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The Drusion: a candidate for Herod's lighthouse at Caesarea Maritima

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Did Herod the Great build a lighthouse for his new harbour at Caesarea Maritima? Ancient accounts record a series of towers around the harbour, the tallest and most magnificent called the Drusion. During the 1990 season divers recorded the ruins of a massive structure—clearly the largest single element of the harbour—at the north end of the Southern Breakwater. Are these remains at the harbour entrance those of both the lighthouse and the Drusion? This paper will: (1) review the germane literary evidence concerning Herod's construction of Sebastos, the harbour of Caesarea Maritima; (2) briefly define the role of lighthouses in the Graeco–Roman world; (3) summarize the excavations and surveys of previous seasons of the Caesarea Ancient Harbour Excavation Project (CAHEP) in the area under discussion; and (4) discuss the feasibility of such a structure from the point of view of Herod the Great, one of the most ambitious builders of antiquity.

Literary evidence

Our principal literary sources for the city and its harbour appear in the *Jewish Wars* (i.408–418) and *Jewish Antiquities* (xv.335–341) by Flavius Josephus. The former, published sometime between AD 75 and 79, includes the following description:

> Having calculated the relative size of the harbour as we have stated, he let down stone blocks into the sea to a depth of 20 fathoms (ca. 37 m). Most of them were 50 feet long, 9 high, and 10 wide (15·25 × 2·7 × 3 m), some even larger. When the submarine foundation was finished, he then laid out the mole above sea level, 200 feet across (60 m). Of this, a 100-foot portion was built out to break the force of the waves, and consequently was called the breakwater (*prokumia*). The rest supported the stone wall (*teichos*) that encircled the harbour. At intervals along it were great towers (*pyrgoi*), the tallest and most magnificent of which was named Drusion, after the stepson of Caesar. (*Jewish Wars* i.411. trans. Oleson).

Twenty years later, he adds:

> The structure which he threw up as a barrier against the sea was 200 feet wide. Half of this opposed the breaking waves, warding off the surge breaking there on all sides. Consequently it was called the breakwater (*prokumatia* or *prokumia*). The rest comprised a stone wall (*teichos*) set at intervals with towers (*pyrgoi*), the tallest of which, quite a beautiful thing, was called Drusion, taking its name from Drusus, the stepson of Caesar who died young. (*Jewish Antiquities* xv.335 trans. Oleson).

Josephus provides the general harbour outline in both sources and, although his political and personal motivations seem to have shifted during these intervening years, there was little or no change in his description of Herod's various building activities including those at Caesarea Maritima. The artificial harbour extended into the sea with wide breakwaters reaching out from shore; the great Southern Breakwater curved outward for more than 700 m defining the southern and western limits of the basin while a second structure, the Northern Breakwater, was perpendicular to the shore and stretched 275 m to the north-west entrance (Fig. 1). Josephus mentions a temple dedicated to Roma and Augustus overlooking the port and describes the quay with its store rooms (*horrea*) and broad promenade for those wishing to stroll along the waterfront. Our ancient witness is very specific about the towers standing outside the harbour entrance to the port and starboard of ships entering the protected haven. To the right (starboard) were great stone blocks, upright and yoked together, with three monumental columns that in turn supported statuary. On the left (port) was a single tower, not as tall as the other pair, that also carried columns with sculpture. Nothing more is known about the sculpture and whom it might have represented. Josephus does not mention a lighthouse in either account[1].

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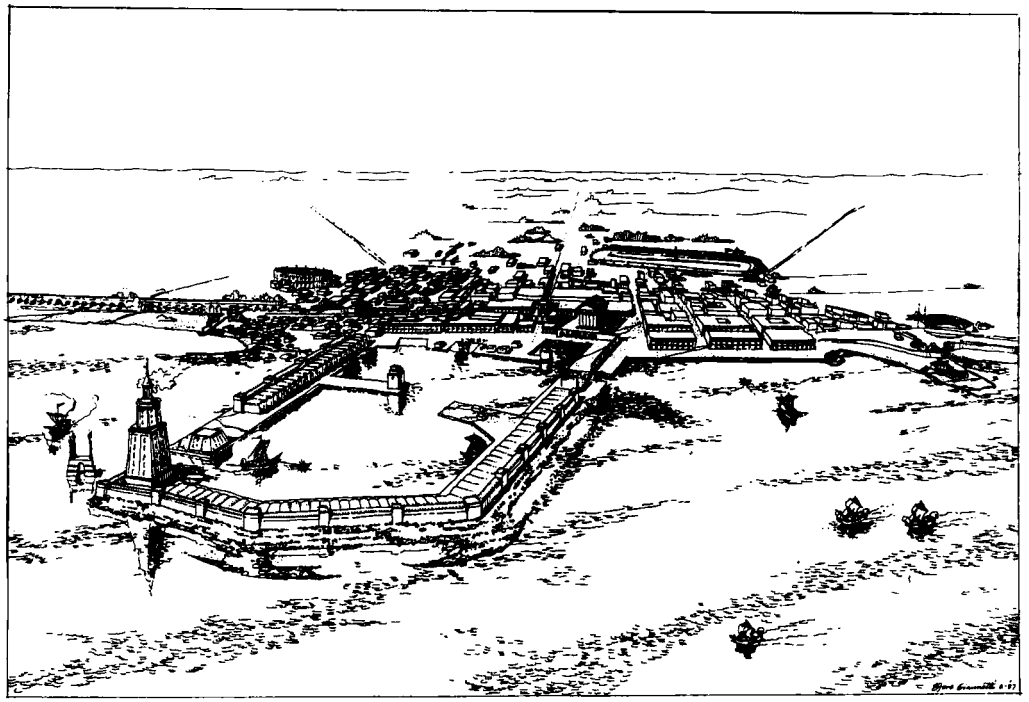

Figure 1. Reconstruction of the harbour of Caesarea Maritime (Stephen Giannetti).

He is also less precise concerning the Drusion, the only monument in the port facility other than the great temple that was dedicated to a member of the Roman imperial family. Apparently the breakwater width consisted of outer and inner portions—the breakwater proper and the warehouses and loading space—divided by a spinal wall with towers at intervals. We are told that the tallest and most magnificent of these towers was named for Drusus, the stepson of the emperor. What characteristics of this tower led to its special status? Was it the size? Position? Function? How many towers were there? Did they punctuate the wall on both breakwaters? Were massive walls and towers primarily to fortify the port facility or were less substantial barriers set up to control traffic of goods through the port for custom's purposes? There are many unanswered questions but the most intriguing is whether or not the Drusion was, in fact, the lighthouse of Herod's harbour.

Early lights

The earliest evidence for beacons to guide Mediterranean sailors is very sketchy and the use of shore lights to lead mariners into a safe haven must go back to the very beginnings of maritime traffic[2]. Early lights were not designed to warn ships against projecting headlands, dangerous reefs, or otherwise difficult waters. Instead they were usually beacons marking the entrances to harbours, by day with smoke or at night as an illuminating fire.

The first lights were probably fires on shore that directed fishermen home after a night's work. But as trade developed creating networks between different regions a more permanent system of communication, perhaps in the form of free-standing towers or columns, replaced the *ad hoc* system of fires on the beach or nearby hill-tops (de Coetlogon-Williams, 1976: 75; Vermeule, 1962: 76–7). These elevated fires provided better visibility and can be seen in later paintings and mosaics from the Roman period (Marucchi, 1904) (Fig. 2). One assumes that such a light would be sufficient for smaller anchorages and certainly was more economical and easier to maintain.

