Gardiner, A. H., 1947, *Ancient Egyptian Onomastica I*. Oxford.
Goddio, F., 2007, *Underwater Archaeology in the Canopic Region in Egypt: the topography and excavation of Heracleion-Thonis and East Canopus (1996–2006)*. Oxford.
Goddio, F. and Bernand, A., 2004, *Sunken Egypt (Alexandria)*. London.
Helck, W., 1980, Meer, *Lexikon Der Ägyptologie III*, 1276–1277. Wiesbaden.
Holloway, R. R., 2006, The Tomb of the Diver, *American Journal of Archaeoogy* **110**.3, 365–88.
Kanawati, N., 1999, *The Tomb and its Significance in Ancient Egypt*. Guizeh.
Kapitän, G., 1984, Ancient anchors—technology and classification, *The International Journal of Nautical Archaeology* **13**.1, 33–44.
Lichtheim, M., 1976, in *Ancient Egyptian Literature, II*, 214–23. London.
Newberry, P. E., 1893, *Beni Hasan, I*. London.
Nibbi, A., 1991, Five stone anchors from Alexandria, *The International Journal of Nautical Archaeology* **20**.3, 185–94.
Nibbi, A., 1992, A group of stone anchors from Mirgissa on the upper Nile, *The International Journal of Nautical Archaeology* **21**.3, 259–67.
Sahrhage, D., 1998, Fischfang und Fischkult im alten Ägypten, in *Kulturgeschichte der Antiken Welt, Band 70*. Mainz.
Vandier, J., 1950, MO'ALLA: La Tombe d'Ankhtifi et La Tombe de Sébekhotep, *Bulletin d'Egyptologie* **18**, 143–4.
Van Elsbergen, M. J., 1997, *Fischerei im Alten Ägypten, Untersuchungen zu den Fischfangdarstellungen in den Gräbern der 4 bis 3 Dynastie*. Berlin.
Winlock, H. E., 1932, The Egyptian Expedition 1930–1931, *Bulletin of the Metropolitan Museum of Art*, section 2, March 1932, 1–37.
Wolf, W., 1957, *Die Kunst Aegyptens, Gestalt und geschichte*. Stuttgart.

New Evidence for Old Sites: a response to the 'reassessment' of the survey data from Capo Colonna, Italy

This response to the 'reappraisal' by Bartoli (2010) of the author's original paper in this journal (2008) requires only a brief note. The subject of the discussion is the interpretation of stone formations discovered during one of RPM Nautical Foundation's (RPMNF) surveys in Calabria, Italy. Over the past five years, Dr Jean-Daniel Stanley, Senior Oceanographer and Director of the Deltas-Global Change Program, Smithsonian Institute, has conducted detailed geological research along the central Calabrian coast, including the Capo Colonna area. His team's conclusions (Stanley *et al.*, 2011) independently support the significant extent of coastal subduction and consequent relative sea-level rise around Capo Colonna which was put forward in the author's 2008 article, as well as high levels of sedimentation build-up and seismic activity for this zone (see also Van Dijk, 1991; Zecchin *et al.*, 2003). Consequently, the ideas offered in Bartoli's reappraisal, as well as his dissertation (2008), are rendered moot, and a point-by-point rebuttal is unnecessary. The argument for numerous stone-carrier shipwrecks at Capo Colonna relied on an interpretation of data, including a reappraisal of that offered by the author, which did not take into account a rise in relative sea-level.

