitation, and the technique will need further testing by excavation of areas where possible remains have been detected by sonic devices.

The earliest harbourworks

In the early centuries of navigation in the Mediterranean men would not have needed to construct any harbourworks. Their boats were relatively small and could have been beached for unloading and then manhandled up the beach for protection from storms; tides in the Mediterranean are so slight that they did not have to be taken into account. The most that may have existed in the way of installations would be posts of stone or timber, or merely a tree or rock, for making fast the boat; props, perhaps, to keep it upright; covering material for the winter; and a few storage huts—the situation ascribed to mythical Phaeacia in Homer.[42] Nothing more would be needed on sea coasts until, as the increase in maritime commerce led to an increase in the size of merchant ships, these became so large that it was much more convenient to be able to berth them against a quay for unloading; on the other hand, small boats and warships were still beached throughout antiquity. The archaeological and literary evidence indicates that this stage was reached in the eastern Mediterranean in the mid-2nd millennium BC.

No harbourworks have yet been found on the eastern Mediterranean coast which are certainly so early in date; but there is little reason to doubt that they existed. Earlier harbourworks are known, from the riverine civilizations of the Indus Valley, Mesopotamia and Egypt. Here river traffic and canal traffic in increasingly large merchant ships and barges developed at an early stage; hauling ships ashore would often be impracticable, and one may reasonably assume at the very least the building of solid river embankments, also serving as quays, by the major city states. Current and flood would remain a problem, and the next logical step was the excavation of docks in the river bank, with an outlet to the river; later the same was done on unprotected sea coasts.

The earliest known example of such a dock is at Lothal, a Harappan site of the late 3rd millennium, close to the Gulf of Cambay, east of the Indus Delta. It is a long rectangular basin



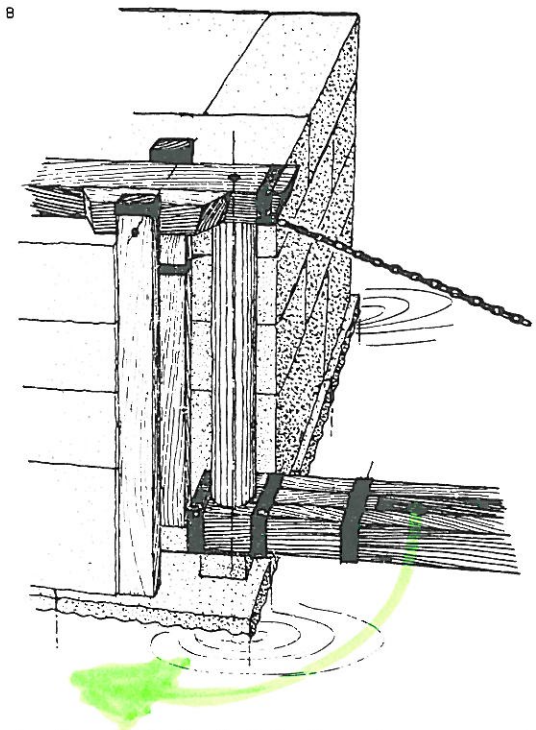


Figure 7. Halieis harbour: A. plan; and B. detail of the fixture for an entrance boom. Courtesy Michael H. Jameson and American School of Classical Studies.

with walls of fired mudbrick and a quay on the city side with a warehouse behind. The basin was approached by a channel from the nearby river, and when the river course changed in about 1970 BC a new channel had to be cut. There is some literary evidence for trade between Mesopotamia and areas which may plausibly be identified with western India, and discovery of some Harappan outposts on the coast of Baluchistan, west of the Indus, confirms the likelihood of this maritime trade.[43]

In Mesopotamia itself we know from records of the 3rd and 2nd millennium BC of the existence of quays and 'mooring-places' for ships, and riverside warehouses. The quays were built of mudbrick and bitumen. The earliest actual remains of harbourworks so far found there appear to be of the late 3rd millennium: two off-river harbour basins enclosed within the walls of Ur in the Third Dynasty. Much later is a small dock cut in the bank of the Euphrates at Til-Barsib, site of an Assyrian palace of about 700 BC; a similar dock seems to be depicted on an Assyrian stone relief of similar date.[44]

In Egypt, where ships of considerable size are depicted on Bronze Age reliefs and wall-paintings and in models, solid-built river embankments must have served as quays. Those beside temples, which are best attested, may have been confined to religious purposes, including, of course, the traffic involved in temple- and tomb-construction. Granted the volume of riverine traffic by the 2nd millennium, it is likely that a number of off-river harbour basins were excavated, to provide extra quay-space under greater protection. Some were temple harbours, but two which were not have been discovered recently: a small one at Serra East in the northern Sudan (early 2nd millennium), and a larger one at western Thebes (early 14th century) now being investigated. Very detailed records survive of ship-building yards operating in the first half of the 15th century, but no remains have yet been found.[45]

It is clear, then, that in the Late Bronze Age Levant there was already the technical knowledge necessary to create artificial harbourworks on the sea-coast also; and in view of the extent of maritime traffic along the Levantine coast at this period in merchant ships which used anchors of immense weight and were clearly too large to beach, it is very likely that such harbourworks were built. Whether we may see them in the cut and built-up reef-breakwaters and reef-islands of Sidon, Tyre, Aradus and Machroud is not yet certain, but a good case has recently been made for a Bronze Age date for many of these rock-cut installations. The earliest harbourworks at Alexandria may be as early in date, but about this we can now only guess.[46] It has also been suggested that some of the earliest artificial harbours may be found in Cyprus.

The major problem in dating these harbours is the difficulty of dating rock-cuttings, for stratigraphic evidence is usually lacking, and unless masonry is incorporated, there is no chance of cross-dating from dated structures with a similar style of masonry. Evidence of sea level changes may one day be certain enough to be used as a basis for dating; particularly promising is the possibility of dating precisely sea level lines which cut across rock-cuttings, or masonry for that matter.[47]

Early in the 1st millennium are to be placed the first certainly datable built, as opposed to rock-cut, harbourworks on the Levantine coast: notably a jetty of the 9th century BC at Tabbat-el-Hammam on the mainland opposite Machroud; it may have taken the place of the anchorage harbour of Machroud which by this time had apparently been submerged.[48] The original harbourworks at sites like Tyre and Sidon are often dated to the Iron Age (1st millennium) and ascribed to the Phoenicians, who appeared in the Levant near the end of the Bronze Age (late 2nd millennium). This may be true, for they were great seafarers and are likely to have improved the great Levantine harbours even if they were not their original builders. Perhaps we may ascribe to them the jetty at Tabbat-el-Hammam, the addition of built quays and jetties at sites like Sidon and the original harbourworks at Athlit and Akko, where the moles consisting of lines of continuous stretches of 'headers' may show a specifically Phoenician building method; one traditionally Phoenician feature, the *cothon*, is strikingly absent from the Levant, perhaps because sufficient offshore reefs were available. Certainly by the 7th century at the latest a number of Levantine harbours had well-

developed harbourworks. Now that man could build walls under water, harbour size was no longer dictated entirely by the natural features available.

By this time harbourworks were also being built in the Aegean. The earliest which are firmly datable, being historically attested, are those built around 530 BC by Polycrates, tyrant of Samos, and mentioned by Herodotus as a major feat of engineering; some remains survive. These by their size clearly marked a new stage, but they were not the first in the Aegean. A quay and breakwater on Delos have been dated to the late 8th century BC; this dating is far from certain, but the late 8th and 7th centuries provide a very likely context for the first large-scale attempts by the Greeks to improve their available natural harbours. This was the period when the Greeks sent out colonies to many parts of the Mediterranean, a process which stimulated the growth of maritime trade; so too, in the 7th century, did the introduction of coinage, which also probably made it much easier to finance major public works, such as harbour construction.[49]

What of earlier harbourworks in the Aegean? The number of good natural harbours on its indented coast was such that the Greek cities of the Iron Age, many of which for obvious reasons developed beside or inland from these harbours, had probably had little need to build much in the way of protecting moles; perhaps they built a shoreline quay or a projecting jetty for larger merchant ships to berth against, but quite possibly nothing at all.

The likelihood of large-scale built harbourworks in the Aegean area in the Bronze Age seems small, though obviously such a statement could be proved wrong by future finds. The one exception might be a few exposed coasts without many naturally protected harbours, but with a relatively large population nearby: notably the north coast of Crete. Cuttings in bedrock at Mallia and Nirou Chani and remains at Amnisos have been interpreted as Bronze Age harbourworks, but their date is quite uncertain. Mochlos, now an island, may have been joined to the mainland by a natural causeway with, on either side, a good protected anchorage—rare on this coast; here there would have been no need to build harbourworks. One site on the south coast of Crete, Kommos, near Phaistos and Hagia Triada, may when fully excavated tell us a good deal about Minoan port establishments.[50]

By the close of the 2nd millennium, according to tradition, the Phoenicians had started to explore the Mediterranean, starting perhaps in Cyprus and going on to found colonies along the North African coast and in parts of Sicily and as far west as Gades (Cadiz). Traditionally Gades was founded in about 1110 BC and Utica near Carthage in about 1100 BC, though the archaeological remains are all later; Carthage not until 814 BC. The Phoenicians developed a line of staging-posts on the route to the west, some small, like Gaphara somewhere west of Leptis Magna, but others developing into major trading-points, the trade being mostly maritime. With the growth of trade the harbours would need to be developed. This may be the origin of some of the North African ports which we see in their later form as great harbours serving Rome, for example Sabratha and Apollonia. In a mood of imaginative speculation we might see Phoenician work in the development of these ports, for on this bleakly harbourless coast, as on the Levantine coast, most of the few possible harbours lay behind fragments of the original coastal reef. Phoenicians from Tyre and Sidon would have known how to improve the natural protection of such reefs by filling the gaps to provide a sheltered anchorage; at some stage this was done at Apollonia and possibly Sabratha, with rubble heaps which are now undatable.[51]

Without being so speculative we can see Phoenicians at work in developing one particular type of harbour, associated with them in antiquity: the *cothon* or artificially excavated harbour. This answered the problem of creating harbours on exposed coasts lacking natural harbours or even offshore reefs. In the centuries before the Romans became able to build harbours out from the shore without any help from nature, a basin was excavated behind the coast, sometimes perhaps making use of existing low-lying ground or a lagoon, and joined by one or more channels to the sea. Carthage itself had a double harbour of this type; the island settlement at Motya in western Sicily had such a basin, though apparently not until the 6th century; Mahdia, ancient Alipota, has a rock-cut harbour basin which would repay exca-

vation. At Motya, for which we have clear historical sources, we can be sure that we are dealing with Phoenician remains, but not necessarily of a harbour; at Carthage the basic layout described by Appian (above pp. 79–80) is pre-Roman, but is apparently not earlier than the mid 4th century BC; and at other North African ports it is difficult to distinguish any certainly pre-Roman remains. It is therefore hard to assess to what extent progress in harbour engineering was due to the Phoenicians of the west. One intriguing site may prove important here: Lechaeum inner harbour, the only harbour in the Greek world which might reasonably be called a *cothon.* But until its foundation date is more firmly established, it is difficult to assess its significance.[52]

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Notes

[1] Philon of Byzantium wrote on *Harbour construction,* but only the title survives. Vitruvius: 5.12.

[2] E.g. Timosthenes of Rhodes, a commander in the Ptolemaic navy in the 3rd century (Fraser 1972, I. 522 & nn.).

[3] *Periploi:* texts in C. Müller, *Geographici Graeci Minores* (2 vols, Paris 1855–61). See Warmington (1934); *Oxford Classical Dictionary* (2nd ed.) s.v.; F. Gisinger, *RE* s.v. Portolani; Delatte (1947, 1958); K. Kretschmer, *Die italienischen Portolane des Mittelalters* (Berlin 1902).

[4] Cary & Warmington (1963).

[5] But numerals in manuscripts of ancient texts are notoriously unreliable.

[6] Strabo 17. 1. 6–10 (791–5); Appian, *Punica* 96 (my translation); Herodotus 3.60; Josephus, *BJ* 1. 408–14; Suetonius, *Claudius* 20.3; Pliny, *HN* 16.202; Pliny, *Ep.* 6.31.

[7] Tomb of Kenamon: Bass (1972), 23, ill. 22; tomb of May at Amarna: N. de G. Davies, *The rock tombs of El Amarna* Part V (London 1908), pl. V; H. Groenewegen-Frankfort, *Arrest and movement* (London 1951), 107, fig. 21; Kemp & O'Connor (1974), 105–6; 3rd-century mosaic: Casson (1971), fig. 191.

[8] See S. Marinatos, *Das Schiffsfresko von Akrotiri, Thera,* in D. Gray, *Seewesen* (1974=*Archaeologia, Homerica,* Vol. 1, ch. G), 140–51; *idem, Excavations at Thera* VI (Athens 1974), 38–57. The bibliography has snowballed: especially valuable is L. Casson, *Bronze Age ships.* The evidence of the Thera wall paintings, *IJNA,* 4 (1975), 3–10; compare ibid. 5 (1976), 285–92, 6 (1977), 181–2, 266–67, 7 (1978), 232–3; T. C. Gillmer, *Mariner's Mirror,* 64.2 (1978), 125–33; P. M. Warren, *JHS,* 99 (1979), 115–29; S. Wachsmann, *IJNA,* 9.4 (1980), 287–95.

[9] BM Cat. *Sicily,* 99 nos 1–8 (no. 2=Fig. 1A); Boyce (1958), 78; G. Vallet, *Rhegion et Zancle* (Paris 1958), 115–6, 326–7 and pl. XVIII. The coin series starts in the 6th century. Lehmann-Hartleben (1923, 237–8) is unduly sceptical.

[10] Valuable discussion of both coin-types in Boyce (1958) with full references. For the 'jars' compare some Campanian wall-paintings, e.g. H. Roux & L. Barré, *Herculanum et Pompeii* (Paris 1841) V. 13; 16 (Naples Museum 9479; 9409). On the sestertii see also Lehmann (1923), 187, 239 (& coin pl. no. 1); BM Cat. *Empire,* I (1923), 221–3, nos 131–4 (no. 132=Fig. 1B); Meiggs (1960), 157–8 and pl. XVIIIa.

[11] Ostia: Meiggs (1960), 162 & pl. XVIIIb; T. L. Donaldson, *Architectura Numismatica* (1859, repr. 1966) 338–40; Lehmann (1923), 197, 239 (& coin pl. no. 2). H. Mattingly & E. A. Sydenham, *The Roman Imperial coinage* II (London 1926), 278, no. 471 (pl. XI.189); BM Cat. *Empire* III (1936), civ & 162, no. 770A; Boyce (1958), pl. 13.12. Side: Donaldson, *op. cit.* 341–4; Lehmann (1923), 192, 238 (& coin pl. no. 9); BM Cat. *Lycia,* 161, no. 112 (pl. XXVIII.19); Boyce (1958), pl. 13.11. Patrae: F. Imhoof-Blumer & P. Gardner, *Numismatic commentary on Pausanias* (1887, repr. 1964), 81 & pl. Q.XXIII (cf. pls Q.XXI–XXII); Lehmann (1923), 211–2, 239 (& coin pl. no. 8; cf. nos 6–7); Boyce (1958), pl. 13.8 (cf. 13.6–7).

