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Discovery of Ancient Harbour Structures in Calabria, Italy, and Implications for the Interpretation of Nearby Sites

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During underwater survey around Crotone, Calabria, Italy, in 2005, structures from two harbour phases were located, possibly dating from the Archaic Greek and Roman periods. Both harbours are close to the Greek and Roman architectural remains on Capo Colonna, as well as to underwater deposits of large stone blocks and other, previously-excavated sites. With the discovery of these harbour structures, new hypotheses arise for understanding the building-material deposits and excavated sites. A critical component of these hypotheses is the assessment of local geological data, specifically ancient sea-level, in relation to the archaeological record.

Key words: Italy, harbour, ancient sea-level, building-stone, Greek, Roman.

In 2005 RPM Nautical Foundation conducted a survey along the Ionian coast of Calabria, Italy. Beginning at the town of Crotone, the survey area extended approximately 35 km to the south and south-west past Capo Rizzuto (Fig. 1). The project was carried out in conjunction with the Archaeological Superintendent's Office of Calabria, represented by Drs F. Prosperetti and A. Zaratinni, the Institute of Nautical Archaeology (INA), and Texas A&M University graduate student Dante Bartoli. Among the project's goals were to map and document known and newly-discovered sites. The structural remains of harbours as well as five deposits of architectural building-materials were located and recorded in the *c*.3-km Punta Scifo-Capo Colonna area (Fig. 2; Table 1). Three of these deposits were already known to the Superintendent's office. Although other sites were discovered and mapped in the overall survey area, this paper will focus only on the sites in the Punta Scifo-Capo Colonna area. The subsequent analysis of the harbours' locations, as well as their probable periods of operation in the context of the area's geological history, provides a new interpretative context for the building-material deposits. This study attempts to form hypotheses regarding the formation and deposition of these sites by taking into account the archaeological, geological, and historical evidence.

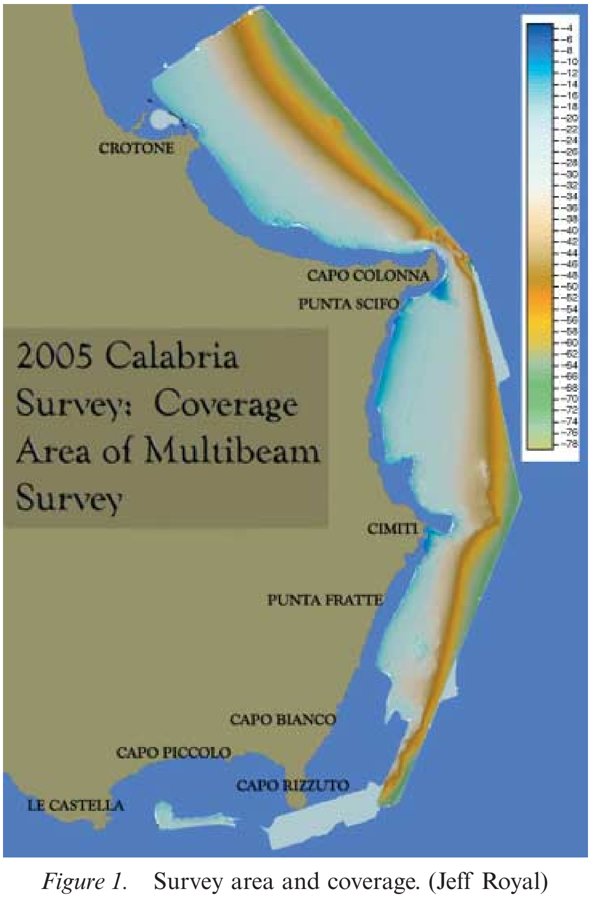

Figure 1. Survey area and coverage. (Jeff Royal)

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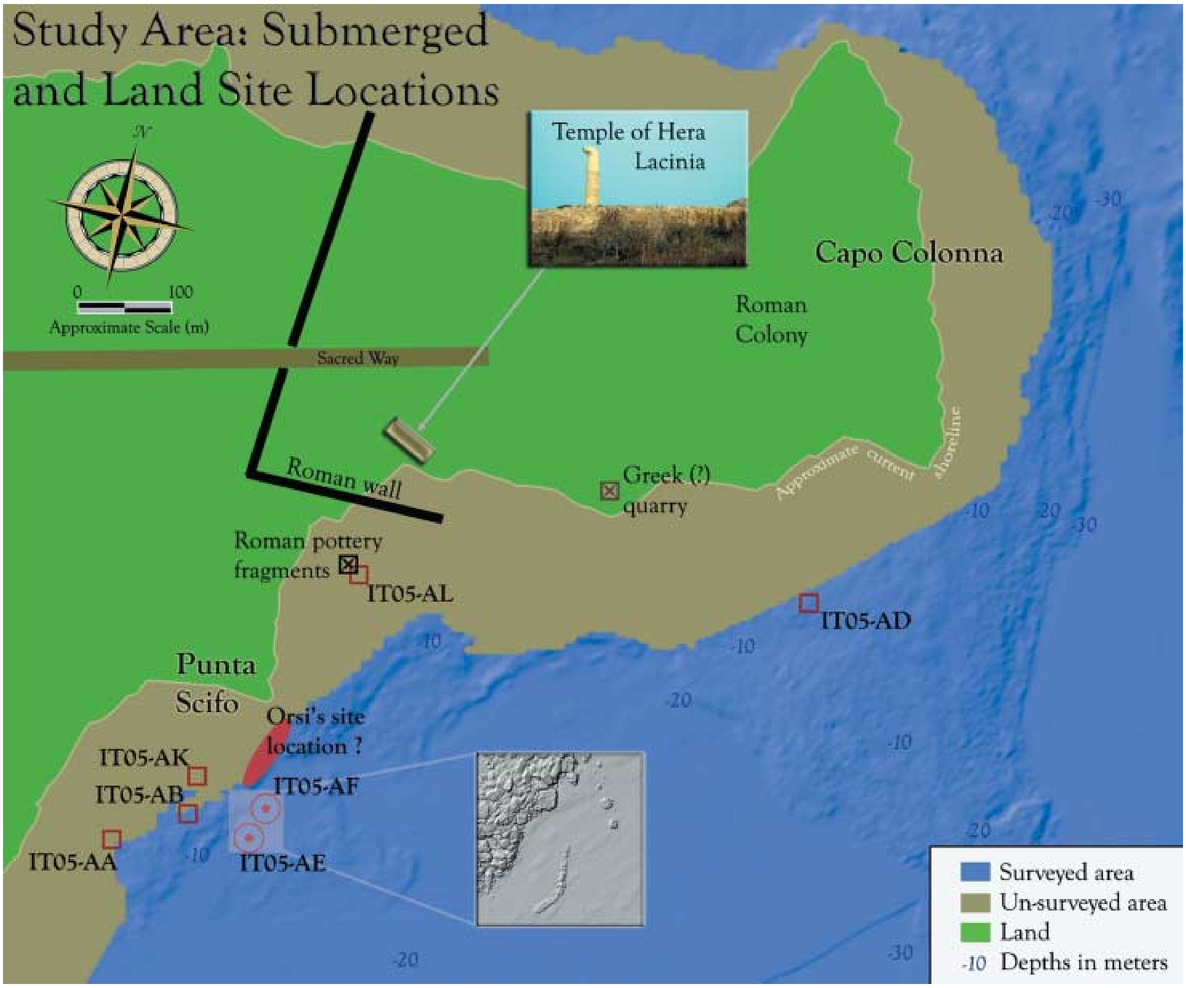

Figure 2. Site locations near Capo Colonna. (Jeff Royal)

Table 1. *Site characteristics (all measurements in metres)*

Site	Estd exposed length	Estd exposed width	Depth, base	Depth, top	Exposed height	Continues into sand
IT05-AA	10	8	–5	–4	1	yes
IT05-AB	23	17	–7	–5.5	1.5	yes
IT05-AD	32	19.5	–6.5	–5	1.5	yes
IT05-AE	42,	6	–12.5	–11	1.5	yes
IT05-AF	5 × 5	4 × 4	–13	–11	2	yes
IT05-AK	—	—	–3.5	–2.5	1	yes
IT05-AL	—	—	–3.5	–2.5	1	yes
Punta Scifo	50	50	–7	–6	1	—

Methodology

Multibeam survey was conducted by RPM Nautical Foundation's research vessels R/V *Hercules* and R/V *Juno*. The *Juno* surveyed from near shore to the 30-m contour, while the *Hercules* surveyed between the 30- and 60-m contours. Multibeam data was processed on board the *Hercules* and reviewed for potential sites, which were investigated by divers and a remote operated vehicle (ROV).