However, a number of particularly substantial errors in Bartoli's article are now in print and warrant clarification and elucidation. Foremost among these inaccuracies is Bartoli's misstatement (2010: 400) that multibeam sonar provides 'only 2-dimensional images, and cannot indicate the height or depth of objects'. Multibeam sonar technology was specifically developed and is now extensively used throughout the maritime industry in hydrographic and geophysical survey because it produces 3-D models of the sea-floor. (For an analytical introduction to multibeam sonar and its uses see Hughes Clarke *et al.*, 1996; Lurton, 2002; Le Bas and Huvenne, 2009). Note in Figs 1–4 the 3-D models and height/depth profiles for selected features near Capo Colonna (the images are of 3-D sea-floor models produced in CARIS HIPS/SIPS and/or IVS3-D's Fledermaus software; no z exaggeration was applied for any image. Initially, published images were derived from the data processed through Surfer 8.0 software, which does not provide the visualization options available in CARIS and IVS software; this software was acquired subsequent to the 2005 season when the data was gathered and all the survey data was recently re-processed to assist in geological analysis for Stanley's research project).

It is understandable that confusion can occur when a researcher is working with data-sets when he has had no involvement in their collection, processing, or analysis. Figures in Bartoli's reappraisal (2010, figs 2–3, 5) were among images produced and provided by RPMNF; these images are plan views of small sectors of the 3-D sea-floor model, as they better communicate spatial reference, yet appear 2-dimensional. For the author's original analysis, 3-D models of stacked stone deposits were used in conjunction with scaled photos and direct tape measurements taken to ascertain dimensional estimates of both individual stones and their stacked formations (Figs 2–3). It should be noted that measurements of stones taken within 3-D analytical software

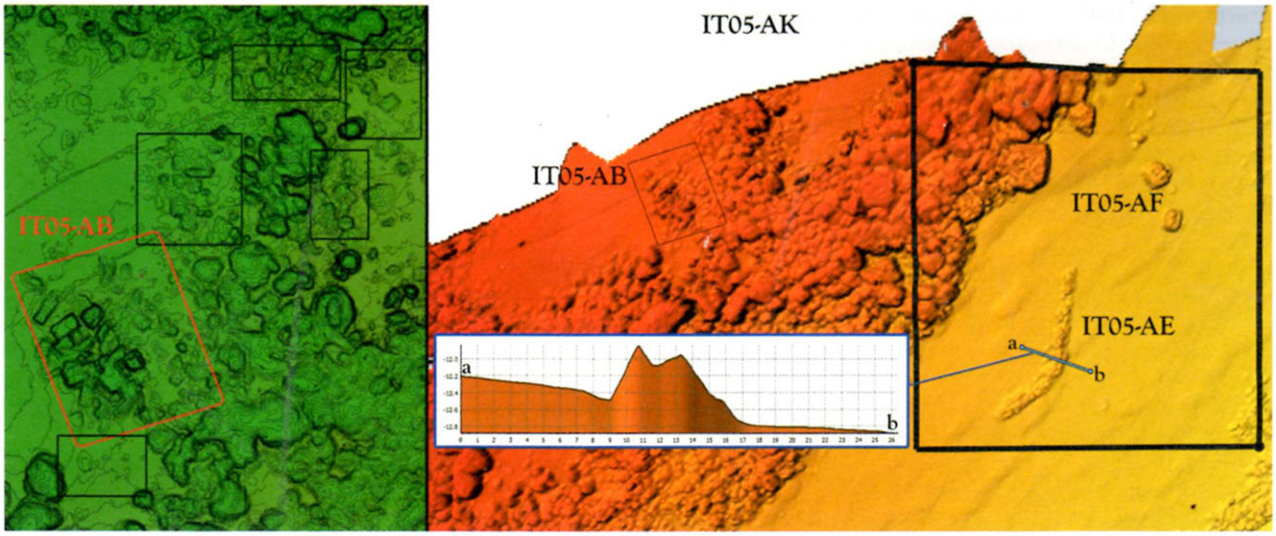

Figure 1. Sites IT05-AB, -AE and -AF, location of site IT05-AK: 3-D model to right includes a height profile (a-b) across central section of possible breakwater. Note the wide dispersal of material comprising site IT05-AB, and the potential other areas of regular stone deposited on the sea-floor demarcated within black boxes in the 3-D model to left. (J. Royal, G. Nickerson and M. Weirathmueller)