[12] Boyce (1958).
[13] Coin of Cenchreae: Imhoof-Blumer & Gardner, *op. cit.* 17 & pl. D.LX; Lehmann (1923), 238 (& coin pl. no. 11: cf. no. 10); Boyce (1958), pl. 13.4; Hohlfelder (1970).
[14] Denarius of Palikanus: BM Cat. *Republic,* I, 517–8, no. 4011 (pl. L.18); Coarelli (1968), 27, fig. 1 & n. 4 (cf. the asses of Ancus Marcius Censorinus, ibid. 29 & fig. 6); B. L. Trell, *NC* (7th S), **12** (1972), 51, whose interpretation I follow. See also nn. 25, 27 below.
[15] Particularly common are those of the reign of Antoninus Pius. Some coins, and especially some rather larger medallions, depict a lighthouse as the central feature of a wider harbour scene. See Thiersch (1909), 9 ff. & pls i–iii; Stuhlfauth (1938); Picard (1952); Boyce (1958), pl. 14; S. Handler, Architecture on the Roman coins of Alexandria, *AJA,* **75** (1971), 57–74, esp. 58–61; Shaw (1972), 102 ill. 4; Fraser (1972), II. 45–6.
[16] A ship alone is commonest; ship and lighthouse: M. Henig, *A corpus of Roman engraved gemstones from British sites* (Oxford 1974), Part I, 142 no. 538; arched mole with lighthouse: Thiersch (1909), 21; BM Cat. *Early Christian Antiquities* (O. M. Dalton, 1901), 14, no. 88; Cintas (1973), 41–6; Debergh (1975, 1977); Hurst (1976), 186.
[17] Ship: Torr (1964), pl. F. Lighthouse: Thiersch (1909), 14; Stuhlfauth (1938), figs 14–15. Harbour scene: Rostovtzeff, *RömMitt,* 26 (1911), 153–4; Lehmann (1923), 227–8; *Libya Antiqua,* 5 (1968), 45–54; J. Deneauve, *Lampes de Carthage* (Paris 1969), 212, no. 1047 (cf. nos 1044–6, 1048–9); Shaw (1972), 103; Fraser (1972), II. 17 § 6.
[18] Dubois (1907), 190 ff.; Picard (1959); Shaw (1972), 106; Casson (1974), fig. 19. Another illustrated: *Apollo* (Dec. 1973), p. 40 (now in the Pilkington Museum of Glass). Eight are now known.
[19] Casson (1971), figs 147–8; Stuhlfauth (1938), pl. 31.
[20] See Meiggs (1960), caption to pl. XX; Lehmann (1923), 235–6 & pl. II; Stuhlfauth (1938), 143–4.
[21] Lehmann (1923), 231–5 & pl. I.
[22] Meiggs (1960), pls XXVIIIa, XXVIa, b, with discussion; Casson (1971), figs 193, 174 (the first two).
[23] C. Cichorius, *Die Reliefs der Trajanssäule* III (Berlin 1900), 11–26 and pls LVIII–LXIII, nos 208–28; Lehmann (1923), 228–31; F. B. Florescu, *Die Trajanssäule: Grundfragen und Tafeln* (Bukarest & Bonn 1969), pls LXVIII–LXXIV; Casson (1971), figs 128, 150. A recently found 1st-century AD relief, probably Jewish work, depicts a ship, probably in harbour, with a lighthouse(?): Rahmani (1976).
[24] Stuhlfauth (1938), figs 8–12; Meiggs (1960), pls XXIIId, XXIVb, XXVa.
[25] Mosaic from Rome: Casson (1971), fig. 154; from Praeneste ('Barberini' or 'Palestrina' mosaic): G. Gullini, *I Mosaici di Palestrina* (*Arch. Cl,* Suppl. Vol. I, 1956), pl. XIX, showing clearly how little of the quay survives and how much of most reproductions is pure conjecture; Toledo mosaic: *Ars Hispaniae: Historia Universal del Arte Hispanico,* II: *Arte Romana por Blas Taracena* (1947), 161; Grange-du-Bief mosaic: J. Guey & P.-M. Duval, Les mosaïques de La Grange-du-Bief, *Gallia* **18** (1960), 83–102; H. Stern & M. Blanchard-Lemée, *Receueil Général des Mosaiques de la Gaule,* II.2 (Paris 1975) 30–5; cf. Coarelli (1968), figs 3–4 for similar depictions on mosaics. New find at Rimini: Gentili (1979).
[26] Scranton (1967); for the full catalogue of the panels by Scranton, L. Ibrahim & R. Brill see *Kenchreai,* Vol. II (Brill, Leiden, 1976).
[27] Temple of Isis painting: Lehmann (1923), 221; Casson (1971), fig. 133; Stabiae painting: Lehmann (1923), 224–7 & fig. 11; Shaw (1972), 107, ill. 17; lighthouse: Testaguzza (1970), 125; ships in shipsheds: Coarelli (1968), fig. 5 [cf. Casson (1971), 365, n. 15; G. B. Pighi, *Convegno Ravenna* 1967, 258–9].
[28] E.g. de la Blanchère (1881, 1884); Koldewey (1890).
[29] Günther (1903a, b); Negris (1904).
[30] Jondet (1916); Taylor (1965), 160–2; Paris (1915, 1916); cf. Ardaillon (1896).
[31] Poidebard (1939); Poidebard & Lauffray (1951). Cf. Frost (1963, 1972); Taylor (1965), 162–7.
[32] Portus: Testaguzza (1964, 1970); cf. Casson (1978). Leptis: Bartoccini (1958). Massilia: Euzennat & Salviat (1968); Euzennat (1976). Motya: Isserlin (1971, 1974); Isserlin & Taylor (1974). Sarepta: Pritchard (1971a, b). Sybaris/Thurii: Zancani Montuoro (1974); Blackman (1977). Carthage: Hurst (1975, 1976, 1977, 1979); Stager (1976, 1977); Eadie & Humphrey (1978); Kuzmanov (1976); Yorke & Little (1975); Yorke (1976); Yorke & others (1976); Hurst & Stager (1978).
[33] Corcyra: G. Dontas, *Praktika* (1965), 74–6; (1966), 84–94. Rhodes: Bradford (1957), 280.
[34] Schmiedt (1964, 1965–67); *Convegno Ravenna* (1961, 1967 passim); Frost (1964, 1966, 1969); Jameson 1969, 1973); Kritzas (1972); Oleson (1977); Whittlesey & others (1977); *Ergon* 1979, 24–5.
[35] Narbonne: Guy (1965); Gayraud (1975), 843–8. Crete: Leatham & Hood (1958–59). Apollonia: Taylor (1965), 168–78; Flemming (1972), 95–126. Other North African sites: Yorke (1966, 1967); Yorke & Davidson (1969). Work by the same club in Italy & Greece: Dallas (1967); Dallas & Yorke (1968); Harding & others (1969). Sardinia: Macnamara & Wilkes (1967); for recent finds: Loppel (1977). Sicilian sites: Syracuse: Kapitän (1967–68); Gargallo (1970a, b); Agnello (1972–73); Camarina: Pelagatti (1976); Blackman (1976–77); Selinus: Purpura (1975), 58–64; Picozzi (1978). Pyrgi: Fioravanti (1972); McCann & Oleson (1974); Oleson (1977). Populonia: Cardarelli (1963); McCann (1971); McCann & Oleson (1974 & in press); McCann & others (1977). Minturnae: Brookes (1974); Ruegg (1978). Santa Marinella (Castrum Novum): Gianfrotta (1972); Frau (1978); Picozzi (1980). Sipontum: Delano Smith & Morrison (1974). Egnatia: Sciarra Bardaro (1979); Freschi & Afloa (1979–80). Portus Uxentinus: *Arch. Reports for 1976–77,* 59. Giannutri: Bruno (1973b). Bay of Naples: Taylor (1965), 178–85, from N. Lamboglia, *Rivista di*

Studi Liguri, **25** (1959), 302–9; de Franciscis (1967); *IJNA,* **4.2** (1975), 381–4. Spain: Hohlfelder (1976) found no remains of Roman harbour installations on the coast of Baetica (Andalusia), and suggests that the Romans simply used the beaches, with lighters, and also the rivers.

These results are now being drawn on for comprehensive studies of particular coastlines: e.g. Bruno (1973a); Delano Smith (1978); G. D. B. Jones & J. H. Little, Coastal settlement in Cyrenaica, *JRS,* **61** (1971), 64–79; Little (1977–78).

[36] Anthedon: Schläger, Blackman and Schäfer (1967, 1968). Larymna: Schäfer (1967). Aegina: Knoblauch (1969, 1972). Gythion: Scoufopoulos & McKernan (1975). Cyme: Schäfer & Schläger (1962); Knoblauch (1974); Schäfer (1974b). Phaselis: Schläger & Schäfer (1971); Blackman (1973c); Schäfer & others (1981). Side: Schläger (1971); Knoblauch (1977). Other sites in southern Turkey: Tigrel (1975); Bolzoni (1977); Carter (1978). See also Wendel (1968, 1969); Flemming (1978); Flemming & others (1973a, b). Cnidus: n. 81. Northern Turkey: Stoop (1978).

Sites in western Greece: Cyllene: Servais (1961); Pheia: Hall (1967); Methoni: Kraft & Aschenbrenner (1977). Paros: Papathanassopoulos (1980).

[37] Blackman (1973b); Flemming (passim); Frost (1971, 1972, 1973).

[38] Fritsch & Ben-Dor (1961); Linder & Leenhardt (1964); Linder (1967); Frost (1972); Dothan & Linder (n.d.); Linder & Raban (1976); Flinder (1976); Raban & Linder (1978); Rougé (1978); Raban (1978). Possible submerged breakwater at Ashdod: Edgerton & others (1974).

[39] Russia: convenient summary by Blavatsky (1972); Romania & Bulgaria: Dimitrov (1977, 1979); Dimitrov & C. Nicolov, *IJNA,* **5** (1976), 81–3.

[40] Cenchreae: Scranton & Ramage (1967); Shaw (1967a, 1978); Halieis: Jameson (1969, 1973); *Scientific American* **231.4** (1974), 110–19; Cosa: McCann & Lewis (1970); McCann (1973); Lewis (1973); McCann (1979 & in press). Work at Pyrgi and Populonia could also now be described as large-scale: see note 35.

[41] Note 26 above; Scranton & Ramage (1967); Shaw (1972), ill. 10–12.

[42] *Odyssey* 6. 263–9; cf. Casson (1971), 362.

[43] Lothal: Rao (1962, 1965, 1973 chap. 5); but see also Leshnik (1968). Literary evidence: A. L. Oppenheim, The sea-faring merchants of Ur, *JAOS,* **74** (1954), 6–17; W. F. Leemans, *Foreign trade in the Old Babylonian Period* (Leiden 1960), 159–66; S. N. Kramer, Dilmun: quest for paradise, *Antiquity,* **37** (1963), 111–5; J. Oates & others, Seafaring merchants of Ur? *Antiquity,* **51** (1977), 221–34. Baluchistan: G. F. Dales, *Antiquity,* **36** (1962), 86–92. On commerce and ports of call see Pirenne (1974) and *Les Grandes Escales,* Vol. I (passim).

[44] Records: Salonen (1942), 33–40; Ur: C. L. Woolley, *Ant. J.,* **10** (1930), 318–19; Til-Barsib: F. Thureau-Dangin & M. Dunand, *Til-Barsib* (*Bibl. Arch. et Hist.* **23**, 1936) 5; Assyrian relief: Laessøe (1953), 17–22. Seasonal changes in river level made the engineer's task more difficult.

[45] Serra East & Thebes: Kemp & O'Connor (1974) with full bibliography; Goyon (1971) suggests that a canal parallel to the Nile was a main waterway to these temple-harbours; shipbuilding records: Glanville (1931, 1932). The island harbour and anchorage at Jezirat Fara'un, near the north end of the Gulf of Eilat, may well have been first used in the 14th–12th centuries, during Egyptian exploitation of copper deposits north of Eilat; but the built breakwater enclosing the harbour bay and bearing a fortification wall has not yet been firmly dated: B. Rothenberg, *Timna* (London 1972), 202–7; Flinder (1977). Discovery of a 12th-Dynasty (early 2nd millennium) port, but no installations, is reported from the Red Sea coast of Egypt: Sayed (1978).

[46] Frost (1970, 1971, 1972, 1973). Alexandria: Fraser (1972), I.6. Cyprus: a suggestion (unpublished) by E. Linder; for Hala Sultan Tekke: Engvig & Åström (1975); McCaslin (1978); for Salamis: Flemming (1974). Ugarit: Astour (1970).

[47] Frost (1972), 112–3.

[48] Braidwood (1940); Frost (1966). Anomalous walls in the water at Dor in Palestine, perhaps of early date, are mentioned by Shaw (1972), 90.

[49] Delos: Paris (1916); Lehmann (1923), 50–1. Many of the early public works in Greek cities of which we know anything were due to powerful monarchs, seeking to build up their city's trade and prosperity, and having control of the necessary resources of finance and labour. S. C. Bakhuizen suggests the importance for the colonization movement of the new exploitation of, and maritime trade in, iron and steel: *World Archaeology,* 9.2 (1977), 220–34.

[50] Nirou Chani: note 113; Mochlos: Leatham & Hood (1958–59); new finds at Mochlos and Dia by Cousteau are reported, but have not been published [only Cousteau, 1977; cf. *Bull. corr. hellénique,* **101** (1977), 621]. Excavation has started at Kommos, but only on land: Shaw (1977); promising traces have been seen in the water: Whittlesey & others (1977), 186–8.

[51] On the Phoenicians, see e.g. D. B. Harden, *The Phoenicians* (London 1962); W. Cullican, *The first merchant venturers* (London 1966). As has been noted, we know almost nothing of ancient harbours in Spain, a principal area of Phoenician, later especially Carthaginian, activity. Miss Frost tells me that she now doubts that filling gaps in reefs was a specifically Phoenician feature. Apollonia: above n. 35; Sabratha: Yorke (1966, 1967); Gaphara: Yorke (1967), 22 (Al Jezirah ?). Some stretches of the coast had natural harbours, e.g. central Cyrenaica: Little (1977–78).

[52] The cothon: Lehmann (1923), 145–6 & n. 1; E. Kirsten, Kothon in Sparta und Karthago, *in* K. Schauenburg (Ed.), *Charites* (Bonn 1957), 110–8. Carthage: Bradford (1957), 231–7; Baradez (1958); Cintas (1973), denying the identification, unjustifiably; Yorke & Little (1975); Hurst (1975, 1976, 1977); Hurst & Stager (1978), with interesting estimates of the scale of excavation required: 120,000 m^3 of earth excavated to make the rectangular harbour and 115,000 m^3 to make the circular. Motya: Isserlin (1971, 1974): recent research indicates that the basin was never a harbour. Mahdia: Yorke (1966, 1967). Lechaeum: Georgiades (1907); Paris (1915); Shaw (1969, 1972: 96); the outer harbour is clearly a later addition. Hurst (1979) gives the first evidence of a possible earlier harbour at Carthage. On the Phoenician(?) and Roman harbour works at Tharros in Sardinia, where investigations recently started under L. Fozzati, see Picozzi (1979); D'Angelo (1979–80).

Part 2 *Greek and Roman harbourworks* will appear in the next number of the Journal.

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*These publications reached me too late to take account of them in this article.

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Ancient harbours in the Mediterranean. Part 2*

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Greek and Roman harbourworks

Introduction

From the 6th century BC onward the main tradition of harbour engineering in antiquity centered on the Greek and then the Graeco-Roman world. The main development was from the use by the Greeks of blocks of ashlar masonry joined without mortar, to the use by the Romans of masonry bonded with mortar and then solid concrete for free-standing structures. Roman engineers were also ready to excavate harbour basins, and their skill, aided by the introduction of mortar which would set under water, enabled them in the Imperial period to impose harbours on harbourless coasts [for example, Terracina, Antium (Fig. 1), Thapsus, Pompeiopolis and Trapezus], and gave them much greater freedom in the choice of sites to develop.[53]

One can also trace a gradual increase in the size of harbours through the Classical and Hellenistic into Roman periods: not only the amount of berthing space or the anchorage area, which before the introduction of concrete might be limited by the natural confines of the sites, but also the scale of mooring facilities, quays and dockside buildings. The other important innovation was the lighthouse.

One main problem in almost all harbour studies is to distinguish any earlier features in a port used and often much developed in the Roman period.

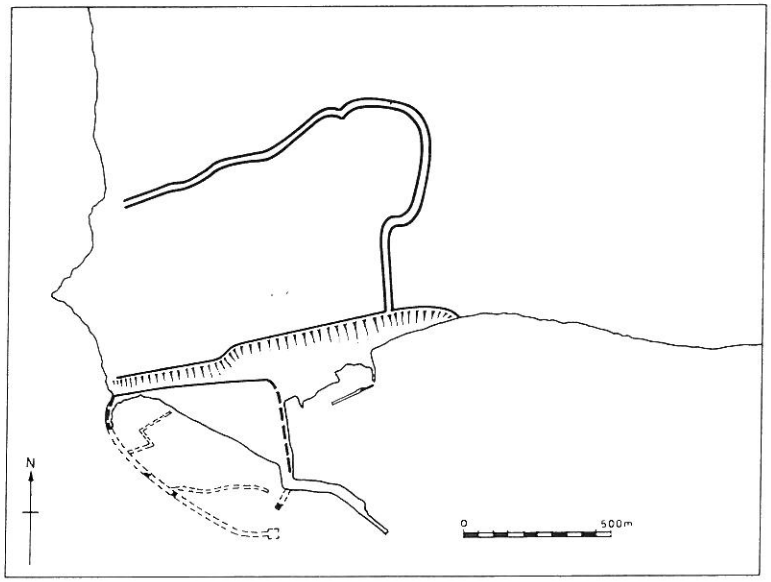

Figure 1. Antium harbour. After Lugli (1940: pl. I).

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The location of Greek and Roman harbours in the Mediterranean

Most of these harbours were on the sea coast; few were on rivers except at their mouths, since few Mediterranean rivers were navigable far upstream in antiquity. However, even if the river was not navigable, the valley was often a major land trade route, and the point at which this reached the sea would be of considerable commercial and strategic importance. Good examples are the ports at the mouths of the great valleys of western Asia Minor. Miletus lay on the coast in antiquity, at the mouth of the River Maeander, but because it was on a rather isolated headland, some land traffic probably crossed by an easy route from the lower Maeander valley to Ephesus at the mouth of the River Caicus, to the north. Further north still, the Royal Road which crossed the Persian Empire, and was a major trade route, ended at Sardis in the Hermus valley; from there roads ran south to Ephesus and west down the valley to Smyrna and Cyme. It is significant that these coastal cities seem to have suffered economic decline precisely when they were liberated from Persian rule by Athens in the 5th century and thus cut off from the hinterland, which was still controlled by Persia.[54]

Harbours like these which were built at or near the mouths of major rivers did, however, experience continual difficulty with the accumulation of river-borne silt and the forward movement of the river mouth. Vitruvius warned engineers not to build ports in such a location.[55] The city sites of Ephesus and Smyrna were moved seawards to remain in contact with the sea; but by the late Roman period even the later harbour of Ephesus was out of use, and though the port of Smyrna is still in use the site has moved westwards and the siltation problem remains. Miletus could not move and now lies well inland. Other harbours near river mouths must have had to face similar problems: for example, the port which in Hellenistic times developed, in place of the (by then) inaccessible port of Pella, by

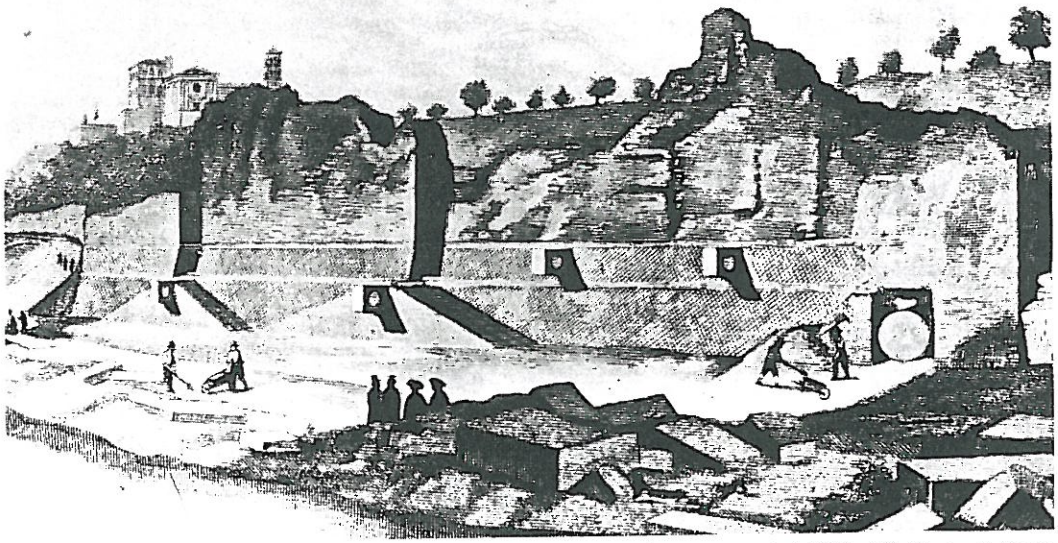


Figure 2. Roman quays on the bank of the Tiber at Marmorata, Rome; excavated 1868–70. Museo di Roma, Archivio Fotografico.

the mouth of the River Axios (Vardar), Thessalonice. Alexandria was fortunate, for it lay west of the delta and the west–east coastal current swept away the Nile silt.