Figure 3. Marble columns, capitals, bases, and blocks from Orsi's site. (Jeff Royal)

The sites in this study were shallow and explored by divers, who employed hand-fanning and metal-detectors and recorded each site by taking photographs and sample measurements. Overall site measurements were obtained in the models derived from the multibeam data.

Previous archaeological investigations

Prior to the 2005 expedition there had been several surveys and excavations within the study area. One of the first formal expeditions was Paolo Orsi's excavation of a site off Punta Scifo in 1908, 1909, and 1915 (Orsi, 1921). This site was *c*.50 × 50 m, *c*.200 m offshore and 6–7 m deep. An estimated 150 tons of whole or broken marble objects were recovered from this large area, including basins, columns, blocks, stands, tables, and altars. Ship timbers were recorded among the marble objects, including oak and light-coloured planks with iron bolts and treenails connecting them to frames (Orsi, 1921: 493–4), construction characteristics typical of the Roman era. An inscription on one column, now in the Capo Colonna museum, places its manufacture at *c*.200 AD (Degrassi, 1952: 55–6). Much of the material from this find now decorates a roundabout in Crotone (Fig. 3).

About 7 km south of Capo Colonna is Capo Cimiti where, in 1959, a purported cargo of five columns was discovered less then 50 m offshore at a depth of *c*.8.5 m (Franciscis and Roghi, 1961). These were mapped and confirmed in our survey. Samples from the columns, which probably date to the Roman period, indicate that the marble is cipollino (Pensabene, 1978: 105). Pensabene also continued the study of the Punta Scifo finds when, in 1975, he catalogued Orsi's finds, housed in various local museums, and recorded numerous other marble objects still on the site (Pensabene, 1978). This revised catalogue provided more comprehensive descriptions for many pieces and confirmed Orsi's dating of the site. Over the following three decades, little systematic work was carried out in the area, although several large piles of blocks were widely known to rest near the shore. In 2003 Dante Bartoli brought this area to the attention of INA, and which led to this 2005 survey project. Although some sites were generally known to the Superintendent's Office and locally, there were no existing site-names, so each site was designated within the project's site numbering scheme to facilitate discussion and analysis.

Site IT05-AA

Located *c*.100 m from shore just south of Punta Scifo, a collection of stones lies at a depth of 5 m

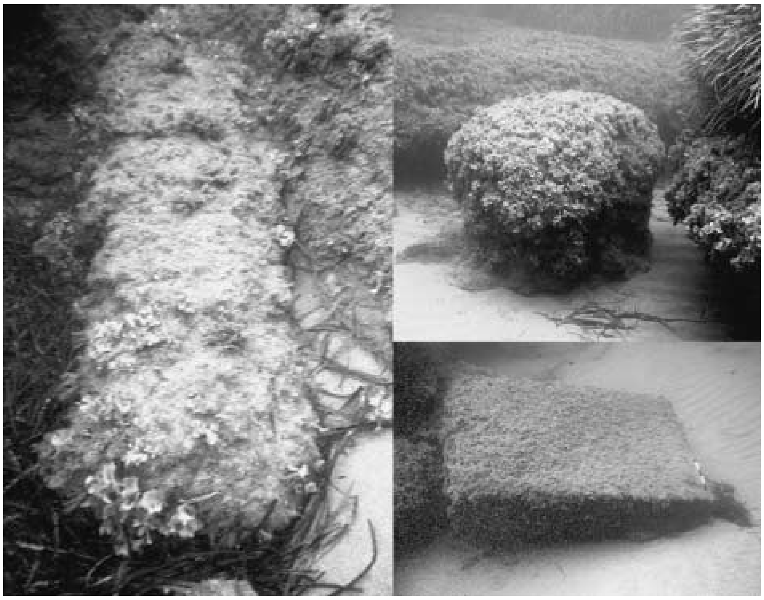

Figure 4. Site IT05-AA, left: column, upper right: mooring stone, lower right: block. (Dante Bartoli)

and reaches a maximum height of 1 m off the sea-floor. Scattered over a 100 m^2 area, this site has obviously undergone post-depositional human disturbance. At least five large rectangular blocks are visible (Fig. 4). Many of their edges are buried in the sand; hand-fanning indicated they extended down at least 0.5 m and other blocks may lie below, as additional stone was observed. Among the exposed material was a flat, square-shaped block, apparently of white marble, *c*.2.5 m along each side and 0.5 m thick. Other building-stones, also apparently white marble, included a column and blocks of varying shapes with roughly-worked surfaces; at least three of which were stacked upon one another. Small, *c*.3-cm-thick, fragments of polished marble, and Roman amphora fragments, were located around the larger blocks, though it is not clear whether these items are associated with the blocks or washed-in material collected between them.

An important object located at this site is an upright, well-carved stone bollard (Fig. 4), with a similar shape to one recently discovered at the Roman port at Pisa. Such bollards are associated with ancient port facilities and were typically situated on pier or wharf structures at *c*.0.5 to 1 m above sea-level. The top of this bollard is now 4 m below sea-level, which is *c*.2 m shallower than Orsi's Punta Scifo site that is dated to *c*.200 AD. Hence, a port facility incorporating this bollard would have operated in the Roman era based on relative sea-levels.

Site IT05-AB

Situated 180 m ENE of site IT05-AA is a deposit of large, presumably white marble, blocks that are 7.5 m deep; a depth analogous to Orsi's Punta Scifo site. Site IT05-AB comprises over 45 roughly-worked blocks covering an area *c*.23 ×17 m, rising 1.5 m off the sea-floor (Fig. 5). Hand-fanning around the site's perimeter indicated that the stones extend at least 0.5 m below the sea-floor. Hand-held metal-detectors were employed around the site with no results. Each of the blocks is large, most being 2–3 m long. Their shapes include square and flat (as at site IT05-AA), long and rectangular, and cuboid. Although degraded and covered with marine growth, they appear originally to have been dressed. They are piled upon one another up to five high in some areas, and some stacks have clearly tumbled (Fig. 6), though the tumbled blocks form no single directional pattern. Based on sample measurements of six of the stones and a specific gravity value of 2563 for marble, the minimum estimated weight of the exposed blocks is over 500 tons. If they are limestone, a specific gravity of 2611 would provide a similar tonnage (Table 2). This estimate would increase if the buried stones are accounted for as well.

Site IT05-AD

Another large deposit of apparent white marble blocks was mapped in the multibeam survey

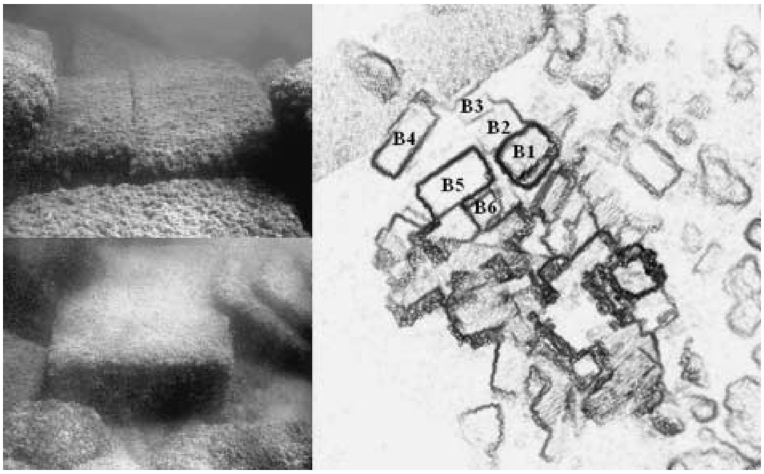

Figure 5. Site IT05-AB, upper and lower left: blocks, right: multibeam image of site with measured blocks referenced. (Jeff Royal)