The first lighthouses

Where were the first lighthouses? The answer to this question is complicated by the nature of

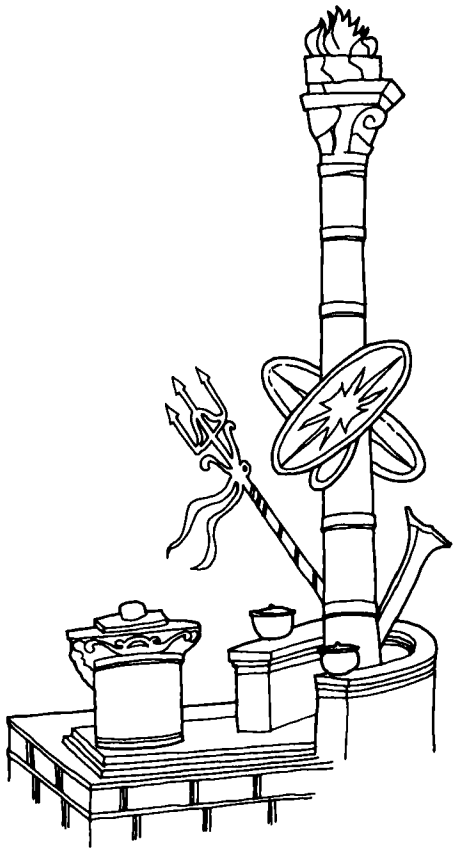

Figure 2. Column with fire from Praeneste mosaic (Yuan).

maritime sites where prime harbour locations were carefully selected and once identified, generally maintained unless rendered useless by siltation. New technology ensured that Roman engineers periodically enlarged or rebuilt most Greek, Phoenician, or Etruscan port facilities, obliterating earlier installations in the name of progress. Likewise, since the harbour and its lighthouse lie at the margin of land and sea, destructive forces of both environments have taken their toll. Winter storms pounded the breakwaters and shoreline installations while inner harbour basins silted up and structures were dismantled for the reuse of their building materials (Oleson, 1988: 147).

The earliest well documented lighthouse is the Pharos at Alexandria, although it is unlikely that the very first example of this building type would have been the largest ever constructed. Other lighthouses of much smaller size must have preceded the Egyptian example including that recently investigated at Thasos (Kozelj & Wurch-Kozelj, 1989). Other likely candidates for Greek lighthouses are those city wall-towers built at the water's edge or often on to the breakwaters, such as that adjacent to the narrow entrance to the military harbour at Knidos (Krischen, 1938; pl. 2). These towers that flanked entrances to early Greek harbours were probably used as lighthouses.

The famous neighbour

The best known Graeco–Roman lighthouse was that at Alexandria (Thiersch, 1909; Clayton, 1988). The tower, built in the first half of the 3rd century BC, was credited to the architect Sostratus whose name appeared in an

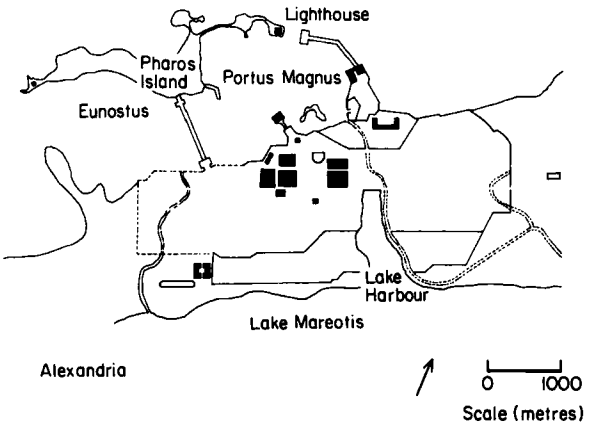

Figure 3. Plan of Alexandria with location of Pharos (Yuan).

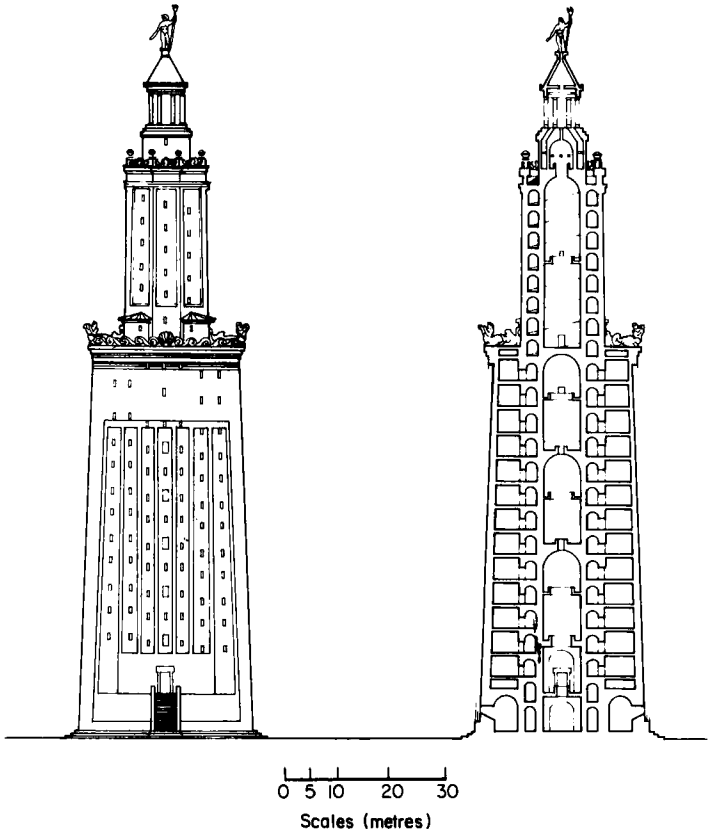

Figure 4. Elevation and section of Pharos after Thiersch (Agnew).

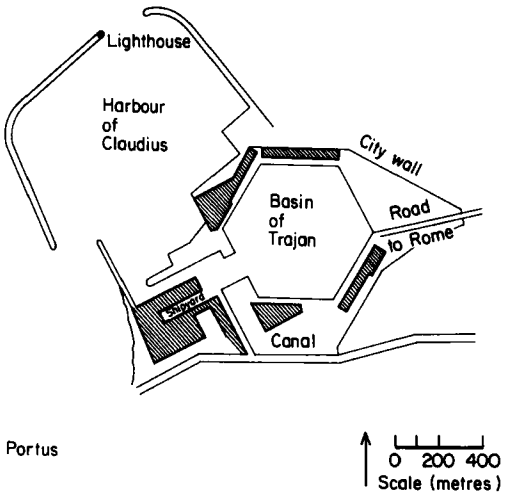

Figure 5. Plan of Portus with location of lighthouse (Yuan).

inscription on the building. This lighthouse stood on an offshore island of the same name, Pharos, connected to the mainland by a long causeway known as the Heptastadion that in turn divided the protected harbour in the lee of that island into eastern and western anchorages (Fig. 3). The tower remained intact until the 8th century when its lantern collapsed[3]. Substantial portions stood through the 14th century but most disappeared within the following century before the construction of Kait Bay fortress.