On the exposed coast north of Rome, a number of the great Etruscan cities, which lie inland, may have had ports inside river mouths, accessible from the sea across coastal lagoons. It has been suggested that deforestation and soil loss led to the drying up of the rivers and the silting up of the lagoons into malarial marshes, thus rendering the ports unusable and the coast uninhabitable. In late antiquity the river port at Aquileia, at the head of the Adriatic, seems to have been superseded by Grado on the coastal bar at the mouth of the lagoon. Lagoon ports such as Ravenna on the south edge of the Po delta, or Narbo on the River Aude just above the point where it entered the coastal lagoon, faced considerable siltation problems.[56]

Rome itself was accessible up the Tiber for smaller ships, and considerable remains of quays have been found along the Tiber (Fig. 2).[57] Larger ships, however, could get no farther than the port at Ostia, just within the Tiber mouth, and most shippers clearly preferred to use Puteoli, 150 miles to the south. For the port of Ostia suffered from silting, and the increasingly large merchantmen in use by the 1st century BC could not get in across the sand bar at the river mouth, a common difficulty in river navigation, and had to offload into lighters; furthermore, the increased volume of traffic was causing congestion in the confined port. The plan for a new port near Rome, originally projected by Julius Caesar, was carried out by Claudius from AD 42 to ensure a safe harbour for the corn transports. Just over 2 miles north of the Tiber mouth he built a massive harbour, Portus (*The* Port), connected by canal to the Tiber, which on its winding course flowed close by. This proximity, allowing easy passage for small craft up to Rome, plus perhaps the existence already of a small bay, seems to have been the reason why the harbour was built north of the river mouth, even though this exposed it to river silt swept northward by the coastal current and prevailing southerly and westerly winds. This factor may not have been fully appreciated at the time, but it was to cause continual problems, and despite dredging and a silt-deflecting mole eventually put the harbour out of action.[58]

Almost all the rivers of Italy and Greece were too short and fast-flowing to be navigable far inland from their mouths; some, like North African wadis, were purely seasonal. River traffic was, however, very important in some areas, besides Egypt and Mesopotamia: in Gaul and central Europe there were a number of larger rivers navigable for long distances, notably the Rhône and Danube and, farther north, the Seine, Rhine and Thames. On these there seems to have been a good deal of shipping, and Roman fleets were based on the Rhine and Danube, but probably few ships left the rivers because of the shallows and rapids which proved an obstacle at the mouths. At the Rhône mouth a system of canals was built by the Roman general Marius to circumvent this obstacle, connecting the important river port of Arelate (Arles) with the sea via Fossae Marianae. Marseilles, it may be noted, lay clear of the delta but with easy access to the Rhône valley.[59] Other river mouths offered fewer problems, apparently; for example, Londinium developed into a major port. At Leptis Magna the problem developed in the course of time and a dam was built to divert the river.

Most ancient harbours lay on the sea coast. They were principally concerned with trade, which in antiquity was mainly by sea where possible, for in the Mediterranean area the sea often provided the 'inside routes' while land transport was comparatively expensive and difficult, especially for bulky commodities, and no less dangerous.[60] The important harbours usually lay on the great sea routes: Phaselis, Rhodes and Cnidus on the route from Cyprus and the Levant to the Aegean and the west; Corcyra and Tarentum, Dyrrachium and Brundisium on the routes from Greece to Sicily and Italy; Carthage on the southern route to the western Mediterranean. Large merchantmen of the Roman period hugged the coast much less, but even they used ports in adverse winds at dangerous capes and straits; hence the continuing prosperity of Cnidus, and the enlargement by Caligula of the port of Rhegium at the Straits of Messina.[61] Other important ports on straits were Byzantium (later Constantinople) on the Bosporus, Sestus on the Dardanelles and, in between, Cyzicus.

In early Greek times, if straits were difficult to navigate or controlled by hostile cities, traders of other cities tried to develop routes bypassing the straits: from Aenus on the Aegean up the River Hebrus, in itself a trade route into the heart of Thrace, and overland to the Black Sea; and across the 'toe' of Italy, for example from Sybaris to Laüs and Scidrus.

The most important isthmus route of antiquity was that near Corinth, which enabled traffic from the Aegean to the west to avoid the dangerous route around the headlands of the southern Peloponnese. This was one of the main factors behind the early prosperity of Corinth and of other harbours nearby to the east, like Aegina. The tyrant Periander did not succeed in cutting the isthmus, but a stone runway was built across it, over which warships and perhaps small merchant ships could be hauled.[62] Goods must have gone across by land from the eastern port (Cenchreae) to the western port (Lechaeum).

Some ports developed as export points for local commodities which were in great demand: already in prehistoric times Melos was a source of obsidian; later Keos exported red ochre; Aliki in Thasos and Proconnesus, marble; and the Black Sea ports, corn and fish to the Greek world. Apollonia, port of Cyrene, exported silphium and later corn to supply the ever-increasing needs of Rome. Other ports too became important as exporters of corn to Rome, notably Alexandria and a number in North Africa—Utica, Thapsus, Sabratha, Leptis Magna and others. Through the latter also came wild animals, exported to Italy to meet the demand for entertainment, and ivory. From the east came luxury goods like silks, spices and ivory and also textiles and papyrus, exported through ports such as Alexandria, Ephesus and Antioch in Syria. From Spain, for example from Onoba and Gades, came metals and also fish-sauce and olive oil.

The main importer of all these goods was Italy and especially Rome. The great increase in import trade made development of the commercial harbours essential: first Puteoli, one of the few natural harbours of Italy; then Portus; then an extra basin at Portus and a new auxiliary port at Centumcellae under Trajan. Even in Italy some ports developed around local industries: for example, Populonia in Etruria, where iron ore from nearby Elba was smelted; and Luna, further north, through which marble was shipped from nearby quarries.[63]

Only a few ports handled a great deal of passenger traffic, in particular those with ferry services across straits and rivers, and those serving the great sanctuaries. Travel for the sake of it, by land and sea, was apparently comparatively rare in antiquity.[64] Private individuals who travelled, notably artists, philosophers and teachers, loom large in the literary tradition and thus have undue prominence. Most travellers will have been merchants or men on official business—ambassadors, officials going to overseas possessions, or soldiers. Private individuals did, however, go to the sanctuaries as pilgrims, or participants and sightseers at the games and festivals, or for cures. Certain ports owed at least their origin, and in some cases their only importance, to the proximity of such sanctuaries: Panormus, near Didyma, to which came also the marble for the temple of Apollo; quite possibly Ephesus; Itea below Delphi; and Delos, despite its lack of a good natural harbour. Later Delos became the great trading centre of the Aegean, but only for the artificial reason that the Romans in 167 BC made its port duty-free, to punish Rhodes for supporting Rome's enemy, Macedon.

Sometimes the process was reversed and sanctuaries grew up by harbours—small refuge harbours, close to dangerous capes. When ships sheltered there in bad weather or contrary winds, it was natural that sailors made offerings to the local divinities or to those who guarded sailors at sea. Thus we find a sanctuary of Poseidon close to Cape Taenarum (Matapan), and of 'Aphrodite of the Harbour' and 'Hera of the Cape' at Perachora, north of Corinth.[65] The refuge harbours and some of the sanctuary harbours provide one main exception to the general rule that ancient harbours were closely linked to city sites.

One other special type of harbour was the private harbour close to the palaces of rich men and monarchs. A number of Greek tyrants had private harbours, for example Dionysius I at Syracuse and Artemisia, widow of Mausolus, at Halicarnassus; at Alexandria there was within the East Harbour and by the palaces a little private harbour of the Ptolemies, rulers of Egypt in the Hellenistic period. In the later

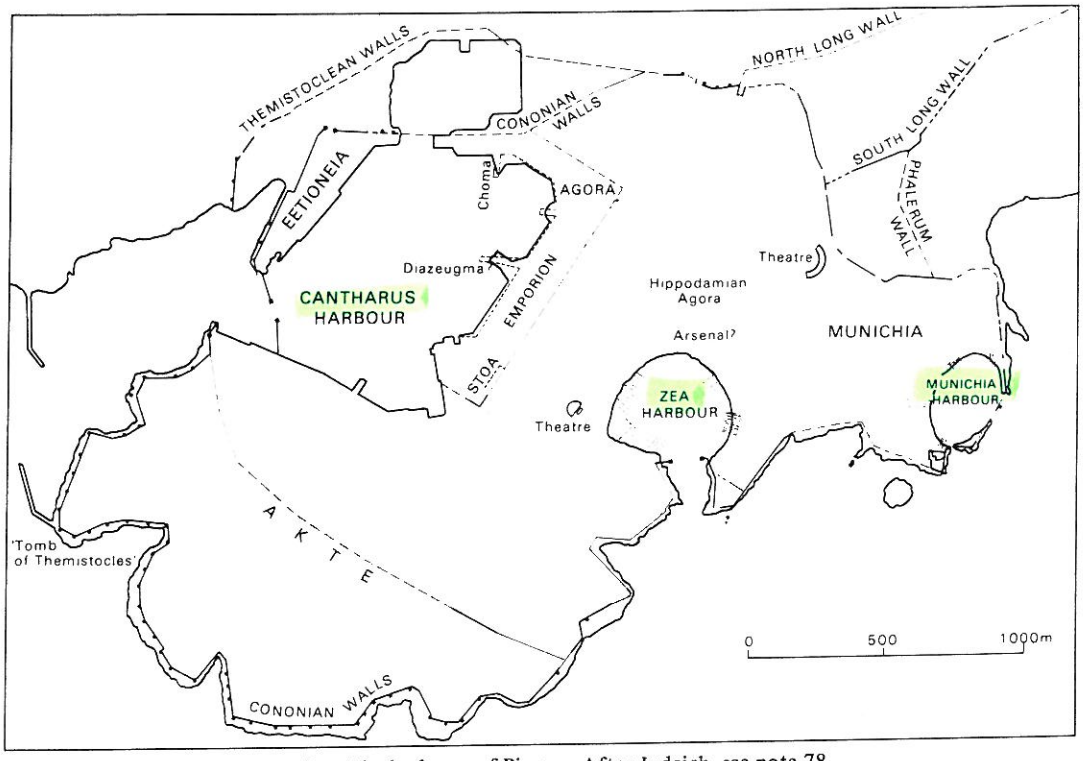


Figure 3. The harbours of Piraeus. After Judeich, see note 78.

Roman period Diocletian had a harbour by his palace at Spalatum (Split) and later emperors similarly at Constantinople. On the coasts of Italy and offshore islands were a number of seaside villas owned by the rich and depicted in Roman art, particularly wall-paintings. These would have had basic harbour facilities, such as those recently found on Giannutri.[66]

Apart from any desire for personal seclusion, monarchs had a sound reason for maintaining a separate private harbour: to keep their warships out of the public view and under direct control and supervision. This was clearly the case with the 'Secret Harbour' at Halicarnassus; perhaps also at Elaea, port of the kings of inland Pergamum. At other harbour sites, too, one harbour or part of a harbour was kept specially for the city's warships; whatever its form of government, every city would have wanted security for its military installations. At Piraeus, port of democratic Athens, the two smaller harbours and part of the larger were reserved for warships (Fig. 3). The military dockyard was probably a restricted area, walled off on the landward side. The naval storehouse to the north, however, could be visited by citizens. At Rhodes unlawful entry into the dockyard was a capital offence, and at Athens arson in the dockyard was considered a serious crime; in Britain today it is, with piracy, the only crime still subject to the death penalty in peacetime. At Carthage, as we have seen, the dockyard was walled off and foreigners were kept out (Part 1: pp. 79–80). At Cnidus there is no sign of a wall, but the smaller harbour was known as the Trireme Harbour (Fig. 4B).[67]

Some naval powers, such as Athens in her heyday or Imperial Rome, maintained naval bases on their own coasts and abroad. Some of Athens' bases were simply for a few triremes, and probably had few harbour facilities; others were also commercial ports, like Naupactus at a strategic point on the Corinthian Gulf.[68] The Roman Emperors developed two large-scale, solely military harbours to serve as bases of the great fleets: at Ravenna, in a lagoon in the Po delta, and at Misenum near Puteoli. The subsidiary bases of these two fleets in the Adriatic

and western Mediterranean were commercial harbours also, as were the bases of the provincial fleets of the east—the Alexandrian, Syrian and Pontic.[69]

The actual siting of ancient harbours

In some parts of the Mediterranean large numbers of natural harbours were available, in others very few. The Aegean area was particularly well

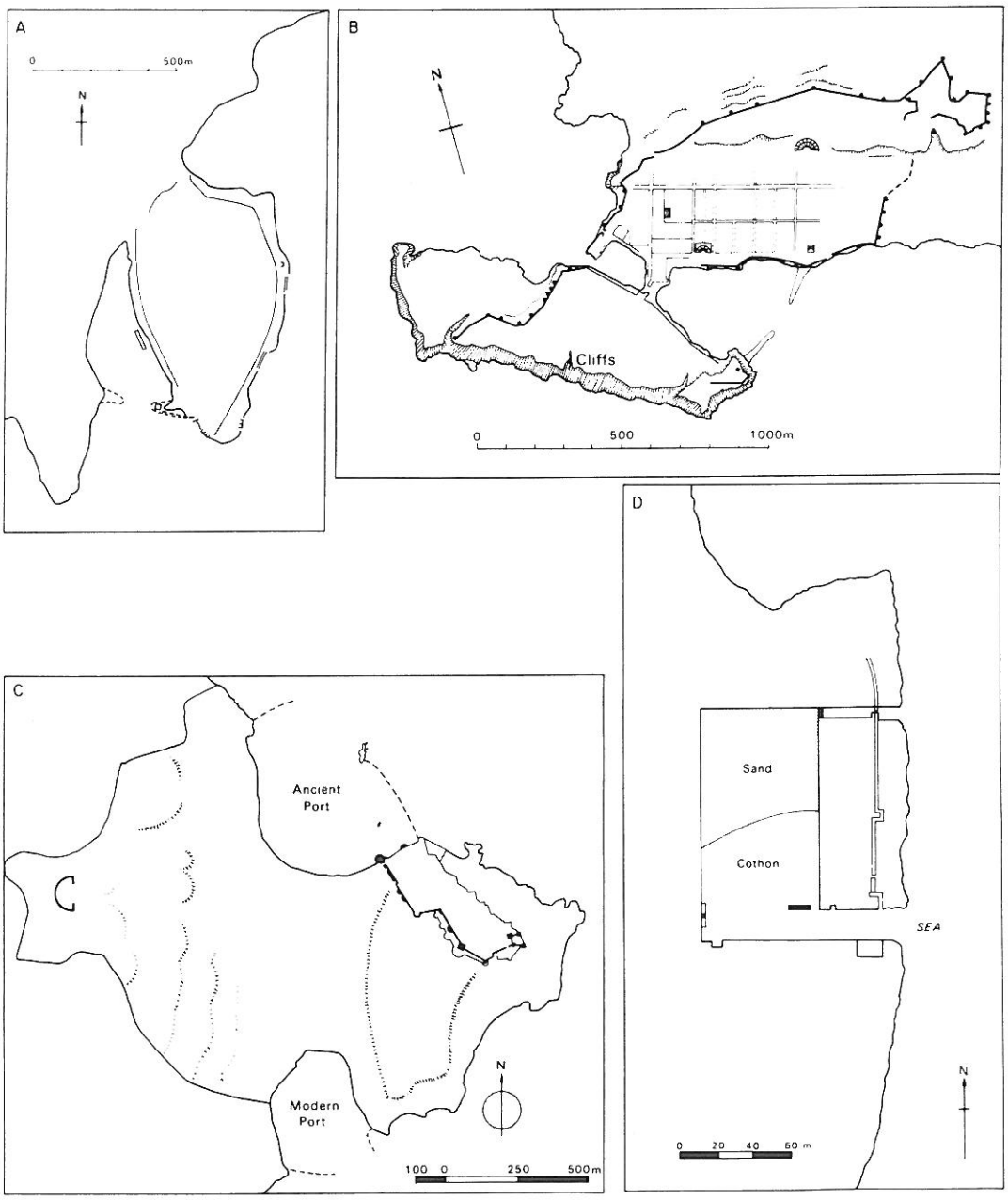


Figure 4. Schematic harbour plans: A. Iasus, after nautical charts; B. Cnidus, after von Gerkan (1924); C. Mytilene, after Koldewey (1890); D. Mahdia, after Yorke (1966).