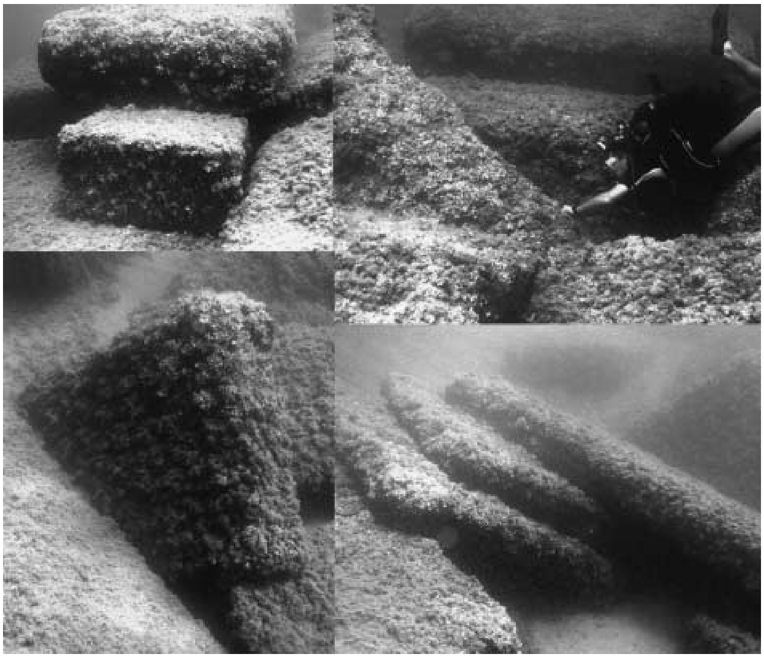

Figure 6. Site IT05-AB, lower left: block protruding from sand, upper left: large stacked blocks, upper right: large rectangular blocks, lower right: tumbled stack of blocks. (Jeff Royal)

c.150 m off the south side of Capo Colonna at a depth of 6.5 m. This rectangular site covering an area of *c*.32 × 20 m and rising to *c*.1.5 m off the sea-floor comprises at least 55 blocks (Fig. 7). Although not confirmed throughout due to the blocks being densely packed, many of those on the perimeter rest on rock with a shallow covering of sand. These blocks have similar dimensions, as well as a similarly-dressed shape, to those from site IT05-AB. However, some are comparatively much longer and narrower at over 6 × 1 m (Fig. 8). Many of the blocks have notches cut into their corners which probably facilitated lading onto a ship. Similar notches are found on the blocks from Orsi's Punta Scifo site. In some instances blocks were stacked up to six high, with some stacks having clearly tumbled to the south-east (Fig. 7). Based on sample measurements of six stones and the specific gravity of marble and limestone, the minimum estimated weight of the exposed blocks is *c*.500 tons, and there are unaccounted-for blocks at the centre of the pile (Table 2).

Table 2. *Measurements of selected blocks (figures in italics are estimes due to inability to access every face)*

Site	Block	Length (m)	Width (m)	Thickness (m)	Volume (m^3)	Wt if marble (mt)	Wt if limestone (mt)
IT05-AB	B1	2.1	2	1.54	6.47	16.58	16.89
	B2	2.55	1.8	0.34	1.56	4	4.07
	B3	*2.5*	1.85	0.38	*1.90*	*5*	*5*
	B4	4.08	1.41	*1*	*5.75*	*15.00*	*15.25*
	B5	3.92	1.97	*1*	*6.75*	*17.5*	*17.75*
	B6	2.66	1.19	1.22	3.86	9.9	10.08
					Total (mt)	67.98	69.05
					Total (st)	66.76	67.81
IT05-AD	B1	4.35	1.05	0.65	2.97	7.61	7.75
	B2	6.40	1.05	0.60	4.03	10.33	10.53
	B3	5.65	1.10	0.50	3.11	7.96	8.11
	B4	6.40	1.15	0.40	2.94	7.55	7.69
	B5	4.20	0.72	0.72	2.18	5.58	5.68
	B6	2.87	1.95	1.07	5.99	15.35	15.64
					Total (mt)	54.38	55.40
					Total (st)	53.41	54.41

Figure 7. Site IT05-AD, lower and upper left: tumbled stacks of blocks, right: multibeam image of site with measured blocks referenced. (Photos, Dante Bartoli; Image, Jeff Royal)

Sites IT05-AE/AF

These two heretofore unreported sites are described together as they appear to be related to one another, forming a single harbour (Fig. 9). They are located *c*.250 m offshore, 125 m east of site IT05-AB, at a depth of 12.5–13 m. Hand-fanning around both sites indicated that they extend for at least 0.5 m into the sand. Based on the visible structures, the harbour stretched at least 100 m from NE-SW, with a central entry from the south-east. Site IT05-AE is a 42-m long rock breakwater, 6 m wide at the sea-floor and rising 1.5 m above it. It has an obtuse chevron shape with straight sides and is aligned generally parallel to the shoreline. The entire structure is comprised of local stones, most less than 1 m long and not dressed (Fig. 10). Its shape, precise line, and uniformity of piled stones is unique to the area and clearly indicates the structure is man-made. Buried stones around site IT05-AE were located only adjacent to the structure and indicated that it continued to widen as it extended downwards; none were located away from it either inland or seaward.

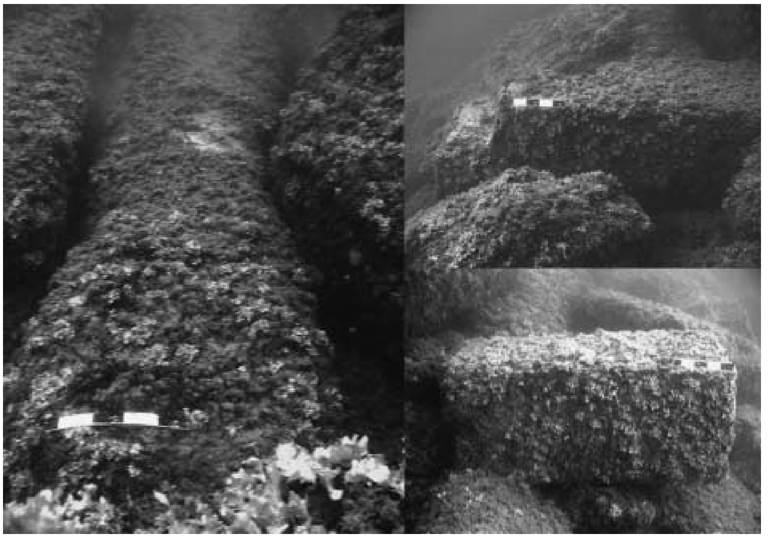

Figure 8. Site IT05-AD, left: long block, upper and lower right: large rectangular blocks. (Dante Bartoli)

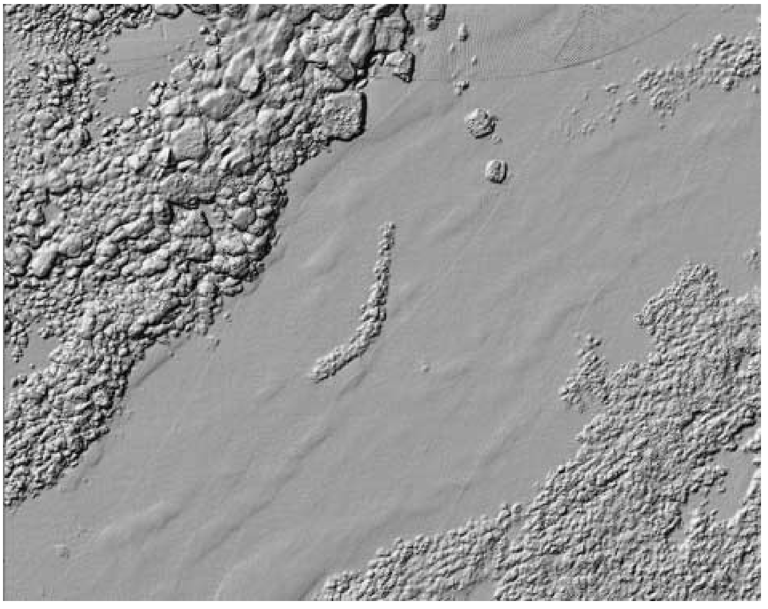

Figure 9. Multibeam image of ancient harbour structures; site IT05-AE is at centre with site IT05-AF to the NE. (George Robb and Jeff Royal)