What did the lighthouse at Alexandria look like? There are many references to this monument in ancient literature and numerous depictions in art of the later Roman period. In fact there appears to be too much evidence, for many of these descriptions are not consistent. Strabo described the site:

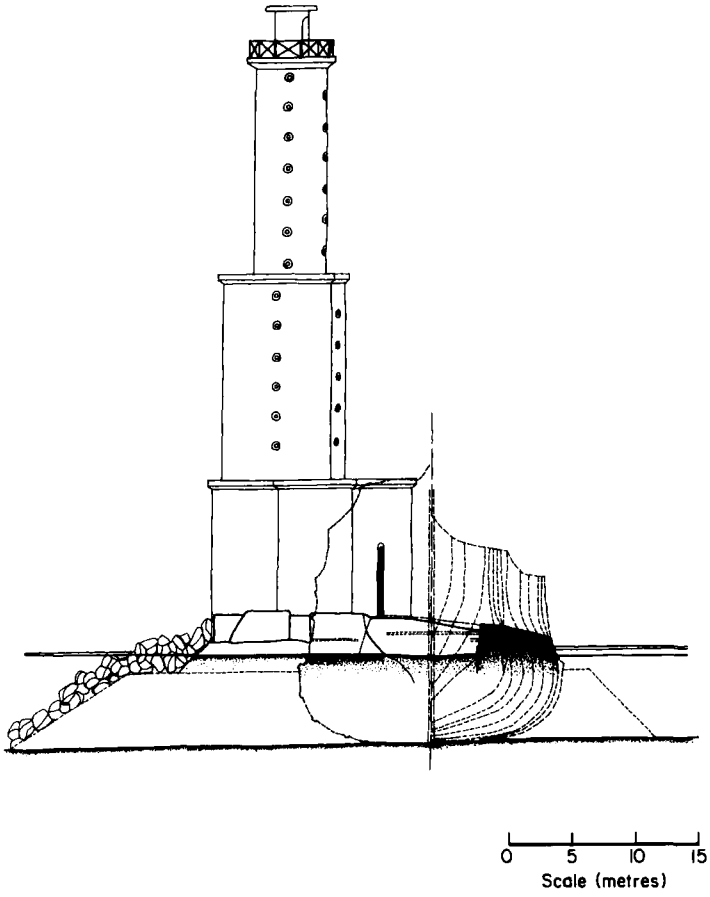

Figure 6. Elevation of Ostia lighthouse after Testaguzza (Yuan).

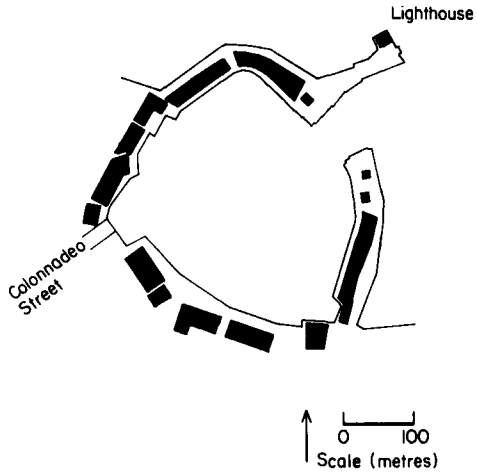

Figure 7. Plan of Lepcis Magna with location of lighthouse (Yuan).

In the great harbour at the entrance, on the right hand, are the island and the tower Pharos, and on the other hand are the reefs and also the promontory Lochias, with a royal palace upon it; and on sailing into the harbour one comes, on the left, to the inner royal palaces, which are continuous with those on Lochias and have groves and numerous lodges painted in various colours. (Strabo, *Geography* 17.1.8).

The most complete description of the lighthouse itself was the 12th-century survey by Ibn al-Sayj of Malaga (1132–1207) (Asin and Lopez Otero, 1933). Devoting himself to a year of study in Alexandria in 1165, al-Sayj visited local libraries and monuments where his experience as a builder was evident in the technical expertise of his Pharos survey. He took direct measurements and, where these were not possible, computed the remaining portions mathematically. On his return to Spain he

Figure 8. View of Lepcis Magna lighthouse after Bartoccini (Yuan).

compiled the data gathered during his travels, including a detailed account of the Pharos, and published a book called *Kitab Alif Ba*, or an ABC compendium of knowledge.

Both ancient illustrations on coins, sculpture, and mosaics and the account of Ibn al-Sayj are in agreement concerning the general massing of the tower (Fig. 4). It stood on a large platform measuring approximately 110 m square and 7 m high toward the eastern tip of Pharos island, probably the position today of the late 15th-century fortress. The first vertical section was approximately 70 m tall and square with sloping sides that diminished from a base of 30 m to an upper platform 24 m square. Within the lower section were 50 vaulted chambers (for the storage of fuel?) as well as a continuous ramp leading upward through the structure. The second section was an octagon, 35 m tall with a diameter of 17 m and the third, cylindrical, 26 m with a diameter of 9 m. The continuous spiral ramp of the lower zone became a series of straight flights in the upper portions. Thus the total height, according to our best account, was just over 130 m. The light on the upper platform came from a fire of resinous woods, probably amplified with large mirrors of polished metal. Goodchild (1957: 522) suggests that this enhanced beam of light might be seen as far as 300 stades (35 miles) out to sea. There are no clearly identifiable remains standing today[4].

Later Roman lighthouses

A comparison of several later Roman lighthouses might be useful for a better understanding of the Drusion. As part of Rome's harbour, the Ostian lighthouse was second only to that of Alexandria in fame and recognition (Fig. 5). It appears on numerous mosaics, coins, wall

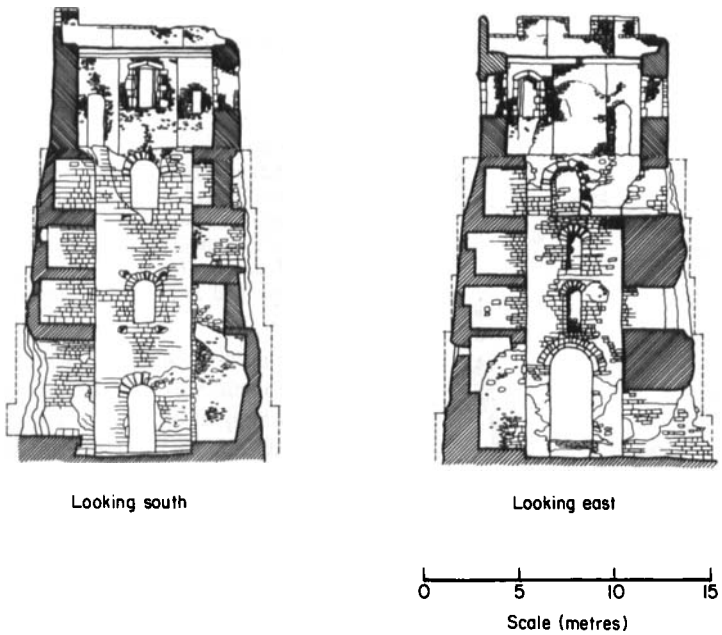

Figure 9. Remains of Dover lighthouse after Wheeler (Yuan).