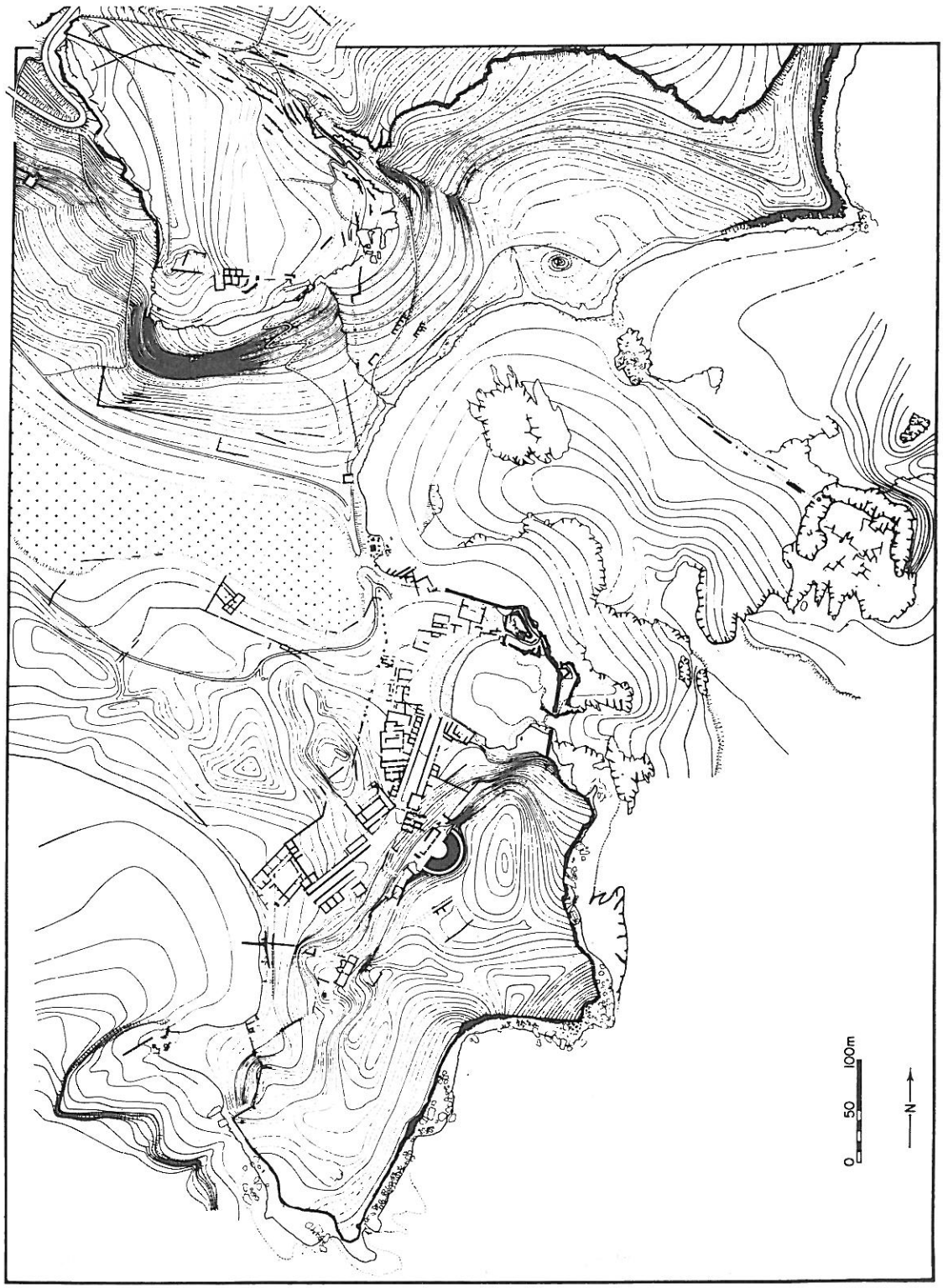


Figure 5. The harbours of Phaselis. Plan by H. Schlager and P. Knoblauch, courtesy Deutsches Archaologisches Institut.

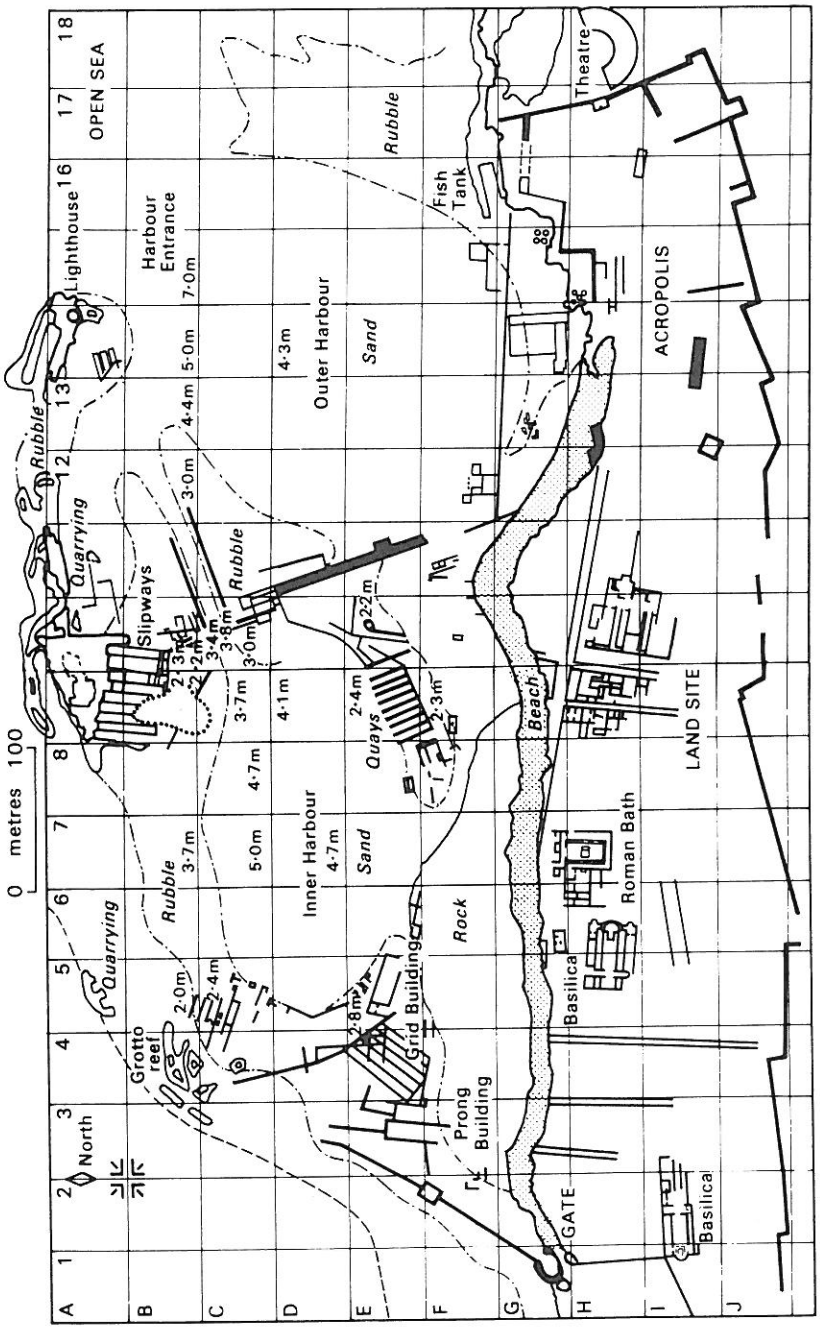


Figure 6. Apollonia harbour. Courtesy N. C. Flemming.

endowed, having on its indented coasts many naturally protected inlets and bays where ships could find shelter; short breakwaters were often sufficient to supplement the natural protection (e.g. Iasus: Fig. 4A). Some ancient sites lay on peninsulae, or partly on offshore islands which could be joined to the mainland by a causeway. These had the advantage of a double harbour: one or other basin would normally be sheltered whatever the wind, and a canal connecting the two was common (Cnidus, Halicarnassus, Cyzicus, perhaps Mytilene: Fig. 4B–C). Some sites had small harbours in indentations of the peninsula as well as the bays on either side (Piraeus, Phaselis: Figs 3 and 5). Where two harbours were available, use of one could be normally restricted to the city's own warships; where more than two were available, as at Piraeus and Rhodes, this could be a permanent arrangement.[70]

However, in some other parts of the Mediterranean—Italy, North Africa and the Levant—harbours were few on straight and exposed coasts. The most had to be made of what little nature offered, such as remains of the coastal reef surviving as offshore islands, as was the case at Apollonia (Fig. 6), Sabratha, Alexandria and Aradus or as a strip of reef joined to the shore, or both, as at Tyre and Sidon. At Leptis Magna the Romans diverted a wadi and developed a great roughly circular harbour basin in the old wadi mouth, behind the coastal reef (Part 1: fig. 3). Another method of creating a harbour was to excavate one behind the shoreline (Part 1: p. 93). In the Bay of Puteoli the Romans tried to link Lake Avernus to the sea and turn it into a major harbour, Portus Iulius, but the project proved a failure because of silting. A few ports were developed within lagoons: for example, at Motya in western Sicily, at Narbo, Forum Iulii and Ravenna, and the inner harbour at Misenum—to replace Portus Iulius.[71]

où est le nouveau débouché du wadi ? → barrage ≠ déviation = piège à sable ?

The new opportunities provided by the Romans' use of concrete structures in the water have been described already. Harbours could now be built on straight coastlines, and much larger than those usually provided by nature. Most harbours of pre-Roman times, and many of the Roman period too, are strikingly small in comparison with some modern harbours; they were probably also much shallower, since ancient ships, particularly warships, were of shallower draught than modern, and there was no need in the Mediterranean to provide for large tidal ranges. Large roadsteads were not used as harbours in antiquity; at Byzantium a number of small bays and inlets off the Golden Horn and Bosporus were used throughout the city's history as harbours, rather than the Horn itself. In antiquity ships anchored close to a lee shore, if they could not be berthed at a quay or beached. Even in a harbour ships were not always safe: Tacitus records that a storm in AD 62 wrecked 200 ships within the harbour at Portus. It was a large harbour, nearly 1000 m across, and if it was crowded, not all the ships could berth against the quays; on this occasion many must have been caught by a sudden storm in the middle of the harbour.[72]

The harbour and the city

As we have seen, most harbours were closely linked with city sites. Many ancient cities were on coasts, a few more on navigable rivers; a number not directly approachable by ship did in fact have outlets to the sea—'out-ports'. This was particularly a feature of the Greek world, common enough for there to be a technical term in Greek, *epineion*; it resulted in part from the early settlement pattern, for as Thucydides noted, in early times the Greeks built their cities inland, for security from attack by sea. Notable examples of such inland cities are Athens, Corinth, Megara and Argos, and one could perhaps add Sparta and Thebes; in Asia Minor Colophon and Pergamum; in Crete Gortyn, Cnossus itself, and many others. Not all Greek cities lay inland, of course; Thucydides also says that 'later' Greek settlements were founded, and walled, right on the coast, especially on peninsula sites where the isthmus could be fortified.[73]

The out-ports were usually not independent cities, but formed part of the inland city. This sometimes received architectural expression in classical times, as at Athens, Corinth, and Megara, where the city was joined to its out-port or ports by long walls to create a single defence system. The inland city thus became a coastal fortress; therein lay the security of Classical Athens, whose power lay at sea.

Whether or not the two sites were technically one city, strains must often have developed between them. The interests of the two groups of inhabitants did not necessarily coincide, and political and social differences grew up between them which led in several cases to open warfare.

Coastal cities and the out-ports of inland cities were normally fortified not only in pre-Roman times, as one might expect, but surprisingly often also during the *Pax Romana*; and the actual harbour basin was often enclosed within the fortifications. If there was more than one harbour, one or more might be fortified. This was done by simply extending the city walls out along the harbour moles, usually to end in towers on either side of the harbour entrance, which became virtually a gate in the city walls. It was a rather vulnerable gate, so that entrances were kept narrow enough for artillery on the towers to be able to sweep the entrance, which apparently meant a maximum width of some 100 m in Classical times, but later up to 300 m; and for chains, cables or booms fixed to the mole ends to be used to close the entrance, which made a much narrower entrance desirable. All these defences are mentioned by ancient writers—historians describing sieges (compare Part 1: pp. 79–80) and the authors of technical handbooks on siege techniques and counter-measures; remains of towers and solid block buildings can still be seen at the entrance of many ancient harbours (Figs 3, 4A–B, 5, 6 and Part 1: fig. 7).[74] Such harbour defence methods have naturally continued in use through mediaeval into modern times; one end of the 16th-century chain which closed Portsmouth harbour entrance still survives.[75]

Where the topography allowed, for example at the narrow entrance to a bay or creek, the entrance moles could be set back so that attacking vessels would be exposed to fire from the shore as well; this was clearly the purpose of the layout of the harbour entrances of Cantharus and Zea in Piraeus (Fig. 3). Where a harbour was excavated, the harbour entrance could be kept narrow (apparently 14 m at Lechaeum), though this must have been inconvenient for the city itself. At Halieis, the entrance was narrowed from an original 20 m to the absolute minimum 7 m, and traces have been found which seem to belong to the fixture for a raisable boom across the narrowed entrance (Part 1: fig. 7).[76]

The early Greek coastal pilots and the geographer Strabo refer to the existence at many ports of one or more 'closed' or 'closable' harbours, though their silence concerning a particular port does not prove conclusively that it had no such harbour. The term *kleistos* has usually been interpreted as 'enclosed' (within the fortification walls), but it should probably be translated 'closable' (by the methods just described).[77] Normally a harbour which could be closed would also be walled, but this may not have been always the case. The need for harbour defence will have been great in the constant warfare of the Classical and Hellenistic periods and again in the unsettled centuries of the later Roman Empire; Portus, for example, was fortified in the 4th century AD.

Even when they were enclosed within the walls there were good reasons for keeping the harbours rather separate from the rest of the city by having a wall also on their landward side. For military harbours there was the obvious need for security, as we have seen; in commercial harbours there was clearly a desire to control the movement of people, especially foreigners, and goods in and out of the city itself—an especially important point if customs dues were levied. The situation must have been not unlike modern ports. The question of customs and harbour dues in antiquity is rather complex, but there is evidence that a distinction was made between goods in transit and goods being imported, and so the 'Emporia' may have been duty-free zones. Furthermore, a number of cities had specific officials in charge of the 'Emporium'. The area must therefore have been clearly defined, and boundary-stones and traces of a wall have been found in Piraeus. In Trajan's harbour at Portus there was a wall, perhaps added later, round the back of the quay, separating it from the warehouses behind; the aim must have been close control of men and goods.[78] Apparatus for closing the harbour entrance could always be used to control shipping movement, as well as to provide protection against enemy attack.