Construction of many ancient breakwaters was accomplished by the piling up of uncut stones, sometimes upon natural features and filling the gaps between them. Piled-stone breakwaters were often quite high and, opposed to cut stone, are constructed with a sloping face which obliquely absorbs the wave force. For example, the 4th-century BC breakwater at Cnidus has large stones piled to a height of *c*.30 m, and the 7th-century BC breakwater at ancient Eretria consists of a rubble bank some 600 m long, extending from the surface to a depth of 20 m (Blackman, 1982: 196). A 300- × 50-m breakwater constructed of rough, piled stones is also found at the harbour of Apollonia, Israel, a site settled in the 6th–5th century BC (Grossman, 2001: 64–5, fig. 45). A breakwater's shape, height, and length are predominately determined by the prevailing local currents and winds. To be most effective, breakwaters are typically angled towards the direction of incoming waves. At Punta Scifo, only the south to east winds can produce hazardous

Figure 10. Lower and upper left: site IT05-AE, upper and lower right: one of the two block-shaped structures of site IT05-AF. (Jeff Royal)

wave conditions, as Capo Colonna provides protection from the north to north-east, and there is land in all other directions (Fig. 2). The harbour structures at site IT05-AE/AF are designed to provide protection from south and east wave action.

Site IT05-AF consists of two square-shaped structures, one 5 × 5 m and the other 4 × 4 m, each rising 2 m above the sea-floor. Direct examination indicated their flat faces are at 90° to one another; conspicuous in the local geological context. However, without removing the heavy growth of grass (not possible within the marine reserve) it is not possible to assess whether the faces are dressed or whether joints are present. These two square structures have the shape of piers typically found in harbours.

Breakwaters were often designed not to breach the water's surface but to allow waves to pass over the top. Overflow combined with breaks in the harbourworks produced a current which allowed silt to move through and out of the harbour. In other instances, breakwaters break the surface to reduce and/or absorb wave action. All the structures from both sites have upper surfaces with a level depth of 11 m. In order for them to have functioned effectively, their upper surfaces would need to have been above or just under the water's surface. Therefore, their construction date must fall within the period when relative sea-levels fit this condition. Undoubtedly, these structures have settled over time and have also lost material from their upper portions. For example, it was noted at Apollonia that erosion and water-movement had removed the upper surfaces (Grossman, 2001: 65). Additionally, stones from breakwaters were often robbed for construction material after they fell out of use. The problem of compaction and settling of breakwaters was particularly acute if they were not built on a solid foundation. An unstable base such as sand is also subject to erosive forces that lower the level of the breakwater over time (Blackman, 1982: 197). Thus it is reasonable to add an additional metre to the structures' current height to account for any settling or lost material. As such, an ancient relative sea-level of *c*.10 m below that of the present is required for these structures to have been viable. Considering their depth and their extension into the sea-floor, their construction must have taken place early in the history of the area. Taking into account the considerable depth difference between sites IT05-AE/AF and IT05-AA, where the latter's depth is *c*.5 m (shallower than Orsi's site dated to *c*.200 AD), a date earlier than the Roman period is suggested for the deeper sites IT05-AE/AF.

Sites IT05-AK and AL

These two sites were not within the multibeam survey area as at *c*.3 m they were too shallow for the research vessels. Each site's composition and location was reported by Dante Bartoli as part of a visual swim-survey inshore of the multibeam survey area. Both sites are comprised of several large, cut blocks buried in the sand, so their overall dimensions could not be ascertained. Excavation is required to determine the full extent and nature of these deposits, but the blocks were similar in appearance to those from sites IT05AA, AB, and AD. Mr Bartoli also reported that site IT05-AL had a concentration of Roman-period pottery fragments near the blocks.

Dating and context

Precise dating of stone remains is problematic without clearly-associated artefacts or inscriptions, such as that on one column at Orsi's Punta Scifo site, which provided a *terminus post quem* of *c*.200 AD. Test sondages and metal-detectors found no artefacts conclusively associated with the block sites to provide dating evidence. The few pottery fragments at IT05-AA were loose on the surface and not securely associated with the stones. Without absolute dating evidence or stratigraphic relationships with other artefacts, a general chronological analysis can be made through measurement-system and stylistic comparisons. Unfortunately, the large blocks and single, badly-encrusted column have no decoration to allow stylistic comparisons.

A general indication of the blocks' date of manufacture may be provided by comparing their dimensions to ancient measurement systems, and their overall shapes to blocks of known date. Of the known ancient measurement systems in the Mediterranean, the most closely related to the measured blocks at sites IT05-AA, AB, and AD are the Greek Doric, Attic, and Samian foot and the standard Roman foot. Given the blocks' rough surfaces due to heavy marine growth, a measurement was considered to match if its unit conversion was within 10% of its metric equivalent. Although only a full examination of each of the sites' blocks will elucidate this further, a Herculean effort as the blocks are large and buried, the initial indication is that these blocks are associated with either the Archaic Greek or the Roman period.

Further evidence is provided by comparison with the blocks found at the temple complex on Capo Colonna, specifically the Doric Temple of Hera (Juno) Lacinia, one of the most opulent in Magna Graecia; 'This temple, they said, was the most venerable shrine in that part of the world; neither Pyrrhus nor Hannibal had violated it' (Livy, XLII.5). It had a single row of pillars all the way round, 48 columns in total, with 19 on the long sides and seven on the short, and a roof covered with marble tiles. First erected in the late-8th–mid-7th century BC, it was rebuilt in the late-6th–early-5th century BC when it became the seat of the Italic League. The robbing of its roof in 179 BC resulted in its degradation by the Imperial period. Blocks from the submerged sites generally match the shapes and dimensions of those observed in the existing stylobate, stereobate, and foundations of the Archaic Greek remains on Capo Colonna, including the Temple of Hera. The long, rectangular blocks from site IT05-AD are of sufficient dimensions to have been used in the architrave of this temple. Considering that the submerged blocks have dimensions fitting the Archaic Greek measurement system, and that their overall shapes and dimensions are similar to those on the Archaic Greek temple complex on Capo Colonna, they were probably manufactured in this period and are associated with this Archaic Greek construction phase.

As with large stone blocks, it is extremely difficult to date breakwaters such as site IT05-AE/AF, as they are essentially a pile of rocks in an active maritime environment. Another difficulty is the determination of the breakwater's original height, and whether it was at or above sea-level. These dating problems also create difficulties in assessing the contextual relationships of the sites in the study area. Although the deposits of blocks and harbour structures are geographically close to one another, as they are to land sites, their contextual relationship is uncertain without some understanding of their approximate dates of construction and deposition.

Ancient sea-level data

The area's geological history, particularly sea-level and its change over time, is crucial to placing these sites in context and making preliminary assessments about the building-material and harbour sites. If sites IT05-AE/AF and IT05-AA possess harbour structures from the Archaic Greek and Roman periods respectively, the geological evidence must support a range of ancient sea-levels and rates of change which made the structures functionally viable during these periods. Data for sea-level changes is typically presented within a larger model in order to account for the many dynamic factors involved in an area's geological history. Geological models are inherently complex and the research for specific areas is often incomplete. Pirazzoli *et al.* (1997: 62) also warn that many sea-level models 'predict just one contribution to a possible range of processes that may control relative sea-level changes. Other possible contributions (e.g. eustatic changes, or impacts on sea-level from climatic or oceanographic origin) may have been neglected'.

Fortunately, there are several geological studies dealing with the Ionian coast of Calabria which have taken into account the multi-variate nature of changes in relative sea-level. Dr Jean-Daniel Stanley, Director of the Geoarchaeology-Global Change Program at the Smithsonian Institution, led a study off Caulonia where he cautiously estimated a 2-m submergence of land and a concomitant rise in eustatic sea-level of *c.*2 m since 500 BC (pers. comm. Feb and April 2006). Thus there has been a rise in relative sea-level of 4 m over the past 2500 years, an average rate of 1.6 mm per year. Stanley also notes that up to 6 m of sand was dumped in some areas along this section of coast during the 1980–90s, a situation that could indicate episodes of more rapid and sudden submergence that would increase the sediment flow into the sea. As this model is based on data from Caulonia, 100 km south-west of Capo Colonna, it provides a general set of conditions for the Ionian coast of Calabria which include subsidence and sand-accumulation.