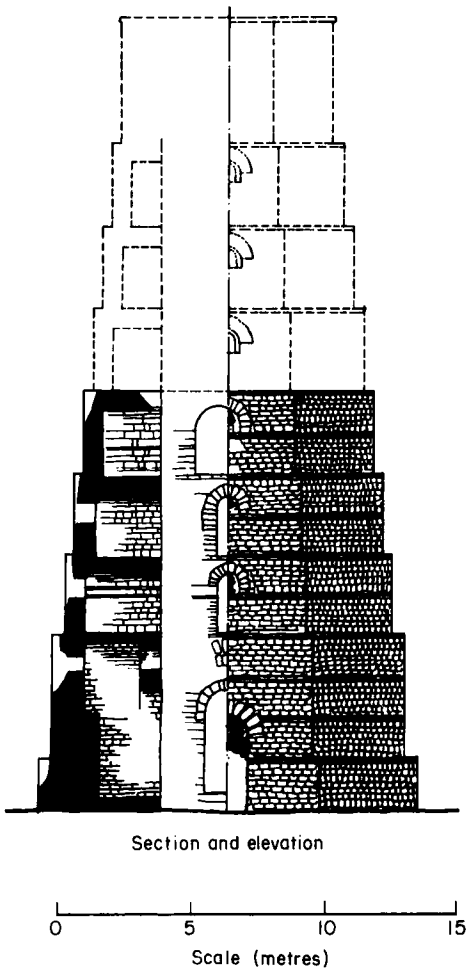

Figure 10. Restoration of Dover lighthouse after Wheeler (Yuan).

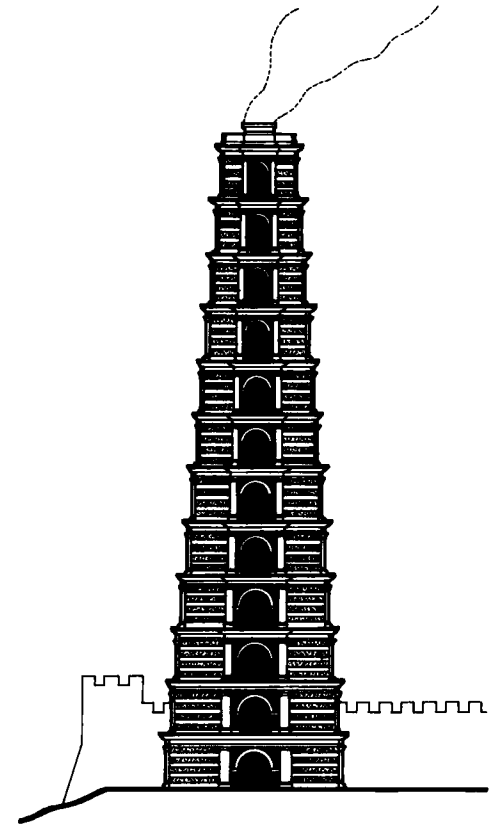

Figure 11. Boulogne lighthouse after Buchwald (Yuan).

paintings, and sculpture as a visual symbol of the port facility (Meiggs, 1960: 162, pl. xviii b). Seen in the Torlonia relief (Meiggs, 1960: pl. xx) the Portus lighthouse, tallest in Italy, stood four tiers high—three square sections and a circular lantern with a fire at the summit. Remains located during the 1957–1960 excavations consist only of concrete foundations (Testaguzza, 1964) that had been poured into the hull of a huge Alexandrian freighter during the initial Claudian building programme (Fig. 6). It is interesting to note that the Claudian harbour at Ostia is very similar in layout to Caesarea and in fact might be the most rewarding to study as a comparison for the Caesarea lighthouse. Was the artificial island formed by this concrete-filled ship following the model of large-scale concrete construction at Caesarea?

Another partially excavated lighthouse is an early 3rd-century example from the Severan reconstruction of Lepcis Magna in North Africa (Bartoccini & Zanelli, 1958: 59–65, Squarciapino, 1966) (Fig. 7). It is located near the end of the northern breakwater in a position very similar to that at Caesarea. The lighthouse, illustrated in a relief panel from the Severan arch in that same city, stood on a square platform with sides measuring 21·2 m (Fig. 8). Above were two long vaults (span 2·43 m), the northern one poorly preserved but the southern standing to a height of 6·20 m. (Bartoccini & Zanelli, 1960: pl. xxxii). Above this substructure was the stone-faced (*opus quadratum*) concrete core of the next section, still preserved to a height of 9 m. The tower consisted of three elements of decreasing square plans, probably patterned after the

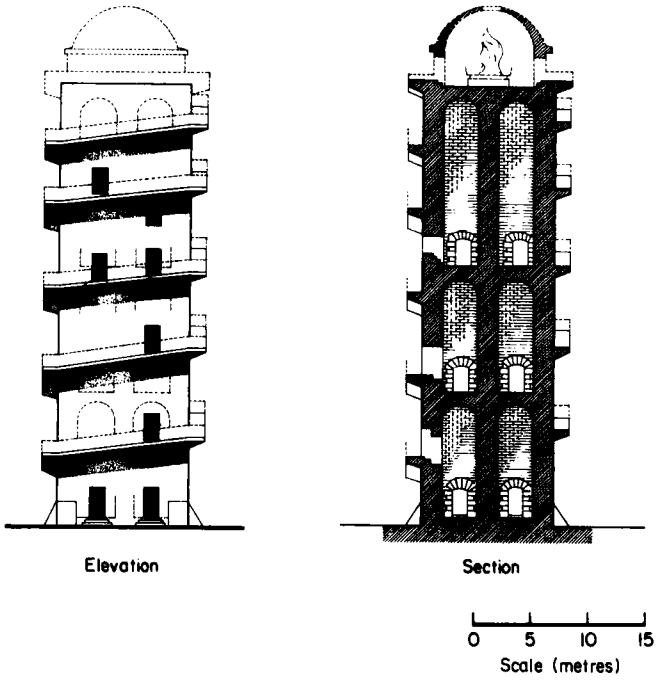

Figure 12. Elevation of La Coruña lighthouse after Hütter (Yuan).

pharos of Ostia rather than that at Alexandria. The second portion, no longer preserved, had a large gorge cornice crowning its upper perimeter and the third, also completely missing, likewise included a cornice of which a single piece remains. Apparently the entrance to this structure was at the second stage, level with the upper zone of the breakwater. A series of ramps and staircases within led to the top floor and beacon. Bartoccini estimated the total height to be between 30 and 35 m.

A pair of lighthouses stood on the hills above Dover (*Portus Dubris*), the principal port of Britain after the invasion (Rigold, 1969; Wheeler, 1929). The two structures date from the late 1st or early 2nd century, one rather well preserved west of the ancient city and another, in poorer condition, built into a later wall on the eastern side. The western tower is octagonal and its sides measure 4·5 m with an interior shaft 4·5 m square. The structure stands 13 m high (Fig. 9) but is restored on paper to twice that size. Although the exterior surface is badly battered, it appears to have been a series of octagons of decreasing size (Fig. 10) similar to the tower that once stood at Boulogne (Fig. 11) on the opposite side of the English Channel. Medieval builders altered the tower when it was incorporated into the church of St Mary-in-Castro and a reference to the *phararius* in 1201 suggests that it returned to service as a lighthouse during that same time.