The idea of a distinct and defined emporium on land by the harbour, where much commercial activity took place, can be traced back a long way. In Sumer in the 3rd millen-

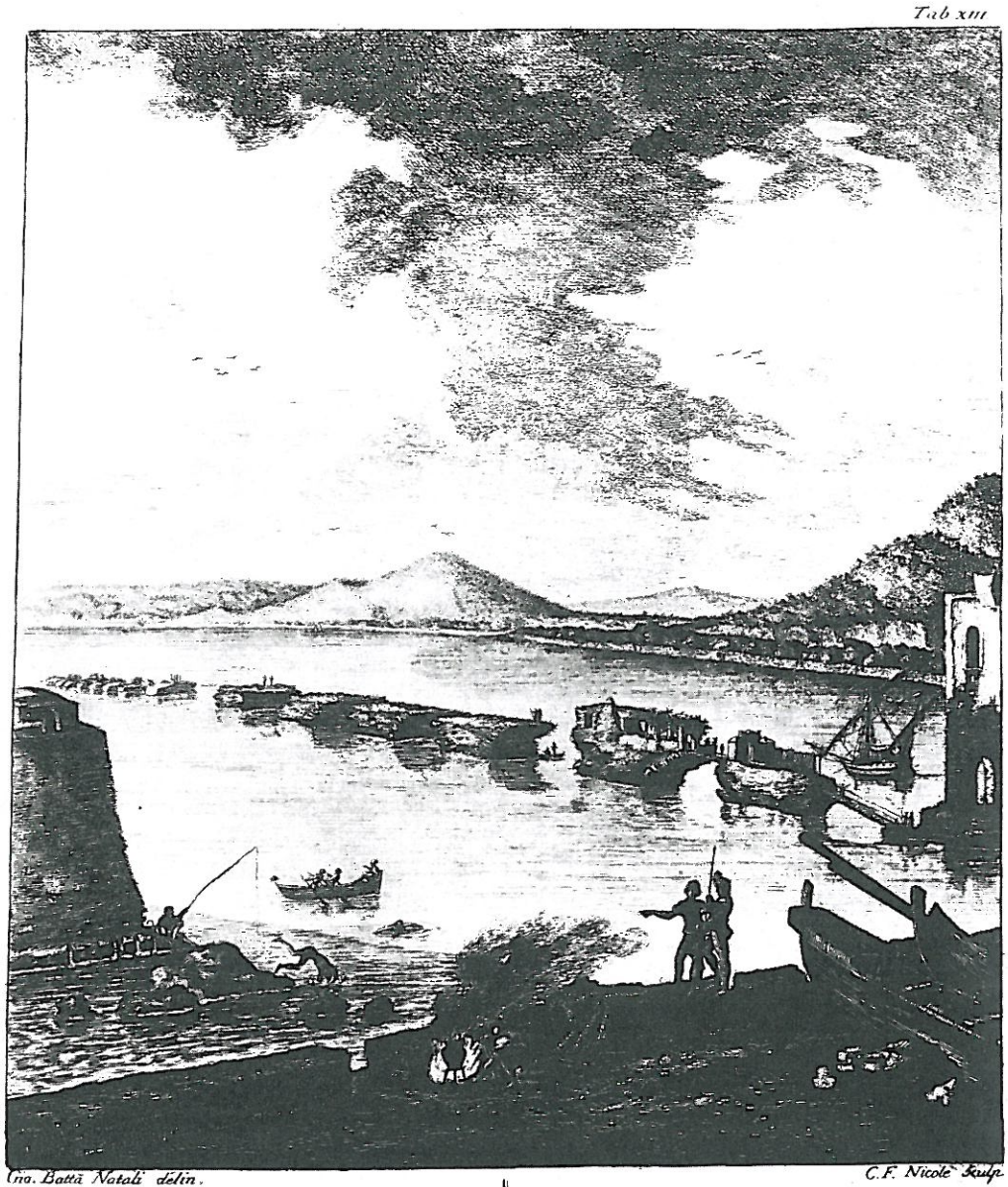


Figure 7. The arched mole at Puteoli (Pozzuoli): an 18th-century view. The piers were built of tufa blocks on concrete foundations; the arches were built of brick and limestone blocks, with a fill of rubble and *pozzolana*. Paoli (1768: pl. XIII), courtesy British Library.

nium BC the trading area by the harbour was administered independently of the town and separated physically from it; foreign traders were allowed to live only there. Later, we find the traders of a group of Greek cities allowed by the Pharaoh to establish a trading emporium on the western branch of the Nile at Naucratis (*c.* 610 BC) with trading privileges and the right to settle permanently. Visiting merchants could also have their own shrines. However, the Greeks were later confined to this one site. One is reminded of the foreign concessions which once existed in Istanbul and Shanghai.[79] Greek cities did not give foreigners such privileges nor confine them so closely, but most of the foreigners in a Greek city must have lived in the port area or out-port. One finds the Athenians granting certain privileges to recognized groups of foreigners resident in Piraeus, for example to build a temple to their native deity; there was there and at Alexandria a 'Foreigners' Emporium'. Delos after 167 BC welcomed traders of every nation, to an extent not found in earlier Greek city-states. In Roman times the foreign community was a standard feature of harbour cities. We know of many groups of foreign traders resident in ports like Ostia and Puteoli, and Jewish communities were especially common.

Moles and breakwaters

The chief purpose of harbour moles and breakwaters was to provide protection against heavy seas; the subsidiary purpose, as we have seen, was protection against enemy attack. Their alignment, particularly with relation to the direction of the prevailing wind and current, and the type of construction used were most important in fulfilling their main purpose, and also in dealing with another problem faced by harbour engineers, ancient and modern—the problem of siltation (see below, pp. 199–202). Recent work has added greatly to our knowledge of this particular subject.

The basic form is the simple breakwater—a natural line of reef or rocks, with or without improvement by man; or a simple bank of piled stone. The early development of rock-cut harbourworks has been mentioned already (Part 1: p. 92). Here man could not dictate the line of the breakwater, but he could improve the strength of the natural barrier to withstand the force of the waves by cutting away the upper surface to a level platform, leaving a wall of natural rock which could be built up with the excavated stone; the force of the waves would be further reduced by the slope of the reef's outer face. Gaps in the natural breakwater could, where necessary, be filled with rubble.[80]

Where there was no natural breakwater, man had to build breakwaters of piled banks of stone, using any available rocks or submerged reefs as foundations, but often having to build these banks up from the seabed in considerable depths. For example, the breakwaters on either side of the commercial (southeast) harbour entrance at Cnidus, built of piles of huge, roughly-cut blocks, stand in 30 m of water—one of the most impressive monuments of ancient harbour engineering (Fig. 4B); at Eretria the harbour was protected on the west side by a rubble bank over 600 m long running out into depths of up to 20 m and ending at a natural reef. Dating such structures is exceptionally difficult; from what we know of the history of the cities, the Eretria breakwater could be 7th-century BC and the Cnidus breakwaters 4th-century BC.[81]

The outer face of such breakwaters would naturally be sloped to prevent undermining; and its roughness and permeability, combined where possible with the structure's alignment at an angle to the prevailing seas, would help to break the force of the waves, whereas a flat impenetrable surface would offer too great a resistance. The height to which breakwaters originally stood above the water cannot always be determined. Some may have lost stones from their upper surface through storms or stone-robbing in later ages, but many still look remarkably unscathed and solid; they will have grown naturally stronger with time. They may, however, have been compacted, and another possibility recently recognized is that they may have been built without a solid natural foundation and may, as a result, have subsided under their own weight, aided by erosion of the underlying sand or mud. This seems to have happened to the very wide breakwater at Cosa, in Etruria, and the north mole at Cenchreae; perhaps also to the northern breakwater at Cnidus and the south harbour breakwater at

Phaselis (Figs 4B and 5). Some breakwaters, which had no buildings on them, were intended to allow waves just to break over them, thus creating a current within the harbour which would help to prevent silting. This would only work with a fairly constant sea level, and we must remember that the ancient, and modern, harbour engineers did not in the Mediterranean have to cope with the problems created by large tidal ranges.[82]

Unless the breakwater had this special purpose, it was rather wasted as a structure if it could not also be used to increase the berthing space available within the harbour. Thus one can trace a natural development: the building up of the inner side of harbour moles to serve as quays and later, perhaps only in Hellenistic and Roman times, the construction of other buildings on the moles, starting probably with lighthouses and signal-towers. The earliest ashlar mole may have been the mole built by Polycrates at Samos around 530 BC and admired by Herodotus, who says it was more than two furlongs long and built in 20 fathoms of water; simple rubble breakwaters without superstructure did, however, undoubtedly continue to be built, so they cannot be automatically dated to an early period. In the early rock-cut harbours of the Levant this further development may have taken place much earlier than in the Greek world, with the creation of rock-cut quays and perhaps also of chambers, partly rock-cut and partly built-up, as on Sidon Island.[83]

The flat surface of the mole was built of solid ashlar masonry, or of rubble faced and paved with ashlar, resting on natural foundations or usually on a rubble bank; a protective breakwater of rubble was often added on the outer side, and at Herodian Caesarea even an extra ashlar wall 7–8 m seaward of the breakwater. Sometimes the mole was faced with ashlar on both sides, sometimes apparently only on the inner side, but the outer side is often now too badly damaged to tell. Such moles could provide much extra quay space, and also carry the city walls along their outer side, with towers at the ends and sometimes at intervals along their course as well. There must often have been only a narrow quay inside these walls, or none at all; but merchant ships could at least moor there in safety while waiting to unload at the shoreline quays, or they could offload into lighters without ever berthing at a quay. In the Roman period probably fewer moles bore fortification walls, leaving more quay-space for unloading and for buildings.

The use of ashlar masonry provides some clues for dating, particularly the types of clamps used to join the blocks, though unfortunately several types remained in use for a very long time. The use of mortar as a binding material between blocks or in a rubble fill is usually regarded as a feature of Roman harbour-works only, but it seems to have come into limited use somewhat earlier.[84] The use of timber tie-beams appears to have been restricted to Roman concrete structures.

Roman harbour engineers were able, by using a local volcanic earth, *pozzolana,* as hardening agent, to build free-standing concrete structures in the water. Vitruvius describes various methods of building concrete foundations under water.[85] These could support a solid structure of concrete or concrete and ashlar and brick, or detached piers joined by arches, another Roman innovation. The latter construction was tried out apparently for a short period in the first centuries BC and AD in a limited area of south-central Italy, Latium and Campania. Here remains have been found of arched moles, notably at Puteoli and Misenum.[86] That at Puteoli was 372 m long and rested on 15 piers each 16 m square (Fig. 7). That at Misenum, the south mole, had two offset lines of piers. Some contemporary works of art, mainly paintings from the same area (Part 1: fig. 5), illustrate similar structures, though one cannot always be sure that they are not of timber; some coins have been thought to depict them, but this is more doubtful. The purpose of the experiment may have been to prevent silting of the harbour basin, by allowing currents of water into it. Perhaps the currents proved too strong and uncontrollable in heavy seas and strong winds; but the main reason for the abandonment of the experiment was probably that the structures fell down! The mole at Puteoli had to be rebuilt in AD 139.

Another innovation, apparently of the Roman period, is the building of breakwaters not connected with the shore. One example is clearly described by Pliny the Younger; summoned by Trajan to the imperial villa at

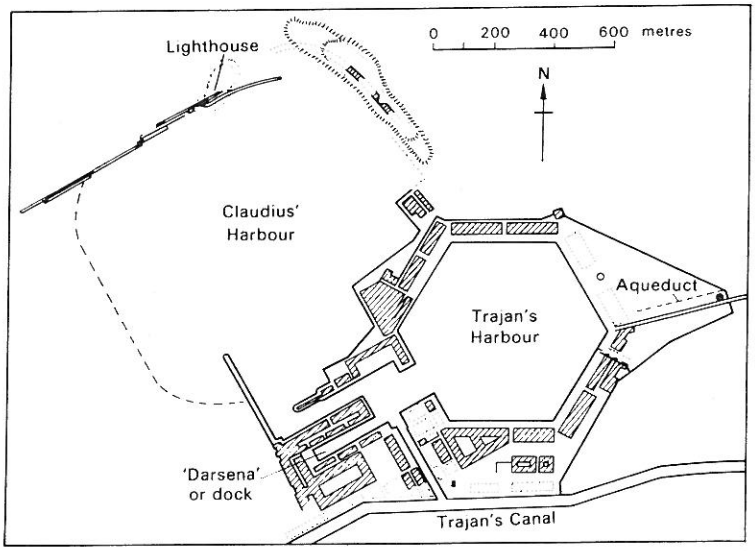


Figure 8. Portus: the port of Rome near Ostia. After Meiggs (1973: fig. 5).

Centumcellae, he was able to witness the building of a new harbour on this harbourless coast north of Rome. In front of the harbour entrance an artificial island was being built: a pile of enormous blocks, brought out by boat and dropped, had now broken surface and piers were being added, to make an arcaded facing or superstructure. Similar methods must have been used to build many breakwaters and mole foundations, for example the breakwaters at Cnidus and the foundations of the moles of Herod the Great's new harbour at Caesarea (10 BC): Josephus describes how huge blocks of stone were let down into 20 fathoms of water.[87]

The model for the breakwater at Centumcellae has usually been thought to be the 'island' built as a foundation for the lighthouse at the entrance of Claudius' new harbour at Portus (Fig. 8). Here a huge merchant ship was sunk and presumably used as a caisson for the core of the foundations, as were also some smaller ships in the concrete parts of the mole. The recent excavations, however, while revealing traces of the ship in the solid concrete, have also shown that the lighthouse stood near the end of the left mole and not on a separate island in the harbour entrance, as some of the ancient references and the coin depictions imply.[88] Perhaps, though, there was an island initially, later joined to the left mole. The variety of construction in the two moles is striking: parts are of solid ashlar masonry, parts of concrete with timber tie beams and faced mostly with ashlar masonry or, on the inside, with brick or with timber: the width varies from 3 to 17 m.

A later development, of the 2nd century AD, seems to have been the deliberate building of long offshore breakwaters and moles, in fact the entire protection of the harbour, with no connection to the shore, for example at Sabratha and Patras (Part 1: fig. 1F). The aim will have been to prevent silting by allowing the coastal current to pass through unobstructed.[89]

An impressive recent discovery is the breakwater at Thapsus, a bank of large blocks which is over 1000 m long and has strikingly resisted the force of the waves. Previously all that was known of it was the concrete superstructure at the inner end; it is not certain how far this extended originally. Two rows of holes survive in the concrete which once held timber tie-beams.[90]

Some Roman harbours like Cenchreae and Leptis Magna had moles wide enough to carry quays, warehouses, fish-tanks, temples, statues, signal-towers and a lighthouse, and Leptis later a fortification wall as well (Part 1: figs 3–4). At the other end of the scale is the narrow concrete mole at Chersonesus in Crete, pro-

tected on the outer side by a breakwater which may be earlier in date.[91]

Little is known of late Roman and Byzantine harbours except at Constantinople, the former Byzantium; harbour construction by the great 6th-century emperor Justinian is described by a contemporary writer, Procopius, but the only known works which probably date from this period are those at Anthedon in central Greece: two apparently hastily-built moles and a quay, with rubble fill in compartments divided and faced by rough courses of mainly re-used blocks.[92]

Siltation problems

Siltation was one of the main problems facing the ancient harbour engineer, like his modern counterpart, for whom, however, dredging machinery is available. Dredging was carried out in antiquity, for there are scattered references to the clearing of blocked harbours, especially Ephesus, but the methods must have been fairly primitive. The depths which had to be maintained were smaller, because of the smaller average draught of ancient ships, even merchantmen, and the small tide range in the Mediterranean, but the results of dredging may often have been short-lived.

Prevention of siltation was therefore the aim: much could be achieved by the skilful placing of moles and breakwaters so as to deflect silt-bearing currents, and of quays and jetties within the harbour. Experience at Sidon, where 'improvements' before the Second World War rapidly led to the silting up of the ancient harbour, shows that some ancient engineers compare well with their modern successors. Not all were as competent: at Ephesus the construction of a mole at the harbour entrance in the 2nd century BC only made matters worse, for narrowing of the entrance reduced tidal removal of the silt.[93]

Another de-silting method was to allow controlled currents to pass through the harbour continuously. This was easy where the harbour had two entrances, like the inner south harbour at Tyre. A secondary channel into the rock-cut basin at Mahdia clearly served the same purpose, and the blocking of this caused the harbour to silt up (Fig. 4D). Where two harbours each had an entrance and were also interconnected, through currents could be maintained: e.g. Alexandria, until the channels through the causeway became blocked. The development of offshore breakwaters, which did not provide an obstruction by swinging round to shore, has already been mentioned.[94]

Where a harbour had only one entrance the problem was greater. If the harbour lay on a river or near the mouth of one, the river current could possibly be diverted through the harbour basin, but in this case the disadvantage would

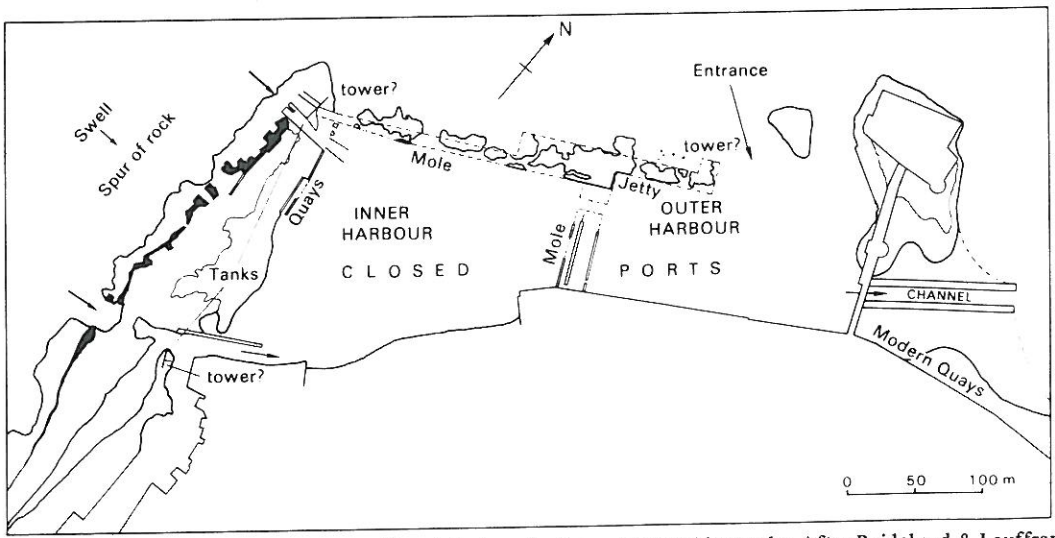


Figure 9. Sidon harbour: on the west side of the inner harbour, two flushing tanks. After Poidebard & Lauffray (1951: pl. II).