Lambeck and Johnston (1995) formulated a model from work conducted in Calabria and Apulia that estimated rates of relative sea-level change of 0.65 mm/year since 2000 BP and 1.125 mm/year since 4000 BP. These rates take into account both subsidence and a *c.*2-m eustatic rise in sea-level since 500 BC, and result in an average rise of relative sea-level for the Ionian coast of Calabria of 1.63 m since 500 BC. Here again this model was not based on data gathered from the area of Capo Colonna, but rather serves as a broad model for all of southern Italy. Hence its conclusions are overly-general for analysis of the immediate Capo Colonna area.

As part of a natural gas survey partially sponsored by the AGIP company, Lena and Medaglia performed an ancient sea-level study in an area which included Crotone and Capo Colonna. Using satellite data from 1993–98, the average subsidence rate from the coastal area of Soverato in the south to around Castrovillari in the north was *c.*9 mm/year. However, for more elevated points, including Capo Colonna, the rate was *c.*12 mm/year (pers. comm. 2003). If this rate is extrapolated backward to 500 BC and combined with the eustatic sea-rise of *c.*2 m, the average rate of relative sea-level rise would be 12.8 mm/year at Capo Colonna. At this rate there would have been a relative sea-level rise of 32 m since 500 BC; an overly-rapid rise not supported by the geological record. Therefore the current rate of subsidence at Capo Colonna, greatly disparate to average rates for the larger coastal area, represents an episodic rapid rate of subsidence, but it does provide a quantifiable example for other periods of rapid subsidence rates experienced here.

Subsidence is also initiated by seismic activity, which can result in a sudden drop of geological formations and a consequent abrupt rise in relative sea-level. Capo Colonna is situated on the Calabria Arc, the southernmost end of the Apennine peninsular thrusts and folds chain. This eastern portion of Calabria includes formations with high earthquake potential which possess major active faults and evidence of centres of high-energy earthquakes. Historically, there have been over 25 large earthquakes since 91 BC between the Straits of Messina and Mount Pollino at the northern end of Calabria (Galli *et al.*, 2006). Generally, the earthquakes in Calabria over the past two millennia have been some of the most powerful and frequent in the Mediterranean. For example, the powerful earthquake of 1638 toppled the remaining columns of the Temple of Hera Lacinia leaving the single column that stands today.

Geological evidence indicates that the area around Capo Colonna is undergoing subsidence with episodes of especially rapid rates, and was subject to a concomitant rise in relative sea-level over the past 2500 years. The consequent effects can be noted by examining early maps of the area. Maps of Magna Graecia from 1700, 1703, 1720, and 1736 all depict two or more small islands off Capo Colonna. While the maps from 1700 and 1703 depict two islands, the more detailed maps from 1720 and 1736 show three additional small islands to the east. Although the assigned names of islands switched between maps, the names of the three largest on the later two maps are consistent: Calypsus, Ogygia, and Dioscorum. The 1736 map places these islands *c.*10 Roman miles (just over 14.5 km) offshore, and in a similar location as shown on the other maps. These islands do not appear on modern nautical charts of the area.

Data synthesis

The average rates of sea-level change in the Stanley and Lambeck-Johnston models place the harbour at site IT05-AE/AF at an appropriate depth, when relative sea-level was *c.*10 m lower, around 4250 and 12,380 BC respectively. These dates are far too early in the context of the archaeological data from the area to be feasible construction dates. Conversely, the average rate of sea-level rise extrapolated from the Lena-Medaglia data would place the port structures at a viable depth *c.*1200 AD. This is too late, as the rate would place the material from Orsi's Punta Scifo site, dated to *c.*200 AD, some 20 m above sea-level when deposited and not submerged until *c.*1550 AD. Such a date for Punta Scifo is untenable—valuable material would not have remained undisturbed on shore for over 13 centuries, and Roman-era ship timbers were found among the stone remains. Moreover, the marble objects possessed extensive marine degradation that required more than *c.*500 years to produce. This site was therefore formed in a submerged setting. Although the range from the three models, 12,380 BC–1200 AD, does encompass the Archaic Greek and Roman periods when the area was settled, it is too wide to assist in understanding the sites. However, examining benchmarks for sea-levels indicated by the archaeological evidence near Capo Colonna helps to narrow the range.

The bollard at site IT05-AA is *c.*200 m to the west of the harbour at site IT05-AE/AF, in a position directly between it and the shoreline. Orsi's Punta Scifo site was deposited in a submerged setting *c.*200 AD and now rests at a depth of *c.*7 m. As this site was near both the shore and the slightly-shallower bollard at site IT05-AA, it is probably associated with activity of a Roman-era harbour. A significant Roman presence in the area is indicated by the late-Republican *balneum* and peristyle structure which are undoubtedly associated with the founding of the Roman colony in 194 BC. Recent work by Ruga and Spadea indicates that the Roman colony founded at Croton was located on Capo Colonna and not the ancient Greek settlement site of Crotone. This Roman settlement grew through the 1st and 2nd centuries AD to have at least three main east-west roads and several cross-streets. Enclosed by walls with towers, this settlement featured houses, a *caupona* (inn), a *taberna* (shop), and a ceramics workshop (Ruga and Spadea, 2005). Capo Colonna also served as a source of building-stone, robbed and quarried during the Roman period, activities that would have required shipment by sea. Such robbing is recorded from an early period in the occupation, as when the marble roof tiles from the Temple of Hera (Juno) were taken:

> Ships were in readiness to take them on board and transport them, the local inhabitants being too much in awe of the censor's authority to prevent the sacrilege ... and when the vote was taken it was decided unanimously that a contract should be made for transporting the tiles back to the temple, and that offerings of atonement should be made to Juno. (Livy XLII.5)

Orsi's site and the harbour structure at site IT05-AA serve as benchmarks for sea-level, as the bollard must have rested above sea-level when in use, and the material from Orsi's site must have been deposited in the sea. If the depth of water when the deposition of Orsi's finds took place was *c.*1 m, which places the bollard 1 m above sea-level, the extrapolated average rate of sea-level rise over the past 1800 years would be 3.33 mm/year. This rate would place the top of the harbour at site IT05-AE/AF at sea-level about 3000 years ago or *c.*1000 BC. If the depth of Orsi's site deposition were *c.*2 m, the average rate would be 2.77 mm/year. This would place the top of the earlier harbour site at sea-level *c.*1600 BC. These rates are slightly higher than those of the Stanley's 1.60 mm/year, and much less than the 12.8 mm/year rate found in the Lena and Medaglia evidence for Capo Colonna. As the subsidence rate at Capo Colonna is greater than the average for Ionian Calabria in general, with periods of dramatic subsidence and frequent