The best preserved lighthouse from the ancient world is the early 2nd-century AD example at La Coruña (*Brigantium*) in north-west Spain (Figs 12 and 13) (Hütter, 1973). Also known as the Tower of Hercules, it stands encased in an 18th-century exterior but retains the lines of its original ramped staircases in later sill courses. According to Hütter, the pharos did not follow either of the two designs discussed above, the Alexandrian model (square base, octagonal stage, and upper cylindrical stage) or the Ostian model (series of platforms of similar shape but of decreasing size).

CAHEP excavations and surveys (Fig. 14)

The tumble of large blocks at the north tip of the Southern Breakwater has always been a major attraction for divers at Caesarea. Even those volunteers working on other projects during the past decade have taken their recreational dives

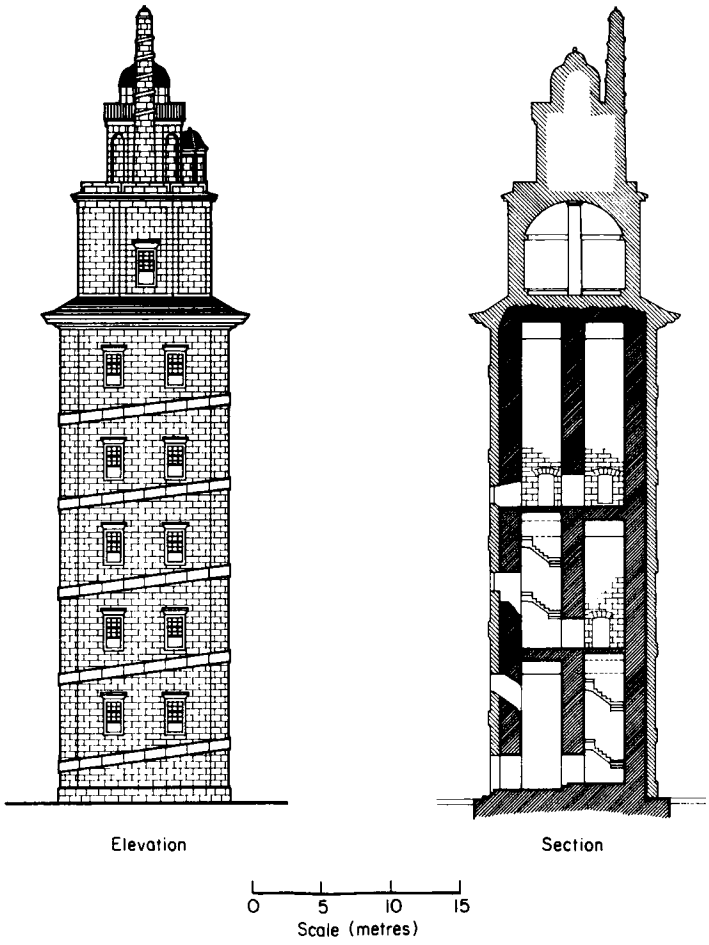

Figure 13. 18th-century elevation and section of La Coruña lighthouse after Hütter (Yuan).

in this part of the harbour. In 1981 excavators studied the two free-standing towers mentioned by Josephus (Area K: Raban, 1983: 245–48; Oleson *et al.*, 1984: 293–4; Vann in Raban, 1989: part i, 149–51), but time did not permit an extension of the trenches towards the nearby breakwaters. Divers saw the collapsed structure only on their way to and from work at the bases of those towers. During the 1983 and 1984 seasons a series of section lines, drawn across the same area under the direction of Professor John P. Oleson, revealed the dramatic topography of that part of the harbour (Oleson in Raban, 1989: part i, 220–1 and part ii, folding plate 4). Survey Line 11, 180 m long at a bearing of 310°, crossed the breakwater just east of the largest concentration of blocks. A study of that area shows a large mass of fallen concrete and kurkar blocks, 30–40 m long, 10–15 m wide, and rising to within 1·5 m of m.s.l.

To date the archaeological evidence for this portion of the harbour is slim. Survey lines indicate a slightly higher ridge along the centre of the Southern Breakwater, best seen in lines 1–3, 7, 9 and 10. The original shape of that breakwater, virtually obliterated by the constant motion of stormy seas, reveals a higher line of preserved rubble slightly seaward of the mid-point, suggesting that the spinal wall did not evenly divide its width. At one point near metre 50 on survey line 3, three large blocks remain from what might have been the underpinning

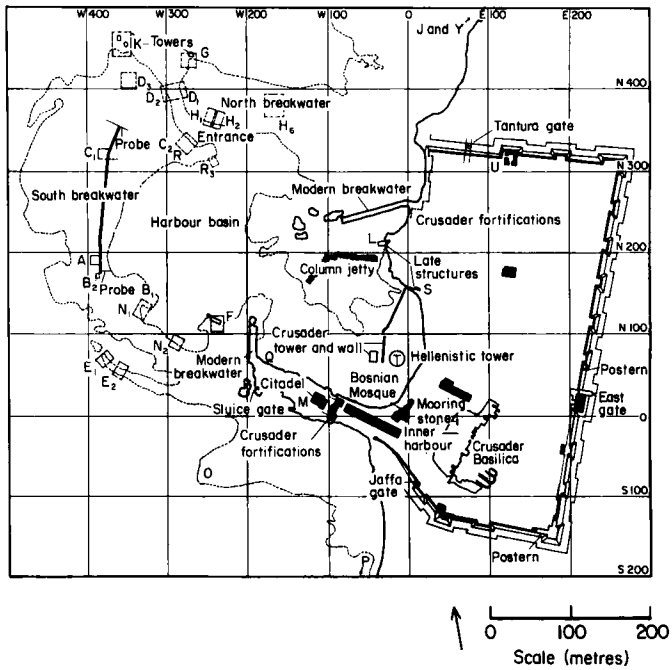

Figure 14. Composite plan of CAHEP excavations in the Herodian Harbour (Vann).

of another structure (Oleson in Raban, 1989: 213–4). The blocks average 3·5 x 4·5 x 1·7 m and are of concrete poured into wooden forms. Clearly preserved on their upper surfaces are the cavities left by timbers used to stabilize the formwork. It seems likely that these three blocks, located near the south-west bend of the Southern Breakwater, were used to support another of the towers along the spinal wall. Divers criss-crossed the breakwaters on many occasions searching for additional examples of such blocks but have found none.

The search for the Drusion intensified in 1990. This season's most spectacular discovery came on the first day of orientation dives for new volunteers. Strong winter storms removed at least 1 m of sand from this part of the harbour, revealing the northern edge of a long concrete block marked with cavities left by the vertical bracing of its wooden formwork (Fig. 15). By the end of the season the north side was exposed along its full length of 14·55 m and the east and west sides cleared for 5·20 m and 3·20 m respectively (Fig. 16). By comparison, the large concrete block located in Area G during the 1982 season measured 11·50 x 15 m (Vann, 1983; Oleson in Raban, 1989: 127–30). The long side of the Area K-2 block, set on a bearing of 95°, is immediately south of the twin towers of Area K, but the exact relationship between the breakwater and these two towers is not clear.