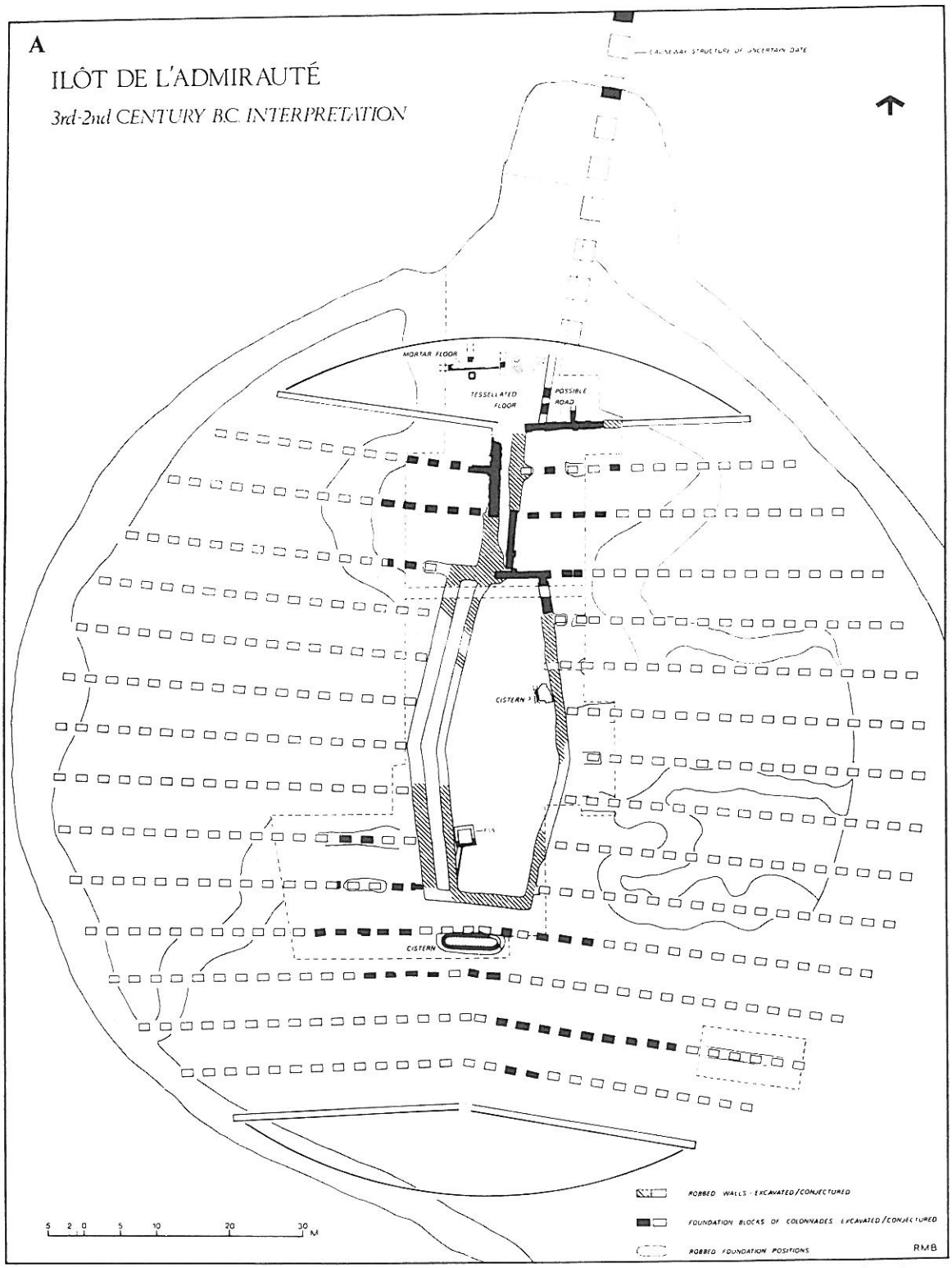
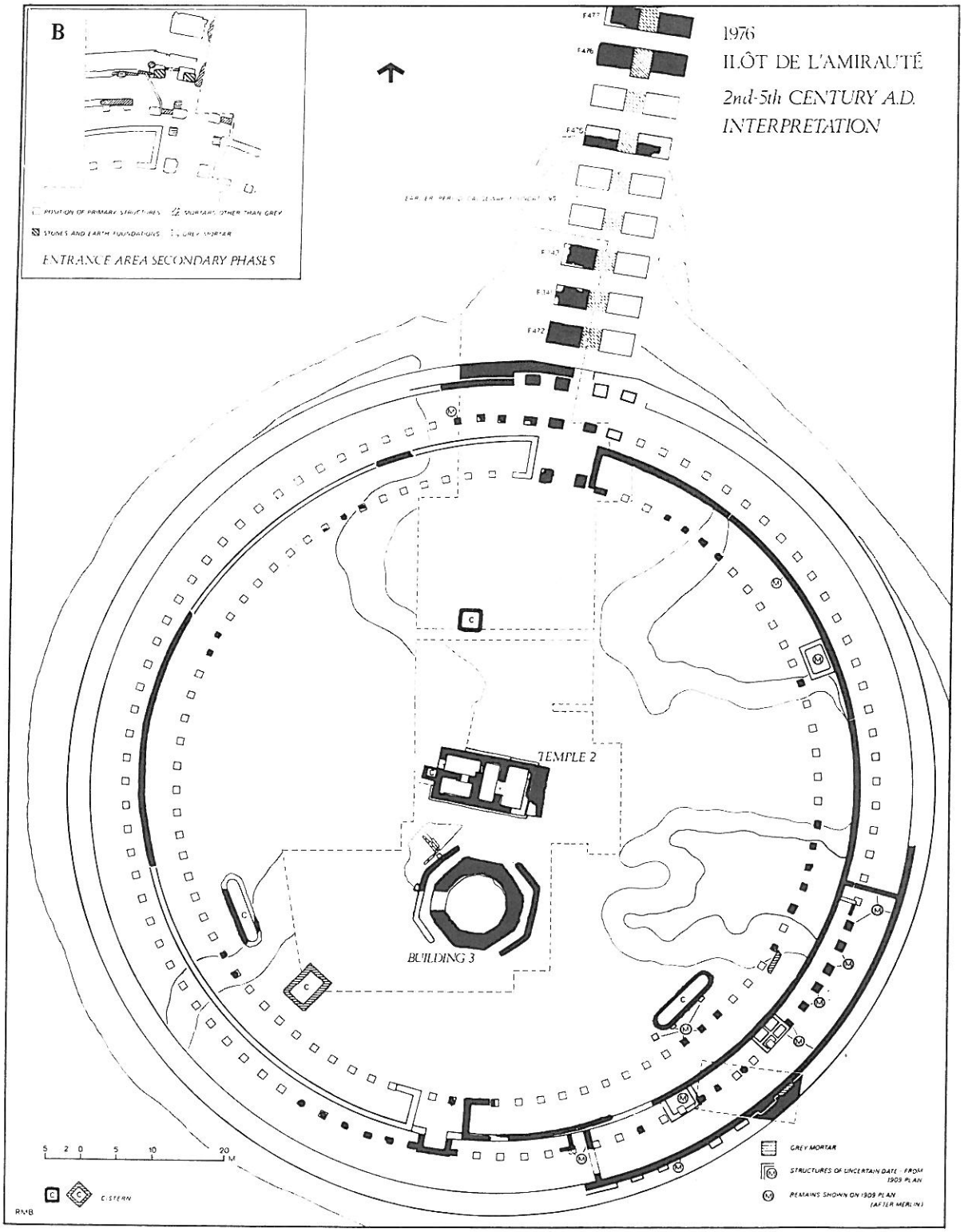


Figure 10. Carthage: the island in the inner (military) harbour. An interpretative plan of the Late Punic (A) and of the Roman (B, facing) remains (Hurst, 1977: figs 4 and 6). Courtesy H. Hurst and Society of Antiquaries of London.



be that the water used was often heavily silt-laden. The arched mole may well have been intended to help maintain currents in the harbour basin; so too the breakwater washed over by the waves or divided into separate masses of rubble, as at Cosa, and jetties built within harbours on piers or timber piles (see pp. 197, 196, 202). An early attempt to achieve the same end may be seen in the underwater ashlar-lined channels through the moles in the north harbour at Mytilene, and tunnels through the mole are reported at Centumcellae, Egnatia and Herodian Caesarea.

At Cosa the inner harbour, like any inner basin, would have been particularly liable to silting; two long channels with sluice-gates were cut through the cliff to bring in silt-free water from the outer end of the promontory, where there was deep water and a rocky bottom, to flush silt from the harbour, either with a head of water or a continuous current. Two tunnels through headlands at Misenum probably had a similar purpose.[95]

The flushing method can be applied most easily on coasts where tides can be used in combination with sluice-gates. This was apparently tried at Seleucia on the then Syrian coast (now Turkey), but it seems the tide range proved too small; instead, streams were diverted along a channel and through a tunnel to flush the basin. The system installed at Sidon to supplement the silt-deflecting moles was more effective: there were two indentations in the natural reef which formed the west side of the inner harbour; from them the water filtered over into two rock-cut tanks with floors sloping inwards towards the basin and sluice-gates at their inner end. When the gates were opened, relatively silt-free water could be shot into the basin to flush out the silt (Fig. 9).[96]

Quays

Though the inner side of moles was often used as a quay, and probably increasingly as time went on, the main quays were usually on the shore. We may assume that quay construction methods developed roughly parallel with those of moles, from rock-cut quays, as on Sidon Island, to roughly faced and paved rubble, as in early Delos, then to well dressed ashlar embankments and then the great concrete structures of the Roman period, usually faced with ashlar blocks or small stone blocks (*opus reticulatum*) or brick or sometimes with timber. Rock-cut quays could have been cut at any period, and are very difficult to date except by general context: the quay at Cnidus could well be 4th-century BC, possibly earlier.[97]

A few solid Roman quays were faced with brick arches, and some quays in works of art seem to be supported on free-standing arches. The only remains found which may belong to such a quay are those of the south quay at Puteoli, whose front wall is split up into two offset lines of piers, which may have been joined by arches; but the wall may be the outer wall of a set of basins. Other quays and projecting jetties in harbour depictions look more like timber structures (Part 1: fig. 5), which are highly likely to have existed in the Mediterranean as they did in Roman Britain and Germany; no certain timber remains have yet been found, but little controlled excavation has yet taken place in ancient harbour basins.[98]

Projecting jetties greatly increased the amount of quay space available within a harbour basin, which was otherwise restricted naturally, until the great man-made harbours of the Roman period, when at Portus, for example, Trajan's harbour alone had six sides nearly 358 m long, almost entirely used as quay. An unusually large earlier harbour, at Hellenistic Delos, had 1700 m of quay space on an original shoreline of 1100 m, produced by a series of broad projections and indentations. Narrow projecting jetties of stone were also built, for example several in the main harbour of Piraeus (Fig. 3) and one in the river harbour at Rome; more durable than timber jetties, they obstructed the currents more and were thus more likely to cause silting. The extent of the use of timber jetties is difficult to judge. On shallow coasts a single long projecting jetty was sometimes built right out across the shallows to water deep enough for ships to berth against its end and unload; for example, at the 'ports' of Acholla and Leptis Minor in north Africa.[99]

Improving techniques produced not only an increase in scale but also a growing tendency to regularity of shape in harbour basins. This is true both of the shoreline quays—a straight-sided inner quay (Miletus), a hexagonal straight-sided basin (Portus, Fig. 8) and a circular basin

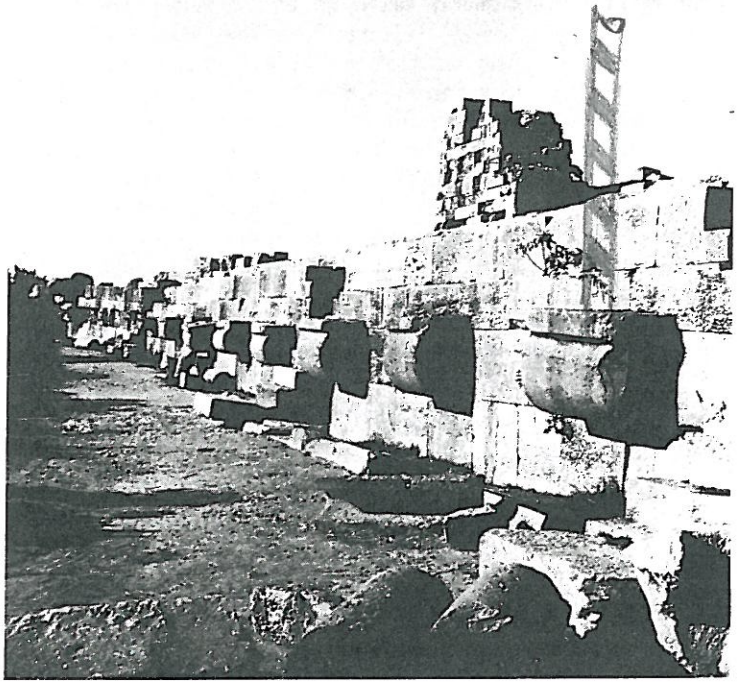


Figure 11. Leptis Magna: mooring-stones projecting from the face of the upper step of two-stepped quay on the east mole. Photograph by D. J. Blackman.

(Carthage inner harbour, Fig. 10); and of the moles which projected to sea—rectilinear at Elaea, curving at Terracina and Pompeiopolis. Harbour depictions on Roman coins reinforce the impression, but as we saw (Part 1: p. 82), this evidence is of doubtful value.

A few quays had two levels, like Leptis (Fig. 11), but most only one. The height of the quay surface above water level cannot have varied a great deal from site to site. Remains are now at different heights with relation to sea level as a result of various changes, but originally quay surfaces need not have been much more than 1 m above the water, granted the small tide range. Convenience would suggest having gunwale and quay surface level for unloading, as depicted on the 'Torlonia relief' (Part 1: fig. 2), but other pictures show the gangway at a steep angle. Ancient merchant ships usually moored stem or stern to, though not necessarily at right angles to the quay, and this allowed maximum use of the quay space; ships made fast to pierced mooring-stones or to bollards or, in the Roman period, to iron rings.

On some, mainly rock-cut quays, for example Sidon island and Mahdia, but also the built north quay at Leptis Magna, holes were simply cut obliquely through the lip, but mooring-stones in a built quay were usually pierced blocks built into its front wall. It has been suggested that the blocks bore metal rings or wooden mooring-posts, but there is no clear evidence of this. Many examples survive, and the 'Torlonia relief' shows one in use at Portus. Around Trajan's harbour a number are preserved, stone blocks set at regular intervals of 14–15 m in the brick quay face; there were probably over a hundred in all. At Rome itself there were many along the quays and river banks (Fig. 2); some had a lion's head carved on the front. At Terracina they line the inner face of the mole, which was used as a quay, and are set in recesses below the quay surface and approached down ramps, while those at Rome are at the top of the ramps. They projected from the piers of the arched moles at Puteoli and Misenum. At Leptis they survive round most of the harbour and, unusually, most are

pierced vertically, not horizontally; in the single-stepped quays they project from the quay face as usual, and in the two-stepped quay they project from the face of the upper step (Fig. 11). At Teos they were wedge-shaped to take the lateral strain. The river harbour at Aquileia had both vertically and horizontally pierced stones.[100]

Bollards were usually set vertically in the surface of the quay. Those found at Narbo have round columns and a square base for secure fixing; those at Delos were roughly rectangular blocks. In the concrete Roman quay at Chersonesus are the stumps of rectangular stone bollards. On rock-cut quays, columns of rock could be left to serve the purpose. A curiosity is the use of *horizontal* bollards in the face of the quay at Phaselis. Appian refers to cables in the commercial harbour at Carthage (Part 1: p. 80), perhaps mooring-cables which ships entering could pick up.[101]

The organisation of berthing and unloading in a busy port was a complex operation. Numbering the individual berths was an obvious step, and this was clearly the purpose of numbered columns found, set back from the edge, on the quays of Trajan's harbour at Portus.[102]

Some of the ancient illustrations provide a glimpse of unloading operations; and inscriptions, particularly Roman, reflect the variety of the operations and the skilled trades involved: crane-operators, stevedores, sand-ballastmen, harbour-boatmen, lightermen, tally clerks, tug-boatmen, and so on.[103]

Behind the quay there was often a roadway, and then buildings for storage and commercial transactions: *stoas* or porticos, and more prosaic warehouses, and in or beyond the emporium, shops and taverns. An important facility was a fresh-water supply. At Leptis Magna there was a barrel-vaulted water-cistern right on the quay at the southeast corner; a watering-point has been excavated at Cosa; and the remains of an aqueduct have been found at Portus (Fig. 8). At major fleet bases the need would be particularly great, and at Misenum a vast underground reservoir fed by an aqueduct was cut in the hill beside the harbour in the time of Augustus.[104]

All that has been said so far about quays and unloading refers to commercial harbours. Purely military harbours seem to have had far less quay space, most of the shoreline being probably taken up by 'shipsheds' (below pp. 204–6). It is significant that when the Athenian fleet went to sea the triremes all had to come round to the *Choma*, a jetty in the commercial harbour, for official inspection and probably also for most of the crew to embark. Military harbours did need plenty of storage space for equipment. At Athens we have many references in inscriptions, and a full description of the large Naval Storehouse built by Philon, which has not been found.[105]

Slipways

In antiquity merchant ships seem to have stayed in the water fairly continuously. When definitely not in use for a period they may have been beached, probably on wooden slips such as one sees in Aegean ports today. The main problems to be faced were rotting and the ravages of wood-devouring creatures such as the *teredo*. From at least the 4th century BC onwards some merchant ships' hulls were protected with lead sheathing. Warships would have been impossibly slow if sheathed with lead; they were coated with pitch and sometimes wax paint. They might be out of use for long periods, particularly in winter, and needed to be preserved out of water if possible, but kept readily available for an emergency. Hence there developed a particular type of covered slipway or 'shipshed'.[106]

In Egypt 'slips' were built on the Red Sea by the Pharaoh Necho (died 593 BC) for his triremes, and by Greeks at a garrison post in the eastern Nile delta at the same period. Herodotus saw remains of them in the 5th century. He also mentions 'shipsheds' at Samos under Polycrates (*c.* 530 BC).[107] Polycrates developed a considerable navy, and it was probably he who built the shipsheds as well as the great mole (p. 197); they may well have been the first in the Greek world. Later on, shipsheds must have existed in all the main harbours of Classical Greece, occupying most of the shoreline of the military harbour or harbour sector. They were usually built in long rows, roofed individually or in pairs. The general effect must have been like that of a row of long narrow hangars sloping down into the water. Appian compared those at Carthage, viewed from the basin, to a colon-