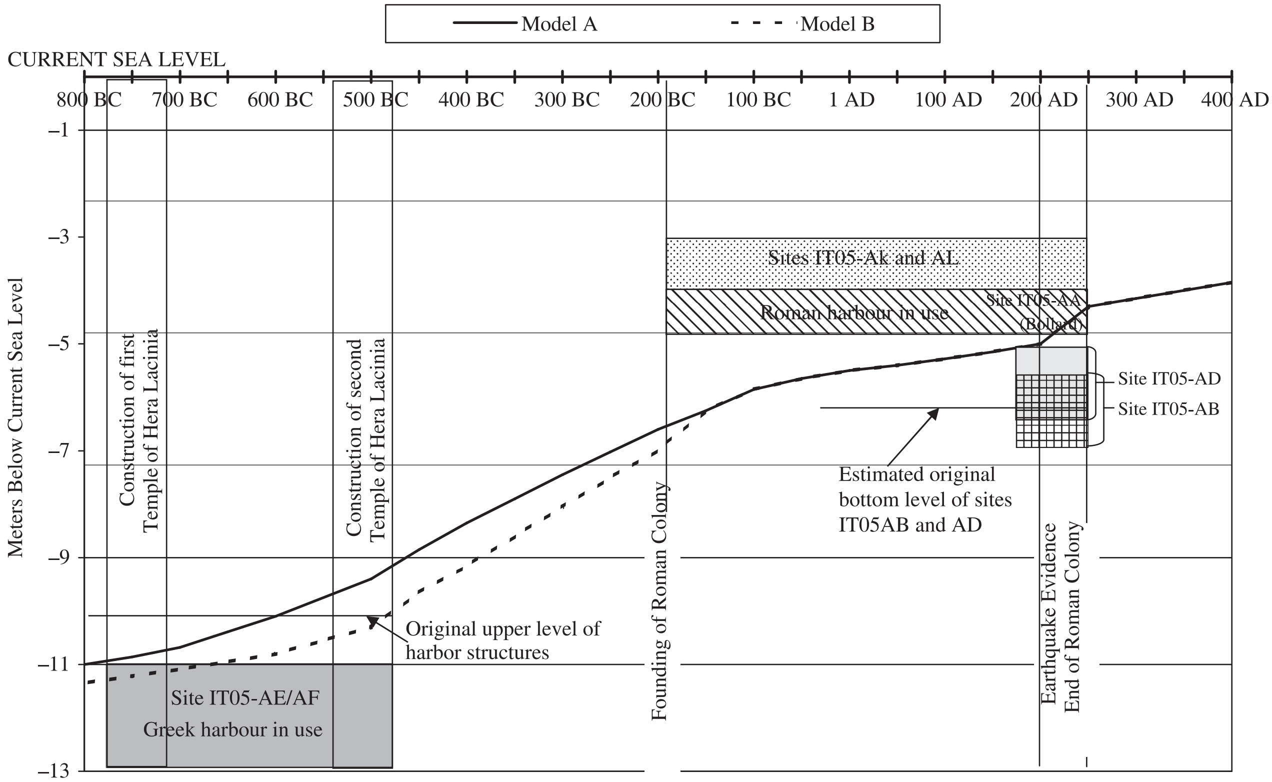

Figure 11. Submerged archaeological sites and hypothesized historical sea-level models at Capo Colonna-Punta Scifo. (Jeff Royal)

seismic activity, an average rate of more than 3.33 mm/year is likely to have occurred over the past two millennia.

Consequently, periods of rapid subsidence prior to the Roman period would make the date for the harbour at site IT05-AE/AF later than the 1000–1600 BC range. The only evident *terminus post quem* for the harbour at site IT05-AE/AF based on the area's settlement history is the earliest occupation period in the immediate area during which known shipping occurred that necessitated harbour facilities: the Greek settlement at the end of the 8th to the middle of the 7th centuries BC. This date would necessitate a rate of 5.71 mm/yr over the *c.*700 years prior to the Roman era, and an overall rate of 3.70 mm/yr over the 2700-year period; rates certainly supportable by the geological evidence. At this time, the major phase of construction in the vicinity included the Greek town of Crotone and the associated temple complex on Capo Colonna. Construction probably continued through the late-6th to early-5th centuries BC when a new temple and associated buildings were erected. A port built at Punta Scifo was logistically logical given the importation of materials required for construction on Capo Colonna, as it is much closer than Crotone's port, a crucial factor when shipping large stone, and is in a naturally protected area.

The separate factors of an eustatic rise in sea-level of 2 m since 500 BC, continued subsidence of Calabria's Ionian coastline, episodes of rapid subsidence at Capo Colonna, and archaeological benchmarks for sea-level, are all accounted for in the hypothetical sea-level models A and B (Fig. 11). Model A assumes the harbour at site IT05-AE/AF was built during the earliest Greek occupation, and the bollard at site IT05-AA was part of a Roman-era harbour. Model B reflects the less-likely possibility that the Greek harbour was built in association with the later rebuilding of the Temple of Hera Licinia. Both models maintain rates of sea-level change supported by the geological studies and bring into accord the archaeological and geological evidence. Using these models, it is then possible to postulate the depositional context of the building-material sites.

Assessment of building-material sites

Each of the three sites IT05-AA, AB, and AD are similarly comprised of large blocks (site IT05-AA alone possesses a column) which are certainly architectural building-materials. The blocks at each site appear to have been stacked and subsequently tumbled, and were not recovered in later periods. The depths of these sites compared to sea-level models A and B indicate that each site was deposited in the sea, consistent with their remaining un-recovered and the extensive marine degradation. Each deposit may have been formed by several different events: a collapsed structure, a shipwreck, or lading/unlading activities. A close examination of each site's composition, size, and morphology can aide in determining which of these events most likely formed these sites.

If these sites were structures which subsequently collapsed, they were presumably constructed at, or above, sea-level. Although the stone blocks are similarly-shaped to those on the temple complex on Capo Colonna, three of these building-material sites are located near the harbour structures at Punta Scifo; sites IT05-AD and AL are closer to Capo Colonna. Based on sea-level models A and B, sites IT05-AB and AD would have been on land from the Greek period until the Roman Republican era, site IT05-AA until the Roman Imperial era, and sites IT05-AK and AL until Late Antiquity. If the three sites near Punta Scifo were part of submerged harbour structures, their depths indicate a Roman date; ashlar harbour structures were less common in Roman harbour construction as concrete was preferred. Without columns, capitals, or bases present at site IT05-AB, and given the fact that the blocks match those from the Temple of Hera, although not in a similar configuration, it is unlikely that this was a structure erected at Punta Scifo. Site IT05-AA alone has a single column present, but does not have the immediate appearance of a collapsed structure. Sites IT05-AK and AL will require excavation to conclusively establish this possibility.

Site IT05-AD is adjacent to the southern edge of Capo Colonna and in line with the Roman wall that surrounded the *temenos* built in the 1st century BC (Fig. 2). This wall was *c*.2 m thick and constructed of large blocks in *opus quadratum* and *reticulatum*, some of which were robbed from the temple complex (Ruga and Spadea, 2005). The destruction layer of Roman buildings on Capo Colonna appears both abrupt and massive, and included both buildings and the surrounding wall. Walls sections, columns, arches, and other structural elements lie directly on the pavement where they remained. Pottery fragments and coins trapped under this layer indicate a *terminus ante quem* of the second half of the 3rd century AD. The evidence suggests a powerful earthquake with a local epicentre. After the destruction of the colony by this earthquake, Roman occupation ended (Galli *et al*., 2006). The Roman wall was found collapsed to the south by the strong horizontal earthquake forces (Ruga and Spadea, 2005). Site IT05-AD is located near the area of the southern portion of this wall, and, therefore, is possibly associated with the collapse of defensive structures. It is also possible these blocks were piled up during the robbing of stones and toppled in an earthquake. In either case, the majority of the stones from a tumble that settled in the sea were probably never recovered as there was available stone on land.

Despite sites IT05-AA, AB, and AD not being excavated, it is possible to determine their likelihood of being a series of shipwreck sites clustered in this area. Typically, the cargoes are the primary surviving artefact for stone-carriers deposited in shallow waters. For 25 suggested wreck-sites of stone-carriers where ship timber remains were addressed, 11 reported no surviving hull timbers, seven reports did not mention surviving timbers, although it was not specifically indicated that timbers were absent, and seven sites reported timbers present (Table 3). Hence these shipwreck sites can be compared to the building-material deposits at Punta Scifo-Capo Colonna in their dimensions, estimated cargo weights, and stowage patterns.