Construction details for this block are most interesting (Fig. 17). The cavities first recognized along the block edge were round, square, and rectangular in section and of various sizes ranging from 10 to 30 cm on a side. There is no pattern of regular spacing across the north side but four posts along the east face—three round and one square—are approximately the same size (26 m) and spacing (82–90 cm centre to centre).

Exterior planks on the north face were 20–30 cm high and 8 cm thick, fastened with beautiful mortise and tenon construction. Tenons measured 8 x 15 cm and were placed 7 cm apart each inserted into a precut mortise along the plank edge then fastened by wooden pegs through both the upper and lower planks[5]. Large bronze bolts were occasionally, but not systematically, used to fasten the outer planking

Figure 15. Plan of Area K-2 including twin towers of Area K investigated in 1981 and the remainder of the north end of the Southern Breakwater (Agnew).

to the vertical posts. A continuous sleeper beam supported both exterior planking and vertical posts as well as two layers of flooring planks set at right angles to one another. The construction process followed a traditional frame-first technique, characteristic of ancient shipbuilding.

Another feature visible after removing only a few centimetres of surface sand was an inner corner. An east-west plank, 1·85 m long, is parallel to, and 2·30 m within, the block's north edge; the north-south plank, 2·40 m long, parallel to, and 3·40 m within, the eastern edge. Both boards are 8 cm thick—identical to the outer planking—and fastened to a round vertical corner post. The function of this element is uncertain. The inner formwork may be part of a more complex system necessary to support a second massive block above, one that measured almost 3 m high. The badly eroded block that appears to be set on top of the K-2 block is also of interest. Its horizontal cavities left by internal bracing indicate that it, too, remains in its original position. Another problem with the recent discovery in K-2 is the lack of evidence for interior stabilization. There may be cavities for such beams still buried within the block but one would expect to see some evidence for their fastening along the exposed faces. At this point there is no significant correlation

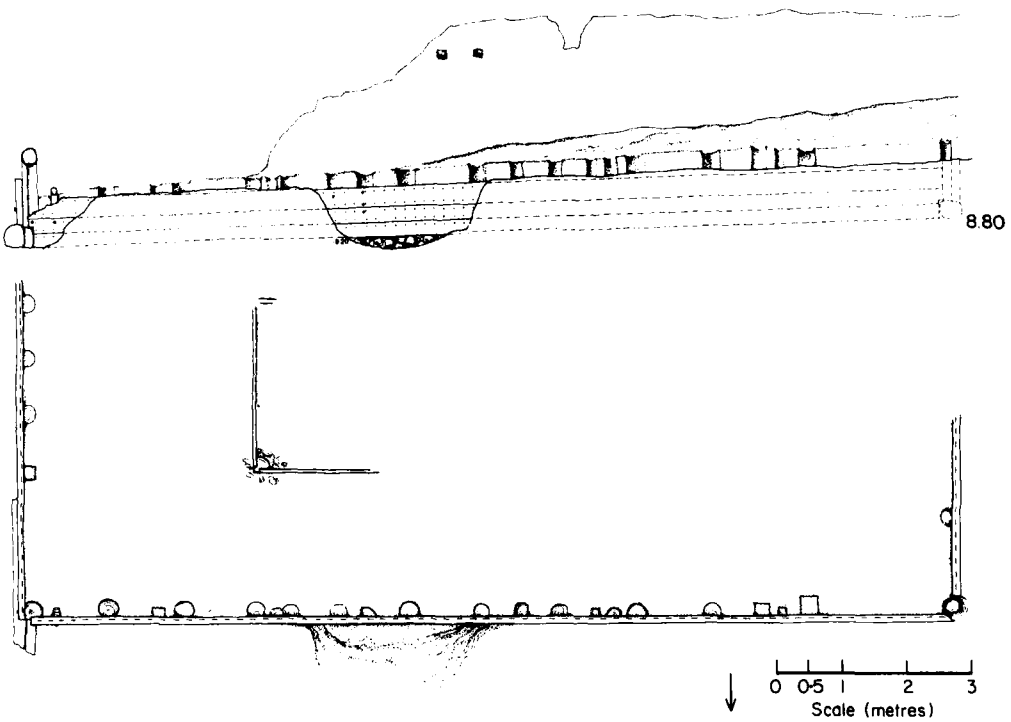

Figure 16. Plan and elevation of Area K-2 block (Agnew).

between the few bronze bolts found along the north face and the far more numerous internal braces that one would expect.

Beneath the fallen rubble is a network of other blocks, perhaps the same size as those in G and K-2, apparently remaining in their original positions. Narrow channels that now separate them were possibly formed by similar cavities of eroded timbers enlarged by the scouring effect of water surging through them over the centuries (Figs 18 and 19). Divers have been able to follow these tight passages among the blocks by removing their tanks and buoyancy-control devices and swimming through with very long extensions of their primary air lines. These passages seem to follow a grid that is parallel and perpendicular to the K-2 block faces. The 'floor' of this area is a platform of well-preserved concrete with numerous horizontal timbers in place, perhaps the remains of earlier bracing.

Herod's predilection for towers

But what of the structure that, judging from its remains, was the largest single element of the ancient harbour? A brief survey suggests that there would be several likely candidates for large buildings at or near the entrance. First, and I believe most obvious, was a lighthouse that by the late 1st century BC was a standard feature for a major port. Second, there was often the requirement for a building to house machinery needed to pull large chains across the entrance in order to close it to traffic. Third, very often the city fortifications enclosed the harbour with large towers standing at or near the entrance to provide defenders with strategic positions. It stands to reason that all three functions might have been met by the same structure.

We know, in fact, that Herod had already built several impressive towers. Netzer's work in the palace and fortified tomb complex at Herodium demonstrates the importance of similar structures in other Herodian projects (Netzer, 1981: 79–84). One of the four towers in this fortress-tomb stood 40 m high. A comparative chart based on an earlier drawing by Professor Netzer shows the relative heights of towers built by Herod the Great compared with ancient lighthouses (Fig. 20).

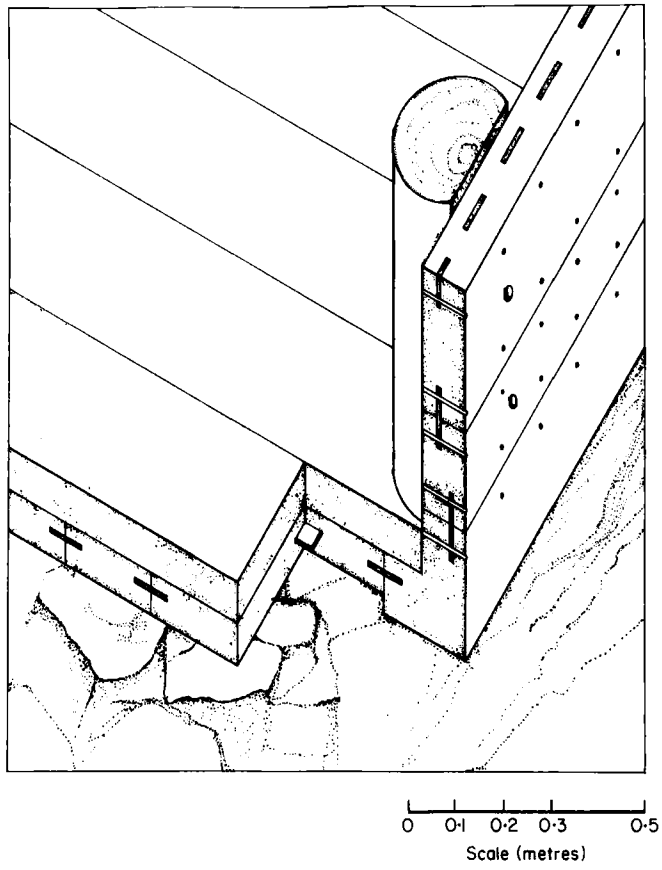

Figure 17. Detail of construction elements (Agnew).