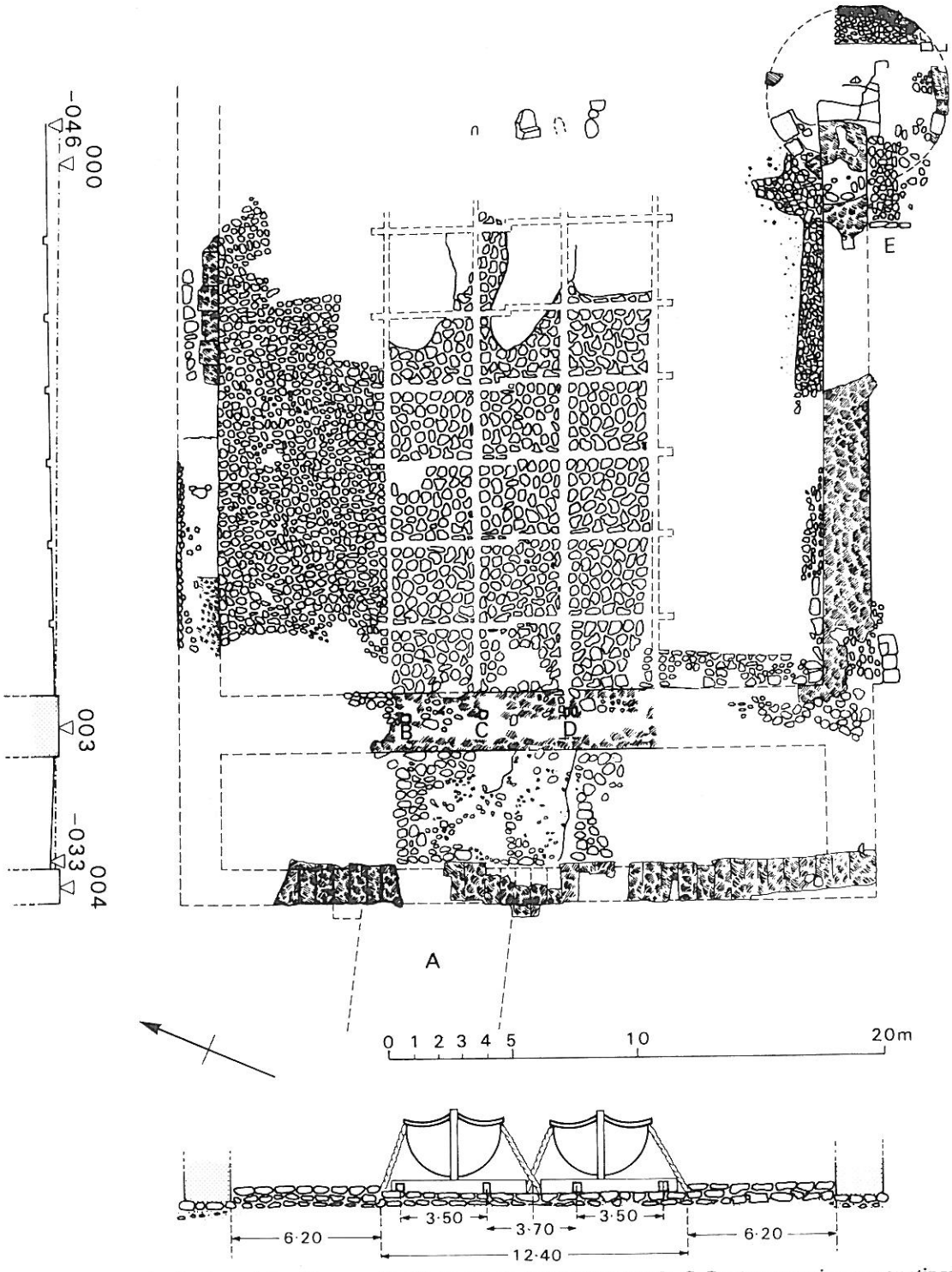


Figure 12. Thurii: plan of the slipways. A: Alignment of the main street; B, C, D: stones serving as mountings for three capstans; E: access ramp to tower. After Zancani Montuoro (1974).

nade surrounding the harbour (see Part 1: p. 80).

The most famous shipsheds were those of Piraeus; dockyard inscriptions record a total of 372 in the mid-4th century BC. They almost covered the shores of the two small military harbours: Zea, the main naval base, had 196 and Munychia 82; the rest occupied the south end of the main harbour, Cantharus (Fig. 3). The fleet size at the time was slightly larger than the number of shipsheds.

The best preserved remains lie on the north-east side of Zea (Pashalimani). Ten investigated in a 'rescue excavation' in 1885 had a continuous back wall with a road behind. Rows of columns running down into the sea formed the partitions between the slips and supported a gable roof over each pair; at intervals a solid wall divided the shipsheds into groups. The fairly open structure provided the ventilation necessary to dry out the ships, but security and fire-prevention also had to be considered, for the roof probably contained much timber and the triremes' timber gear, oars and spars, was stowed beside them.

The actual slips were low platforms cut in the bedrock, flat in cross section and sloping seawards; there are no traces of 'keel-slots', and perhaps timber runners were laid on the slips, which have a gradient of 1 in 10. They average 37 m long to the present waterline; the 'dry length' was perhaps somewhat longer originally, if we allow for a small rise in sea level. They have a clear width between the rows of columns of just under 6 m; this defines the maximum beam of ancient triremes, and probably also quadriremes and quinqueremes, since there is no clear evidence that the latter required new or remodelled shipsheds.

A small group of similar shipsheds was found in 1958 on the landward side of the West Island at Apollonia: 10 slips cut in the rock, most with a central runner and one with a 'keel-slot'. Their total length appears to be 40 m and they are now totally submerged. If we allow a minimum depth of 0·80 m at the foot for the stern to float in, the original length would have been about 28 m—surprisingly short. The gradient is so shallow (1 in 14) that ships could probably have been manhandled up the slips, but pulleys or winches must have been used in the steeper shipsheds. A number of similar remains have recently been identified in the military harbours of Rhodes and Aegina. Some of the former are now partly overlain by medieval buildings, and the latter are now submerged; both would be interesting to excavate.[108]

Recently a pair of slips has been excavated at the seaward edge of the city of Thurii, the 5th-century successor of Sybaris on the same site, in southern Italy (Fig. 12). In the central strip of a fine cobbled ramp is a grid of slots, clearly for a timber grid or 'cradle' and shores supporting a ship.[109]

At Oeniadae in western Greece an entire chamber holding five shipsheds was cut in the rock; here the slips were not flat in cross section but cut to fit the ship's sides, and they swung up at the inner end to fit the ship's stern; all warships had to be hauled up stern first because of the ram on the stem. The shipsheds have roughly the usual width, just over 6 m, but are unusually long (47 m). Recesses at the head of each slip and at one side of the chamber will have been used to store gear. At Sunium another, but smaller rock-cut chamber containing two slips lies just within the fortifications: short, narrow, steep slips to house two small guard-ships at this strategic point. Two deep rock-cuttings containing single slips have been found recently in Crete, near Siteia and at Matala, and groups of three slips at Rhethymno and at Dor in Israel.[110]

At other great harbours of antiquity, for example Carthage and Syracuse, there were impressive complexes of shipsheds, mentioned or described by ancient authors. At Syracuse little or no remains have yet been found, but at Carthage recent excavations have revealed considerable remains of 3rd-century BC stone shipsheds, 5·9 m wide, probably preceded by 4th-century timber shipsheds 6·4 m wide, centre to centre (Fig. 10).[111] At Rhodes and Syracuse there were shipsheds holding two ships. An innovation at Carthage was the addition of an upper storey to house the gear.

The Romans also used shipsheds. Though no certain remains have been found, a number of representations of them survive, on coins, mosaics and paintings, with ships just showing inside the arcade (Part 1: fig. 1H). At Rome they lined the south side of the Campus Martius in the Republican period.[112]

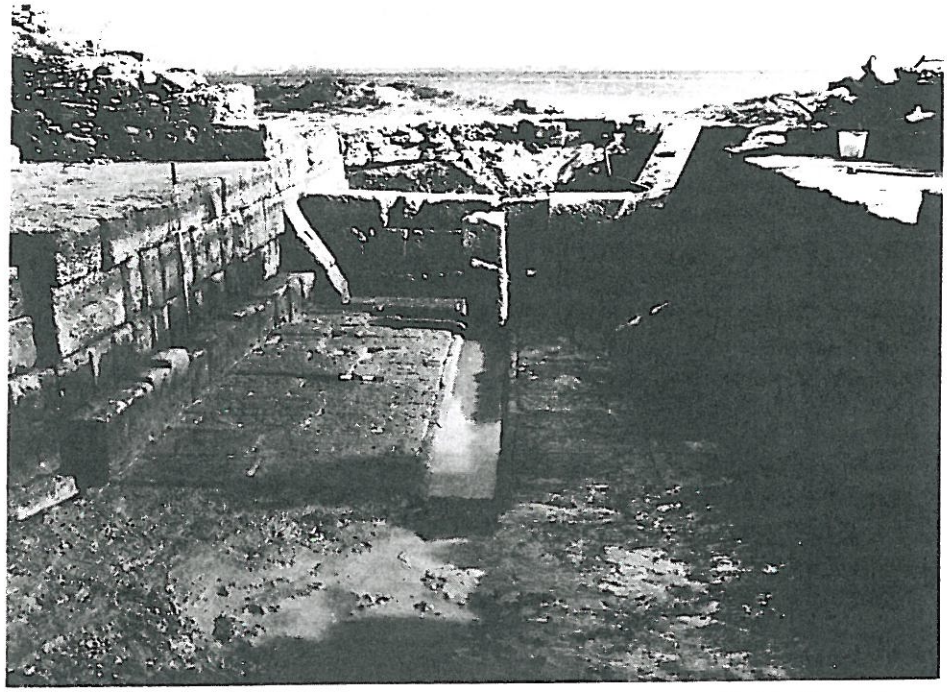


Figure 13. Motya 'dry dock': the channel south of the 'cothon', looking south. The blocking wall rests on mud above the pavement and the pillars are secondary. Courtesy B. S. J. Isserlin.

Dry docks and shipbuilding yards

Though a few small docks have been found, none of them appear to have been drainable. Draining a dock would have been very difficult in a nearly tideless sea without powerful pumps. One exception may be the entrance channel to the *cothon* at Motya (Fig. 13). This does seem to have been closable, and has the side steps or 'altars' typical of a dry dock and a central 'keel-slot' which could have served as a drainage sump; it may therefore have served occasionally as a makeshift dry dock.[113]

It is clear, however, that usually ships were simply beached, if major refit was necessary. Minor repairs could perhaps be carried out in shipsheds, though they had not much space for work. There is literary, inscriptional and pictorial evidence for shipbuilding, mainly of Roman date, but no remains found can be certainly identified with shipbuilding facilities; they were probably less permanent than most other harbour installations, like the timber grids and slips still seen in the Aegean today, and would have left little trace.[114]

Lighthouses

We have no evidence for the use of lighthouses before the Pharos was built at Alexandria in the early 3rd century BC. Beacons may well have been erected at harbour entrances, but this is only conjecture. We hear of 'Marks of the Emporium' in 4th-century Piraeus, and these may have been columns erected as navigation marks at the commercial harbour entrance; this may also have been the purpose of the Colossus of Rhodes. A Roman painting shows a navigation mark on a hill (Part 1: fig. 5). Throughout antiquity lighthouses marked harbours rather than hazards to navigation.[115]

The Pharos at Alexandria, like the Colossus, deservedly became one of the 'Wonders of the Ancient World'. It was built on the west side of the entrance to the east harbour, on the eastern tip of the then offshore island of Pharos. It had a succession of tapering storeys, probably three in number: the first square, the second probably octagonal and the third round; and it was over 130 m high. The fire at its top could be seen over 30 miles away. We know nothing about the lantern, but the fuel was probably

↳ slipway sur façade est à Leptis

naphtha or petroleum and a mirror was used. This lighthouse served as a model for later ones; it lasted in its original form until AD 956 and with reconstructions until the 14th century.[116]

The lighthouse at Portus stood near the harbour entrance, on and close to the end of the west mole of Claudius' harbour. It probably had four storeys of decreasing height, one cylindrical on three square or two cylindrical on two square, and was commonly depicted on ancient mosaics, reliefs, coins and lamps (Part 1: pp. 82–5; Part 1: fig. 2). The lighthouse at Leptis Magna, which had at least three levels, stood in a similar position, and so did most others.[117]

A few, however, stood on commanding heights. At Apollonia a circular foundation on the top of the East Island was probably for a lighthouse, marking the eastern end of the offshore reef which shipping had to round to enter the harbour. At Corunna in northwest Spain the present lighthouse on a promontory still preserves a Roman core. At Dover there were two hill-top lighthouses in Roman times.[118]

Conclusion

In the study of ancient harbours we are often dealing with fragmentary remains preserved at foundation level; few sites have buildings surviving or restorable to such an impressive height as those of Leptis Magna. However, future underwater excavation should produce exciting finds. In recreating the visual image of what an ancient port looked like in operation, we obtain some help from pictorial evidence. The sounds and the smells we can only imagine, helped by such passages as the one in which Aristophanes pictures the Athenians preparing for a naval expedition:[119]

> 'the city would at once have been full of shouting troops, fuss over trireme commanders, payment of wages, gilding of Pallases [figure-heads], roaring colonnades, measuring of rations; wineskins, oar-straps, bargaining for casks, garlic, olives, nets of onions, garlands, anchovies, flute-girls and black eyes; the dockyard would have been full of the noise of oar spars being planed, trenails being hammered, oars being fitted with their straps, flutes and boatswains' calls, whistles and piping'.

Notes

[53] General outline of the main developments: Lehmann (1923, 1926); Mouterde (1951). Harbours on harbourless coasts: see schematic plans in Lehmann (1923); at Claudian Portus there may have been a pre-existing bay (Meiggs 1960: 153 & n. 5).

[54] Ports of western Asia Minor: see G. E. Bean, *Aegean Turkey* (London 1967); 5th-century decline: J. M. Cook, *Proc. Camb. Philol. Soc.*, 187 (NS 7), (1961), 9–18, stressing Persian control of the fertile lower river valleys. Compare Amphipolis on the Strymon near its mouth: Lazaridis, *Comptes Rendus Acad. Inscr. (Paris)*, (1977), 194–214.

[55] Vitruvius 5.12.2. The port of Myus, for example, was completely put out of action by the progression of the mouth of the River Maeander; swamps formed and the site became uninhabitable.

[56] Etruscan coast: Bruno (1973a); Manzari (1976); Aquileia: Brusin (1934), 16–26; Ravenna: below n. 69; Narbo: Grenier (1934), 483–92; Guy (1955); Gayraud (1975), 843–8. See also Delano Smith & Morrison (1974); Kraft & others (1977); Delano Smith (1978).

[57] Lanciani (1897), 510–32; Gatti (1936); Le Gall (1953), 194–204.

[58] Bradford (1957), 248–56; Meiggs (1960), 51–62, 153–71; out of action probably by the 8th century AD (Meiggs, p. 171). Dredging, by the sand-ballastmen, was closely controlled: Cébeillac-Gervasoni (1979).

[59] Ports in Gaul: Grenier (1934), 476–509. Underwater discoveries have defined the site of Fossae Marianae: Monguilan & others (1977). Finds of Roman period port installations have recently been reported at Aventicum (Avenches), an export centre for building stone, and at Brigantium (Bregenz), a key junction of road and water routes: Bögli & Weidmann (1978); Vonbank (1972); and a riverside quay at Avaricum (Bourges): Ferdière (1979); cf. *Gallia*, 37 (1979), 316–7, 475. A parallel to Marseilles may be seen in the sites of Gades and Onoba on either side of the mouth of the River Baetis (Guadalquivir), the main river of Baetica.

[60] Ancient maritime trade: see e.g. Lehmann (1926); F. M. Heichelheim, *An ancient economic history*, 3 vols. (Leiden 1958–70); idem, *OCD* (2nd ed.) s.v. 'Commerce' (all with bibliographies).

[61] Harbour dues would have been a valuable source of income. Rhegium: Josephus, *Ant.*, 19.205.

[62] Verdelis (1956, 1958); R. M. Cook, *JHS*, 99 (1979), 152–3; a similar construction on a smaller scale existed at Alexandria: Fraser (1961). Periander did succeed in cutting the isthmus joining Leucas to the mainland, thus producing a safer voyage up the west coast of Greece.

[63] Harbour development: Meiggs (1960), ch. 4; Puteoli: see now J. H. D'Arms, *JRS*, 64 (1974), 104–24; Centumcellae: Bastianelli (1954); Populonia: Minto (1954); note 35 above.

[64] On the motives for travel see Casson (1974).

[65] Perachora: Blackman (1966).

[66] Syracuse: Lehmann (1923), 106–7; Halicarnassus: Frost (1963), 146–9; G. E. Bean, *Turkey beyond the Maeander* (London 1971), 112–3: Flemming (1972), 127–8; Blackman (1973b), 125–6. Alexandria: Fraser (1972), I.23; Spalatum: G. Niemann, *Der Palast Diokletians in Spalato* (1910), pl. XVIII; Constantinople: Janin (1950), 218 ff.; Giannutri: Bruno (1973b) [compare Pausilypon: Günther (1903b), 145–9; idem, *Pausilypon* (Oxford 1913)].