The depositional pattern of the stone cargo in the vast majority of stone-carrier shipwreck-sites had an oblong shape, with the sites' long axes measuring approximately twice their width. The lengths of the sites were often reported to be *c*.30 m (Table 3), such as the Torre Sgarrata (Throckmorton, 1989), Marzamemi A (Kapitän, 1969), and Methone C wreck-sites (Throckmorton, 1965), while the Isola della Corenti wreck-site was reported to be 45 m long (Kapitän, 1961). However, these estimates represent the reconstructed size of the vessels, whereas the sizes of the stone cargo deposits were about half the estimated vessel lengths. For example, examination of the site-plan for the Torra Sgarrata wreck-site, estimated to have been 30 m long, indicates its cargo of 42 blocks covered an area *c*.16 × 14 m

Table 3. *Stone-Carrier Wrecksites*

Wrecksite	Date (AD)	Site Location	Cargo Origin	Primary Cargo	Site L	Site B	Appr. Depth	Est. deposited depth	
								SL-2	SL-4
Capo Granitola A	*c.*225–275	Sicily	Italy, Greece, Asia Minor	Yes	30	15	–3.0	–1.0	1.0
Capo Granitola D	3rd–4th	Sicily	Asia Minor?	Yes	—	—	—	—	—
Capo Taormina	2nd	Sicily	N. Africa	Yes	—	—	–25.0	–23.0	–21.0
Carry-le-Rouet	1st BC	Harbor, S. France	S. France	Yes	10	—	–6.0	–4.0	–2.0
Cimiti	Roman	Capo Rizzuto, Italy	Greece	Yes	12	6	–8.5	–6.5	–4.5
Dramont A	Roman	S. France	—	Yes	—	—	–30.0	–28.0	–26.0
Isola della Correnti	3rd–4th	Sicily	Asia Minor?	Yes	40–48	12–13	–8.0	–6.0	–4.0
Izmetište	2nd	Croatia	Adriatic	Yes	8	6	—	—	—
Kizilburun	2nd/1st BC	SW Turkey	Thrace	Yes	20	8	–47.0	–45.0	–43.0
Mahdia	110–90 BC	Tunisia	Attica	Yes	26	—	40.0	42.0	44.0
Margarina	Rmn Imp	Croatia	—	Yes	—	—	—	—	—
Marzamemi A	*c.*200–250	Marzamemi, Sicily	Attica	Yes	30	8–9	–7.0	–5.0	–3.0
Marzamemi B	*c.*500–540	Marzamemi, Sicily	Thrace	?	—	—	–7.0	–5.0	–3.0
Methone C	*c.*200–250	Greece	Egypt?	Yes	30	20	–9.0	–7.0	–5.0
Naxos Bay	3rd	Naxos, Sicily	Euboea	Yes	17	9	–24.0	–22.0	–20.0
Porto Novo	1st	SE Corsica	Tuscany	Yes	15	7	–11.0	–9.0	–7.0
Punta del Milagro	Roman	Tarragona, Spain	—	Yes	—	—	—	—	—
Punta Scifo	*c.*200	Punta Scifo, Italy	Phrygia	Yes	50	50	–5.0	–3.0	–1.0
Salakta	ea. 3rd-mod	Tunisia	—	Yes	—	—	–5.0	–3.0	–1.0
San Pietro	ea. 3rd	Apulia, Italy	Thrace	Yes	—	—	–4.0	–2.0	0.0
Sapientza	Roman	Sapientza Is., Greece	—	Yes	—	—	–7.0	–5.0	–3.0
Şile	100–125	Turkey-Black Sea	Asia Minor	Yes			–6.0	–4.0	–2.0
St. Tropez A	2nd	S. France	Tuscany	Yes	—	—	–6.0	–4.0	–2.0
Torre Chianca	Mid. 3rd	Apulia, Italy	Euboea	Yes	—	—	–6.0	–4.0	–2.0
Torre Sgarrata	*c.*180–205	SE of Taranto, Italy	Thasos; Asia Minor	Yes	16	14	–11.0	–9.0	–7.0
IT05-AA	Roman	Punta Scifo, Italy	?	Yes	10	8	–5.0	–3.0	–1.0
IT05-AB	Roman	Punta Scifo, Italy	?	Yes	23	17	–7.0	–5.0	–3.0
IT05-AD	Roman	Capo Colonna, Italy	?	Yes	32	19.5	–6.5	–4.5	–2.5

(Throckmorton, 1989: 263, 269). Likewise, while the vessel at the Porto Novo wreck-site was estimated at 25 m long, its cargo of 9 large stone blocks covered an area of *c.*15 × 7 m (Bernard *et al.*, 1997: 53–5). These similar dimensions in sites, of *c.*15 m long, are inherently logical considering the constraints of shipping heavy stone in wooden ships, and that 30–40-m-long ships were large in the Roman period.

The construction materials and methods of Roman-era ships also limited their tonnage capacity. A review of these known stone-carriers provides a typical tonnage range for cargoes of building-materials and other stone on Roman-era ships. The estimated weight of stone cargoes from 17 purported wreck-sites ranges from 24 to 350 tons, with 15 of the 17 wreck-sites having 250 tons or less of stone present (Table 3). For the seven sites where ship timber remains were located, the estimated cargoes range from 24 to 250 tons. This is a reasonable tonnage range as a cargo of over 300 tons was substantial in the Roman era and would have required one of the largest ships constructed. Likewise, a review of stone cargo wreck-sites by Bernard *et al.* (1997: 54–5) indicated that average cargos were between 90 and 200 tons, and a cargo of over 250 tons was considered very large, for example the Porto Novo vessel that carried 138 tons of marble yet was estimated to be 25 m long.

Another common characteristic found in this sample of wreck-sites is that there are rarely instances of large blocks being stacked, and when this occurred it was only two blocks. Minimal stacking was a practical consideration as excessive stacking of heavy stone blocks would have made vessels unstable and produced undue point loads on the interior of their hulls. Furthermore, the orientations of the stone blocks at these wreck-sites were largely consistent. At sites where rectangular blocks were present, the long axes of the blocks ran parallel to the overall long axis of

Table 3. *Continued*

Wrecksite	App. Tons	Primary Material	Type(s)/ Origin(s)	Architectural Elements	No. of Elements	Hull Rem	Reference
Capo Granitola A	150	Marble	Proconnesian	M Blocks; *c.*3 × 1 × 1 —trapazoidal	60	—	Purpura, 1977
Capo Granitola D	—	Marble	White	Corinthian and Ionic columns	—	—	Purpura, 1983
Capo Taormina	100	Marble	Green	Columns, blocks	37, ?	—	Kapitän, 1961
Carry-le-Rouet	24	Lm	Local	Blocks	24	X	Kainic, 1986
Cimiti	100	Marble	Cipollino	Colunms; 8.5L × 0.9D	5	—	Franciscis and Roghi, 1961
Dramont A	—	Stone	?	Blocks, *c.*4 × 1 × 1	—	?	Santamaria, 1965, 1975
Isola della Correnti	350	Marble	White	Blocks	—	—	Kapitän, 1961
Izmetište	—	Gran/Lm	Adriatic	Blocks	9	—	Jurišić, 2000
Kizilburun	75	Marble	Proconnesian	Columns, capital, blocks, stelai, louteria	8, 1, 15+, 6, 2	X	Carlson, 2006
Mahdia	250	Marble	Hymettan/ Pentelic	Columns, bases, capitals; decorative	70	X	Taylor, 1965; Hellenkemper-Salies, 1994
Margarina	—	Marble	?	Columns, blocks	11, ?	?	Vrsalović, D., 1976
Marzamemi A	170	Marble	Hymettian	Columns, Bases, other; 172 tn M	5; 3; 7	—	Kapitän, 1961
Marzamemi B	—	Marble	Proconnesian	Basilica elements—columns, etc	—	?	Kapitän, 1961, 1969
Methone C	132	Marble	?	Column frags	26	—	Throckmorton, 1965
Naxos Bay	95	Marble	Cipollino	Columns, blocks, other	24, 13, 2	—	Basile, 1988
Porto Novo	138	Marble	Carrare (Luna)	Column sections, blocks	4, 5	—	Bernard, *et al.*, 1997
Punta del Milagro	—	Stone?	?	Column drums	—	?	Ripoll, 1961
Punta Scifo	200	Marble	Pavonazzetto	Basins, stands, columns, blocks, altars	5, 5, 8, 2, 2	X	Orsi, 1921
Salakta	—	Marble	?	Architrave and pilaster parts	—	X	Parker, 1992
San Pietro	150	Marble	Proconnesian	Sarcophagi and sarcophagi blanks	23	X	Ward-Perkins and Throckmorton, 1965
Sapientza	300	Marble	White/Gray	Blocks	—	?	Parker, 1992
Şile	—	Marble	Proc/Breccia	Sculpture; column elements, blocks, plaque	6; 8, 3, 1	?	Beykan, 1988
St. Tropez A	230	Marble	Carrare (Luna)	Column drums, bases, slab, architrave	12	—	Benoit, 1952
Torre Chianca	120	Marble	Cipollino	Columns	5	?	Parker, 1992
Torre Sgarrata	160	Marble	White, alabaster	Sarcophagi; Blocks; Column, other	18; 23; 1, 2	X	Throckmorton, 1989
IT05-AA	*c.*50	Marble?	?	Blocks, column	*c.*10	?	
IT05-AB	500+	Marble?	?	Blocks	*c.*45	?	
IT05-AD	500+	Marble?	?	Blocks	*c.*55	?	

the site, and so parallel to the ship's long axis. This is also a result of practical stowage considerations, as when aligned along the ship's long axis rather than along its beam it ensured large rectangular blocks rested flush on their seating material and low in the ship's hold.