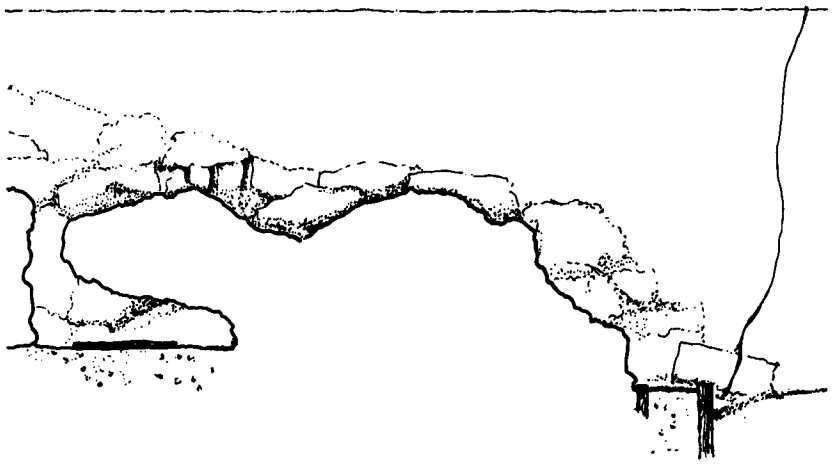

Figure 18. Section looking west between Area K-2 and channels to south. Not to scale (Agnew).

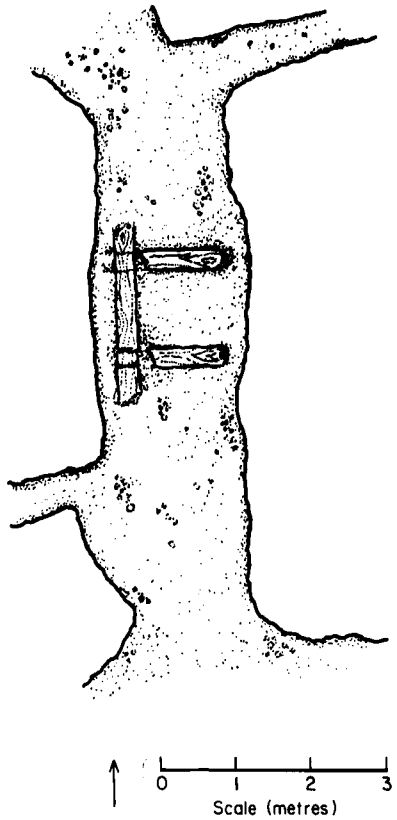

Figure 19. Plan of channel with exposed timbers (Agnew).

Particularly important for an understanding of Herod's attitudes toward building are the three towers associated with his palace in Jerusalem that are described by Josephus.

> Opposite this tower was Hippicus and near to it two others, built by King Herod in the Old Wall, and superior in size, beauty, and strength to any in the whole world. For apart from his love of grandeur and his ambitions for the City, the king made the splendour of these works a means of expressing his own emotions, naming the towers after the three persons he cared for most, his brother, friend, and wife, to whose memory he dedicated them. (*Jewish Wars* v.161).

The dedications of the towers were significant. One was named Meriamme who, despite being his favourite wife, was put to death by his own command. A second was dedicated to his deceased brother, Phasael. The third of these Jerusalem towers was named for Hippicus, a friend who had died in battle.

The Jerusalem towers were 41, 37, 28 m high, (*Hippicus, Phasael*, and *Meriamme*, respectively) and set along a high ridge of the western city wall, elevating them another 13–16 m. *Hippicus* was 12 m square at the base with a lower section 15 m high. Josephus described the structure as 'solid' although it probably included internal stairs. The second level was a 10 m deep reservoir and above, a two-storied structure divided into an assortment of rooms. Crowning the top was a ring of turrets and a rampart. The second tower was also square, 20 m on a side and 20 m high. On the second level was a colonnade 5 m high, protected by breast-works. A smaller tower, divided into a suite of rooms including a bath, rose within the colonnade. According to Josephus, *Phasael* was as luxurious as the palace itself and modelled on the famous lighthouse of Alexandria. The third tower stood on a solid base 10 m square and 10 m high. Josephus states that the king felt it appropriate for the tower named for his queen should be more ornate than those named for his brother and friend.

Concerning their construction he adds:

> they did not consist of ordinary small stones or lumps that men might carry, but of white marble, cut into blocks, each 10 meters long, 5 meters wide, and 2·5 meters deep, so perfectly united that each tower looked like a single rock, sent up by mother earth and later cut and polished by artists' hands into shapes and angles; so invisible from any viewpoint was the fitting of the joints. (*Jewish Wars* v.175.)

In his discussion of the towers, Netzer (1968: 57) points our their functions, first as elements of the city fortifications but at the same time luxurious private apartments. In fact, according to Netzer's theory,multiple purpose appears to be one of the hallmarks of Herodian building projects. Thus a single tower in the harbour might have served as a fortification while at the same time it housed a signal fire and machinery to close the harbour. Finally, the fact that the Drusion was identified by name clearly demonstrates its importance.

In conclusion, comparative studies of classical harbours suggest that Caesarea should have had a lighthouse and the eye-witness account of Josephus tells us that not only did the port facility have a series of towers along a central wall, but that one of these was larger than the others and given special identity by being named for a member of the Roman imperial family.