[67] Piraeus: Hill (1932); A. E. Raubitschek, The gates in the Agora, *AJA*, 60 (1956), 279–82; Panagos (1968), 188, 198; Blackman (1968), 182–3. Under the Dockyards Protection Act (1772), 'arson in HM Dockyards' and 'piracy with violence' are capital offences, but the death penalty is not mandatory.

[68] Small bases: Budorum (Salamis), Rhamnus and Thoricus in Attica, Atalante Island off Locris; commercial ports: especially Naupactus, Pagae, Samos, and various cities on the Bosporus and Hellespont.

[69] Roman fleets and their ports: Starr (1960); for Ravenna, also: *Studi Ravenna* (1961); *Convegno Ravenna* (1961, 1967); Cortesi (1967); for Misenum also: Maiuri (1937), 76–87; Paget (1968), 169; Gazzetti (1979). Forum Iulii (Fréjus) was important under Augustus until superseded by Misenum.

[70] For sites see above nn. 36, 54, 66, 67 and Lehmann (1923); Mytilene: Koldewey (1890); Mouterde (1951); Rhodes: Bradford (1957), 277–86.

[71] See also above nn. 17, 31–2, 35, 51, 52. The causeway joining Pharos island to the mainland at Alexandria (the 'Heptastadion') had two bridged openings for ships and currents to pass from one great harbour to the other, and the military dockyards lay within these two harbours; the 'Diolkos' (n. 62) may have supplied the connection when the openings became blocked. Portus Iulius: Maiuri (1937), 136; Jacono (1941); D. Adamesteanu, *Convegno Ravenna* (1961); Paget (1968). Lagoon harbours: above p. 187 and n. 56; n. 69.

[72] Lehmann (1923), 248–9; (1926), 549; Tacitus, *Ann.*, 15.18.3.

[73] Thucydides, 1.7; Lehmann (1923), 24–5; Blackman (1969). A number of Italian examples could be added, particularly in Etruria: e.g. Tarquinia (out-port Graviscae) & Caere (out-port Pyrgi); cf. also Cyrene (out-port Apollonia). Political strains: e.g. Athens, Colophon.

[74] Full discussion, with ancient sources: Lehmann (1923), 72–4; Philo of Byzantium has much detail in his *Mechanica* (H. Diels & E. Schramm, *Abh. Akad. Berlin*, 1919, no. 12, 61 ff.); Vitruvius mentions hauling machinery for chains from tower to tower (5.12.1). Others towers: Aegina, Akko, Elaea, Forum Iulii, Naupactus, Samos and Thasos, where they stood also at intervals along the mole. A mosaic from Ravenna shows the harbour entrance flanked by walls ending in towers (Starr 1960, 21, n. 46).

[75] Portsmouth chain: ordered 1522, constructed 1545, renewed 1664–66. Other examples: Dartmouth, Fowey, Penrhyn (Falmouth).

[76] Jameson (1969), 334–7, figs 6, 7; (1973), 222–38, figs 1, 4.

[77] Traditional interpretation, with full discussion: Lehmann (1923), 65–74; E. Kirsten suggests that the word simply means 'sheltered', whether naturally or otherwise: *RE*, **XIX**.2 (1938), 1655, s.v. *Phalasarna*.

[78] Emporia, customs and harbour dues, officials: Lehmann (1923), 28–45, 120–1; Heichelheim (n. 60) II.134, n. 49; D. C. Gofas, *Bull. corr. hellénique*, 93 (1969), 337–70 (with references). Piraeus: W. Judeich, *Topographie von Athen* (2nd ed. Munchen 1931), 446 ff.; Panagos (1968), 173–4; Portus: Meiggs (1960), 163. The separate identity of the harbour is symbolized by the harbour deity (on whom see Boyce 1958, 69–72).

[79] Sumer: A. L. Oppenheim, *Ancient Mesopotamia* (Chicago 1964), 78–9, 116; but cf. K. Polanyi in Polanyi & others (1957), 12–26. Naucratis: Herodotus 2.178; the excavator, W. M. Flinders Petrie, thought he found remains of a dock by the ancient lines of the canal, closer to the site than the present canal [*Naukratis*, I (2nd ed. 1888), 10–11].

[80] Walls partly of natural rock: e.g. Sidon island, Arwad (Frost 1972, 1973); cf. above p. 93 and n. 51.

[81] Cnidus: C. T. Newton, *A history of discoveries at Halicarnassus, Cnidus, and Branchidae*, Vol. II (London 1865); J. M. Cook & G. E. Bean, The Cnidia, *BSA*, 47 (1952), 202 ff.; I. C. Love, reports in *AJA* since 1968. Eretria: Lehmann (1923).

[82] Cosa: Lewis (1973), with valuable general discussion; Cosa's broad breakwater now paralleled at Populonia: McCann & others (1977), 282–3. Cenchreae: Shaw (1978); Phaselis: Blackman (1973c); Schäfer & others (1981).

[83] Samos: Herodotus 3.60; Mouterde (1951). The exact original form of the great south mole cannot now be established. It is likely that it, and the shorter north mole, bore fortification walls already in the 6th century; in that case the ashlar remains noted on the south mole could be remains of this rather than a paved quay. The next earliest known example would be Piraeus in the early 5th century. Sidon island: above n. 80.

[84] Mouterde (1951), 30. Here is a subject for further research.

[85] Vitruvius 5.12: the concrete could be poured into a simple timber caisson or, in the absence of *pozzolana*, laid dry in a (drained) caisson consisting of a double frame of timber piles with clay packing between; cf. Dubois (1902). Schläger (1971) noted and discussed the evidence for the construction of the concrete mole at Side: cf. Knoblauch (1977). Traces of a form of pine planks and poles have recently been found around the submerged walls of a harbour building and quay wall at Pyrgi: Oleson 1977, 304ff.; cf. his n. 19 for other parallels. Add now Herodian Caesarea: Raban & Linder (1978), 241; Raban (1978); Egnatia: Sciarra Bardaro (1979); Freschi & Alloa (1979–80); and the Roman bridge or causeway at Carthage: Hurst (1976).

[86] Dubois (1907), 249–68; Lehmann (1923), 163–8; Maiuri (1937), 79–82; Shaw (1972), 97–8; n. 18 above. Most of the examples are from Campania, but there are possible examples at Antium and Terracina in Latium. Coins: e.g. Part 1: fig. 1B. Purpose: Lehmann (p. 168) denies aim of preventing siltation—it was simply the new, and economical, fashion. It is not certain how (or whether) the piers at Misenum were joined. Reconstruction in AD 139: *CIL*, X.1640–1.

[87] Pliny, *Ep.* 6.31; cf. A. N. Sherwin-White, *The letters of Pliny* (Oxford 1966), 396–8; Lehmann (1923), 192–5. Josephus, *BJ*, 1.411–3; Lehmann (1923), 179–81.

[88] Meiggs (1960), 154–7; Testaguzza (1964, 1970).

[89] Patras: Lehmann (1923), 211–2; Sabratha: Yorke (1967), 20–2. Alexandria too seems to have had a detached breakwater in late antiquity (Lehmann 1923, 216).

[90] Lézine (1961), 143–9; Yorke (1967), 23–4; Flemming (1980), 172. 180 m beyond the end of the breakwater was a detached feature, possibly a lighthouse or artillery tower.

[91] Chersonesus: Leatham & Hood (1958–59).

[92] Constantinople: Janin (1950). Procopius, *De Aedificiis*, 1.8.7–9; 1.11.18–22; 4.10.5–17; 5.4.3 (but cf. *Anec.*, 8.7–8; 19.6; 26.23). Anthedon: n. 36 above.

[93] Sidon: Frost (1963), 67–71 (general discussion), 92–3; Ephesus: Strabo 14.1.24 (641); cf. Livy 37.14.5. Later operations at Ephesus are attested in AD 61, and under Hadrian, and in the 3rd century. Compare Portus: above p. 187 and n. 58. See Wendel (1969); Kraft and others (1977).

[94] Tyre: Poidebard (1939); Frost (1963), 83–5 (but its identification as a harbour has recently been doubted: Frost 1971, 108–9; 1972, 110–1). Mahdia: n. 52. Alexandria: p. 82 and n. 17. The Claudian harbour at Portus may originally have had another entrance at its southwest corner.

[95] Cosa: Lewis (1973), 254–5: recent work, however, indicates that the 'inner harbour' was in fact a fishery, for which the channels would have ensured a change of salt water and the Spring House a supply of fresh water: McCann (1979). Mytilene: Mouterde (1951), 22; Blackman (1973b), 135, date uncertain, mortar apparently used. Centumcellae: Bastianelli (1954), 37–8. Egnatia: Sciarra Bardaro (1979); Freschi & Alloa (1979–80). Caesarea: Raban & Linder (1978); Raban (1978). Misenum: Maiuri (1937), 80; Gazzetti (1979), 56. Early example in Egypt?: Goyon (1971), 141–2.

[96] Seleucia: Poidebard & Lauffray (1951), 31–2; Lehmann (1923), 214–6. Sidon: Poidebard & Lauffray (1951); Frost (n. 93). Cf. Paget (1968), 159–60, quoting Lewis. The 'dry dock' at Massilia is now interpreted as a drain-fed flushing-tank: Euzennat (1976), 546–7.

[97] Rock-cut quays: also Mahdia (Punic?); Giannutri (late 1st century AD, perhaps with masonry laid on the levelled rock). At Delos, too, the natural shelf of bedrock was used wherever possible.

[98] Brick arcade: e.g. Claudian Portus; the 'Barberini mosaic' may show an arched quay, but little of it survives (see n. 25). Puteoli: Dubois (1907), 261–5; Lehmann (1923), 168–70. Depictions of timber structures: also a mosaic from Veii showing elephants being loaded on to a boat along a small wooden jetty projecting from shore [G. Gatti, *BullComm.*, 28 (1900), 119, fig. 1]; Trajan's Column: Florescu (above n. 23) pl. III. Actual remains: Carales (?): Lehmann (1923), 250–1; Theodosia: Blavatsky (1972), 115: timber piles, perhaps supporting a solid built mole; compare Aquileia, and Brigantium (n. 59 above). Roman timber remains are reported at Lattes: Prades (1974). Massive Roman quays have recently been revealed at Caesarea and in the commercial harbour at Carthage: Raban & Linder (1978); Raban (1978); Stager (1977).

[99] Other Roman quay lengths: Claudian Portus, 1350 m maximum; Leptis Magna, 1200 m; Terracina 1200 m. Piraeus jetties: Judeich (n. 78), 445; Rome: Le Gall (1953), 201 (compare a mosaic in Kassel: Moll 1929, pl. B/X.35). Acholla and Leptis Minor: Yorke (1967), 22–3.

[100] Quay heights, and mooring-stones: von Gerkan (1933); Blackman (1973b); Williams 1976; ships may sometimes have moored broadside on for unloading and then moved to fore-and-aft moorings. Portus: Meiggs (1960), 162–3, 170; Testaguzza (1970), 80, 104, 162–3, 166, 170; Rome: n. 57; Terracina: de la Blanchère (1881); Lugli (1926), col. 131–2; R. Mengarelli, *NSc* 1900, 636–8; Aquileia: Brusin (1934). Metal rings: Lehmann (1926), 562; Degrassi (1955), 135. Ships' mooring equipment: Casson (1971), 252. Mooring angle: Le Gall (1954); Rougé (1966); in a river broadside mooring would obviously be commoner.

[101] Bollards: also Fréjus (Donnadieu 1927, 41–68; Aubenas 1881, 500 ff.) and many other sites. Rock-cut at Matala (Blackman 1973d) and Nisida (Gunther 1903b, 273).

[102] Testaguzza (1970), 163, 169, 171. The possibility that the main purpose of such columns was to support a roof must not be ignored (cf. Giannutri: Bruno 1973b).

[103] Harbour operations: Casson (1971), 369–70; Rougé (1966), 162–4; (1978). Sand-ballastmen: Cébeillac-Gervasoni (1979). Cranes: see also Shaw (1967b); Williams (1976); Casson (1976). Remains of a base, possibly of a crane, have been found on a riverside quay of Roman York: P. Addyman, *Univ. Birmingham Archaeol. Soc. Bulletin* 16 (1977–78), 68–71. A curious graffito in Sabratha theatre appears to show a floating crane and a five-masted ship (!), but only a drawing has been published: Turba (1954). Cf. Vitruvius 10.2.10.

[104] Delos provides good evidence for the buildings behind and also light booths on the quays (Paris 1916). Water supply: Leptis: Bartoccini (1958), 96–7; Cosa: Lewis (1973), 256–7; McCann (1979); Misenum: Maiuri (1937), 83–5 (cf. 81–2 for another reservoir); Starr (1960), 16; Gazzetti (1979), 56–7. The 'freshwater-fountain' at Marseilles (Shaw 1972, ill. 24) is a mistaken caption, Shaw tells me—the structure is a 'dry dock' or flushing-tank (see notes 96, 113). At Cenchreae and Fréjus there is a well beside the harbour; at Antipolis an aqueduct and watering-point: Clergues (1972).

[105] Amit (1965), 78–9; Panagos (1968), 169, 226–9; Marstrand (1922); Jeppesen (1957); Shaw (1972), 92–3.

[106] Beaching merchant ships: Theophrastus, *HP*, 5.7.2 (quoted by Casson 1971, 212, n. 51); cf. Launey (1933, a very fragmentary inscription). Lead sheathing: Blackman (1972a); Swiny & Katzev (1973). Survey of shipsheds: Lehmann (1926), 563–4; Blackman (1968) (with full bibliography; only recent finds, or discussions, are noted below); (1973b), 126–31.

[107] Herodotus 2.159.1; 2.154.5 (the word could mean 'hauling equipment' rather than 'hauling-way': cf. Thuc. 3.15.1); 3.45.4. For Necho see now A. B. Lloyd, *JHS*, 95 (1975), 45–61; L. Basch, *JHS*, 97 (1977), 1–10. Slips seem to be referred to in *Iliad* 2.153.

[108] Piraeus: new finds in Zea and Cantharus reported by O. Alexandri, *Arch. Deltion*, 29 (1973–74, published 1979), *Chronika B*1, 99, 144–45, 151. Apollonia: Flemming (1972), 103–11; Rhodes: Blackman (1972b); Aegina: Knoblauch (1969; 1972).

[109] Zancani Montuoro (1974); Blackman (1977); a branch of the River Cratis must have run close by to the east. Perhaps other 'keel-slots' should be similarly interpreted, but the grid is not parallelled elsewhere.

[110] Davaras (1967); Blackman (1973d); Raban & Linder (1978); Raban (1978). A rock-cutting by the River Neda in the Peloponnese has been similarly interpreted: F. A. Cooper, *Athens Annals of Archaeology*, 5 (1972), 359–63.

[111] Hurst (1975, 1976, 1977). In 1979 Hurst cast doubt on the interpretation of the 4th-century timber structures as shipsheds; but ship's nails and barnacles were found on the timber sleepers on the ramps of the stone shipsheds.

[112] Lehmann (1923), 183, n. 4; Le Gall (1953), 103–10; Coarelli (1968). The supposed shipsheds at Ostia must be deleted: Meiggs (1960), 126. Possible remains of Agrippa's *navale* at Lake Avernus: Jacono (1941), 665 and fig. 3. Vitruvius (5.12.7) recommends vaulted roofs to minimise the use of timber in their construction.

[113] Docks: Nirou Chani/H. Theodoroi (Frost 1963, 107–9; Blackman 1973b, 132); the *darsena* at Portus (Meiggs 1960, 159–62; Testaguzza 1970, 173–4); Marseille 'dry dock' (Euzennat & Salviat 1968, 16; but see notes 96, 104); Motya (Isserlin 1971, 1974). Two dry docks and associated carpenter's shop were recently excavated in the centre of Canton, dating from the Chin Dynasty (246–207 BC): Lei 1978. Shipyards (?) at Fos: Monguilan & others (1977), 60.

[114] Lehmann (1923), 119, 183, n. 4; Köster (1923), 71ff.; Casson (1971), 203ff. Greek inscriptions also refer to 'drying sites' (*psyktrai*). Of known shipsheds those at Thurii would have had the space for shipbuilding, and rock-cut basins by those recently found at Dor could have been used for pre-soaking timbers.

[115] Piraeus: Lehmann (1923), 68, n. 1; Colossus: Gabriel (1932); Maryon (1956).

[116] Thiersch (1909); Picard (1952); Fraser (1972); Frost (1975); Vailati & Curto (1980); above n. 15. Cf. Fakharani (1974).

[117] Portus: Stuhlfauth (1938); Meiggs (1960), 154–8, cf. 170; Testaguzza (1970). Leptis: Bartoccini (1958), 59–65. Side: Knoblauch (1977). Some 'towers' at mole ends may in fact have been lighthouses (see n. 90), or sea marks (e.g. the 'Tower of Flies' at Akko), as may certain colossal statues (Vermeule 1962). The 2nd-century AD structure on the island in the inner harbour at Lechaeum probably served as a 'leading light', being aligned on the outer harbour's entrance channel (Shaw 1969); a Roman period lighthouse on the inner harbour island at Carthage was similarly aligned on the entrance channel of the inner and perhaps also the outer harbour: Hurst (1975, 1976) but now (1979) he is doubtful; cf. Fréjus: Donnadieu (1927), 50.

[118] Apollonia: Flemming (1972), 120–1; Corunna: Hague (1973), 293–303; Hutter (1973); Dover: Wheeler (1929); cf. Caligula's lighthouse at Boulogne: Wheeler (1929); Goodchild (1956), 522–3. See now Hague & Christie (1975), 1–9; Williams (1976).

[119] *Acharnians* 545–54 (my translation).