The building materials at sites IT05-AA, AB, and AD do not compare favourably with this sample of stone-carrier wreck-sites in size, tonnage, stacking-pattern, or orientation. The substantial sand cover at sites IT05-AK and AL makes the overall size and shape, as well as stacking pattern, difficult to assess without excavation. Site IT05-AA is relatively small in overall size and tonnage, within the range of known wreck-sites; but it is irregularly shaped and the blocks are stacked at least three high. Although most of the exposed material could conceivably comprise a ship's cargo, the bollard present is an altogether unlikely cargo item. Sites IT05-AB and AD are much larger than known stone cargoes, 23 × 17 m and 32 × 20 m respectively, and had a much greater total number of blocks compared to the sample of wreck-sites. Each of these sites has at least 500 tons of block present, which is significantly greater than the largest of the cargoes in the sample of wreck-sites. The size of the ships needed to carry greater than 500-ton cargoes would be at least an extraordinary 55–60 m long. The blocks also have a random orientation with no indication of a lading system as observed in known wreck-sites. Moreover, both these sites exhibit blocks stacked up to five high, far greater than any known wreck-site. Such stacking would be a highly unlikely stowage arrangement for large blocks. If future evidence were to determine these were shipwreck sites, the sheer size of the vessels required to carry these tremendous cargoes would make these unusual sites very interesting indeed.

The large blocks at sites IT05-AA, AB and AD were unlikely to have been formed by intentional dumping, as they were obviously stacked and subsequently toppled, and they are much too large to dump as a group. However, a deposit formed by lading activity would have the appearance exhibited by each of these building-material sites, particularly if disturbed by a powerful disruptive force. Blocks ready for lading were undoubtedly stacked so as to facilitate their lifting and lading aboard ships, as well as to conserve space in the limited work-areas found at harbours. At some point these stacked blocks toppled. An extremely large wave would have toppled them towards shore, which they are not. If these piles of blocks were disturbed by seismic events common in this area and tumbled into the sea, they would produce the deposits observed at these sites. The only known event in the Roman era that would topple these stacked blocks was the earthquake at the first half of the 3rd century AD. Some blocks stacked on the shore or piers would undoubtedly have fallen into the water and made recovery difficult. Conversely, the building materials which remained on land could be recovered with relative ease, as took place on Capo Colonna in the Roman era. The robbing of stone from earlier buildings was common throughout the Roman era, not only for the construction of the Roman colony (Ruga and Spadea, 2005), but for export to other construction sites. For example, as noted earlier, when the marble roof tiles from the Temple of Hera were removed in 173 BC by the censor Quintus Fulvius Flaccus, who was erecting a temple to Fortuna Equestris. As the Senate felt a sacrilege was committed on a functioning temple, the tiles were shipped back to Capo Colonna and deposited in the courtyard (Livy XLII.5).

Conclusions

Based on the archaeological and geological evidence, a preliminary hypothesis can be formed which takes into account all the finds in the Punta Scifo-Capo Colonna area. The early Greek colonization period at Crotone began during the 8th to early-7th century BC. Over the next several centuries the promontory of Capo Colonna was transformed into a complex of sacred buildings, highlighted by the two phases of construction at the temple of Hera Lacinia. As the temple complex rose in prominence through the 5th century BC, the demand for building-stone for the temple complex remained high. In order to facilitate the shipping of heavy stone for this complex a port was needed; large blocks can be transported more economically and efficiently by sea than by land. Considering that Crotone's harbour was 8 km distant, a harbour built at Punta Scifo (site IT05-AE/AF) to facilitate this construction on Capo Colonna was both economically and logistically warranted; this being the closest point for a protected harbour.

The coastline around Capo Colonna, along with much of the Ionian coast of Calabria, is both descending and seismically active. The rate of subsidence is variable over time, and was probably relatively slow during the early Greek colonial period when the harbour was operational. At the beginning of the 4th century BC mercenary garrisons of Dionysius of Syracuse occupied the temple area and it is unlikely they maintained the port, which allowed it to silt up. Survey indicated no subsequent construction or remains of other harbour structures successively progressing coastward until the Roman-period evidence. The rate of subsidence in the Roman era allowed harbour facilities to function without excessive silting, attested by the bollard at site IT05-AA. This Roman-era port was *c*.300 m further inland from, and over 7 m above, the Greek-era harbour structures. The values of, and changes in, relative sea-level necessary to have made the Greek and Roman harbours structures viable is possible given the time between them and the geological evidence for the Punta Scifo-Capo Colonna area. A Roman-era port would have allowed the shipping of supplies and construction materials directly to the colony, goods to be shipped out, and the loading of building-materials robbed from the temple complex on Capo Colonna. The robbing of building-material for construction in the Roman colony must have began shortly after its founding in 197 BC, while the exporting of building material from Capo Colonna is first attested in 179 BC. Material gathered for lading operations at a port would explain the mix of architectural materials at site IT05-AA associated with the bollard. Such activities may also explain some of the finds at Orsi's Punta Scifo site formed during the Roman era.

The block deposits at sites IT05-AB and AD were also formed during the Roman era, because sea-levels during the operation of the earlier harbour would place these sites 4 m above sea-level, and it is unlikely such a substantial quantity of valuable material remained untouched for centuries. A relative sea-level during the 2nd to 3rd centuries AD places the upper surfaces of these sites around sea-level. As the blocks from these two sites match those from the temple complex on Capo Colonna, they were probably robbed materials stacked for eventual lading onto ships. Site IT05-AD is not within the harbour area and may have been either a staging area directly off of Capo Colonna for lading a vessel or associated with the collapsed remains of the Roman colony's outer defensive works. The block stacks at both sites IT05-AB and AD were clearly subjected to a violent force that toppled them in several directions where they have remained untouched. Hence, they were probably formed in the early 3rd century AD when they were toppled by an earthquake.

The great quantity of building and decorative materials from all of the submerged sites in the Punta Scifo-Capo Colonna area was not appropriated in subsequent periods. Such materials would have warranted salvage, particularly considering the subsequent activity in the area by the Ostrogoths, Byzantines, Normans, and Spanish. The subsidence rates alone do not explain their attaining sufficient depth to deter salvage attempts. However, the seismic activity that toppled the structures on the Roman colony could have dumped materials into the sea and resulted in rapid sudden submergence. This event would have also submerged the Roman-era harbour structures and ended the facility's useful life, making the clearing of material in the harbour area redundant.

The interpretation of Orsi's finds near Punta Scifo as a single shipwreck site is also questionable given the contextual evidence. The site at 50 × 50 m is quite large when compared to other known stone-carrier wreck-sites, and such a wide scatter of heavy objects seems unlikely if originating in a ship's hold. The fragments of ship timbers dispersed amongst debris do not necessarily indicate that this site was formed by a single ship-wreck. Such a wide scatter of objects and the accumulation of fragmentary ship timbers are more typically attributed to debris associated with harbour activity and numerous ship mishaps, such as that during the Roman occupation.

The hypotheses presented in this paper are only preliminary and are offered to serve as a basis from which to conduct further studies. Each of the sites requires excavation and subsequent material analyses to gain a better understanding of their formation. Under the stewardship of Drs Prosperetti and Zaratinni, areas such as these sites off Punta Scifo-Capo Colonna are now receiving appropriate attention and study. It is hoped that they will be able to continue their work and develop a programme for studying this area. It is also hoped that Dante Bartoli's continued work in the area will provide new data.

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