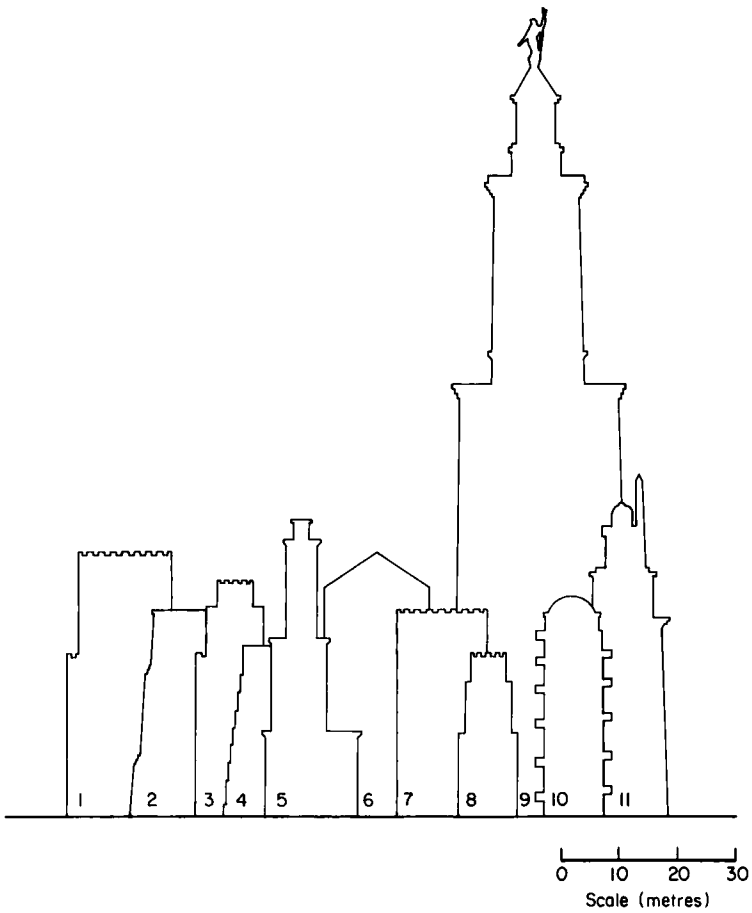

Figure 20. Comparative chart of Herodian towers and ancient lighthouses (Yuan). 1. Phasael; 2. Leptis Magna; 3. Hippicus; 4. Dover; 5. Portus; 6. Herodium; 7. Antonia; 8. Meriamme; 9. Alexandria; 10. La Coruña ancient; 11. La Coruña—18th century.

Likewise, past archaeological surveys indicate that the largest structural remains still in the water are to be found at the mouth of the harbour, the exact location in which one would expect a light-house. Finally, a brief survey of the building career of King Herod strongly suggests that he would have probably welcomed the opportunity and challenge to build yet another tower. The discovery of a large foundation in Area K-2 does not prove that our collapsed structure was a lighthouse, or for that matter the Drusion. Unless specific architectural elements appear we will be limited to Josephus's statement that the Drusion was 'a beautiful thing'. Two tentative proposals record current attitudes about the Caesarea lighthouse (Fig. 21). The first, based on its famous neighbour at Alexandria, is a three-tiered structure with square base, octagonal superstructure, and cylindrical turret. Its reconstructed height of 40 m is based on other Herodian towers and later Roman lighthouses, although this figure might have to be revised after further site survey. The second proposal of substantially the same size of building is based on the later Ostia/Dover type of a series of superimposed elements of the same shape. The investigation of Caesarea's lighthouse will continue and ideas for reconstruction will no doubt continue to evolve before final publication.

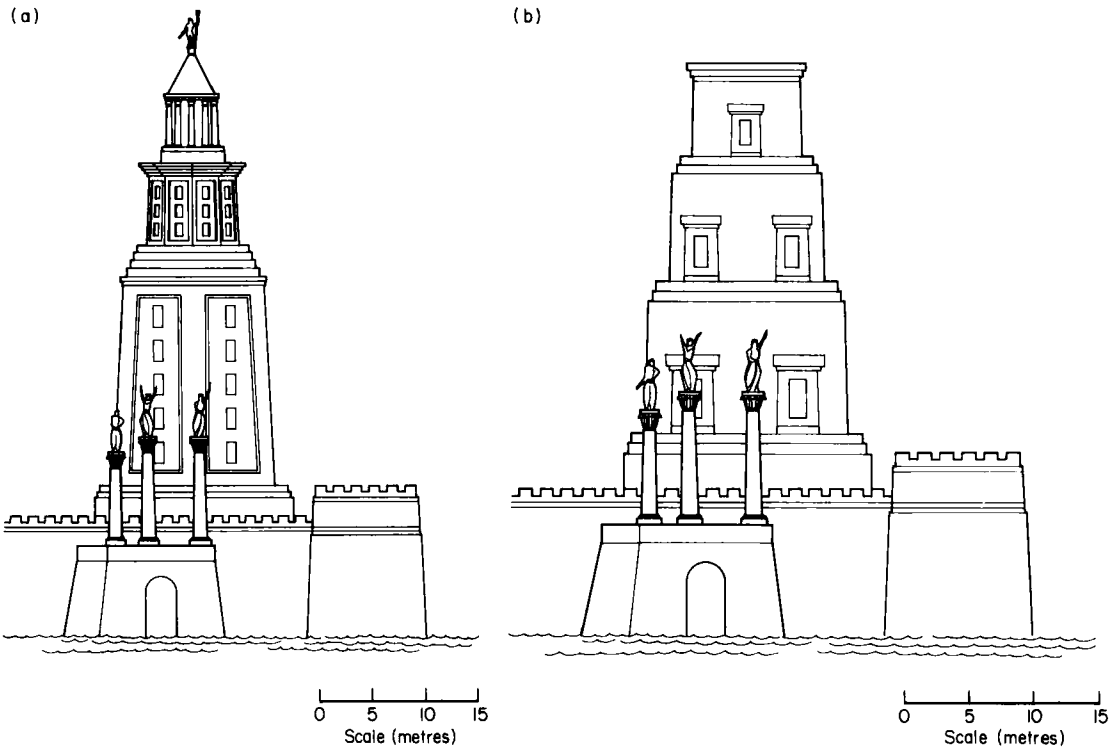

Figure 21. Proposal for Drusion based (a) on Alexandria Type (Yuan), and (b) on Ostia Type (Yuan).

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Notes

[1] The lack of a specific lighthouse reference in Josephus is not the only suspected omission in his description of the city and its harbour. See Vann, The Harbor that Herod built, the harbor that Josephus saw, in: Little, B. J., (Ed.), *Text-Aided Archaeology*.

[2] For a discussion of early lighthouses see: Daremberg, C. and Saglio, E., *Dictionnaire des Antiquitès grecques et romaines* (Paris, 1877) 4, part 2, 1449–1456; Pauly-Wissowa, *Real-Encyclopädie der klassischen Altertumswissenschaft*, 19th Band 1857–1869; Beaver, P., 1973, *A History of Lighthouses* (Secaucus, NJ); and Sutton-Jones, K., 1985, *Pharos, the Lighthouse of Yesterday, Today and Tomorrow* (London). For general discussion of lighthouses within surveys of ancient harbours see: Blackman, D. J., 1982, Ancient harbours in the Mediterranean, *IJNA*, **11**.2: 79–104 and 185–211; Oleson, J. P., 1988, The technology of Roman harbours, *IJNA*, **17**.2 (1988) 147–157; Shaw, J. W., 1972, Greek and Roman harbor-installations, in Bass, G. F., (ed.), *A History of Seafaring*, (London) 87–112; and Casson, L., 1971, *Ships and Seamanship in the Ancient World* (Princeton: Princeton University Press).

[3] Initial damage to the Pharos followed the Arab conquest of Egypt. In 956 there was earthquake damage after which a small mosque was constructed on top of the tower. It is interesting to note that the term 'minaret' means 'where the

fire burns' and it is possible that those towers associated with mosque architecture evolved from this famous lighthouse. For a comprehensive survey of early illustrations of the Pharos and photographs of early Muslim minarets see Thiersch, 1909: 97–173.

[4] Recently divers found fragments of a 7 m female figure, four sphinx bases, columns, and part of an inscription with the Latin letters IV during underwater investigations of the harbour from 1961–1968 (Frost, 1975).

[5] The pegs were 8 cm long with a diameter of 12 mm and were set 55 mm apart vertically and 15 cm apart horizontally. Two pegs fixed each within its mortise. Samples of wood and concrete are now in laboratories for analysis; results not yet available.

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