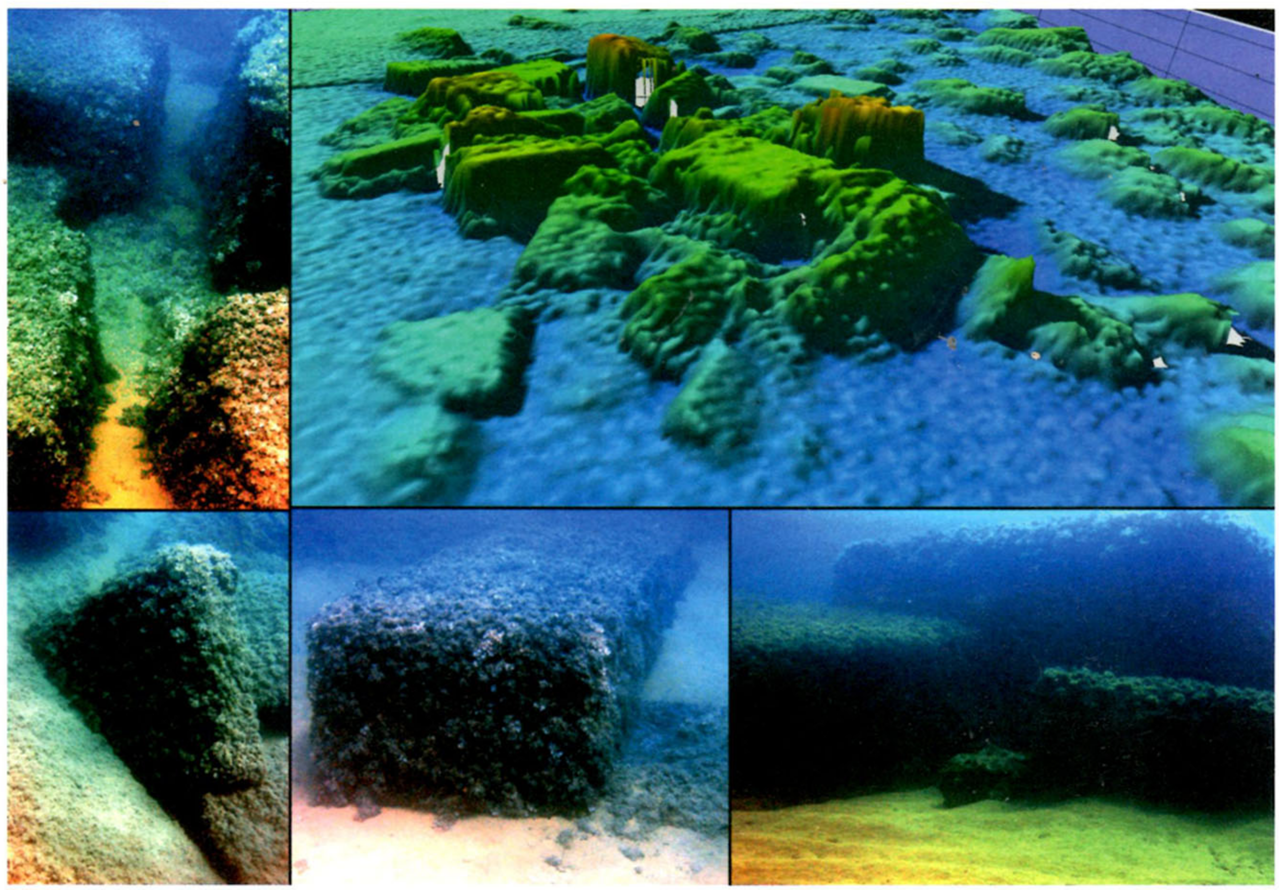

Figure 2. Site IT05-AB: stones throughout the deposit are clearly discernible in the 3-D model (top right) continuing under the current sea-floor. Likewise, large stone blocks can be seen at the site (photographs) almost completely buried with other stones lying atop them. (J. Royal and G. Nickerson)

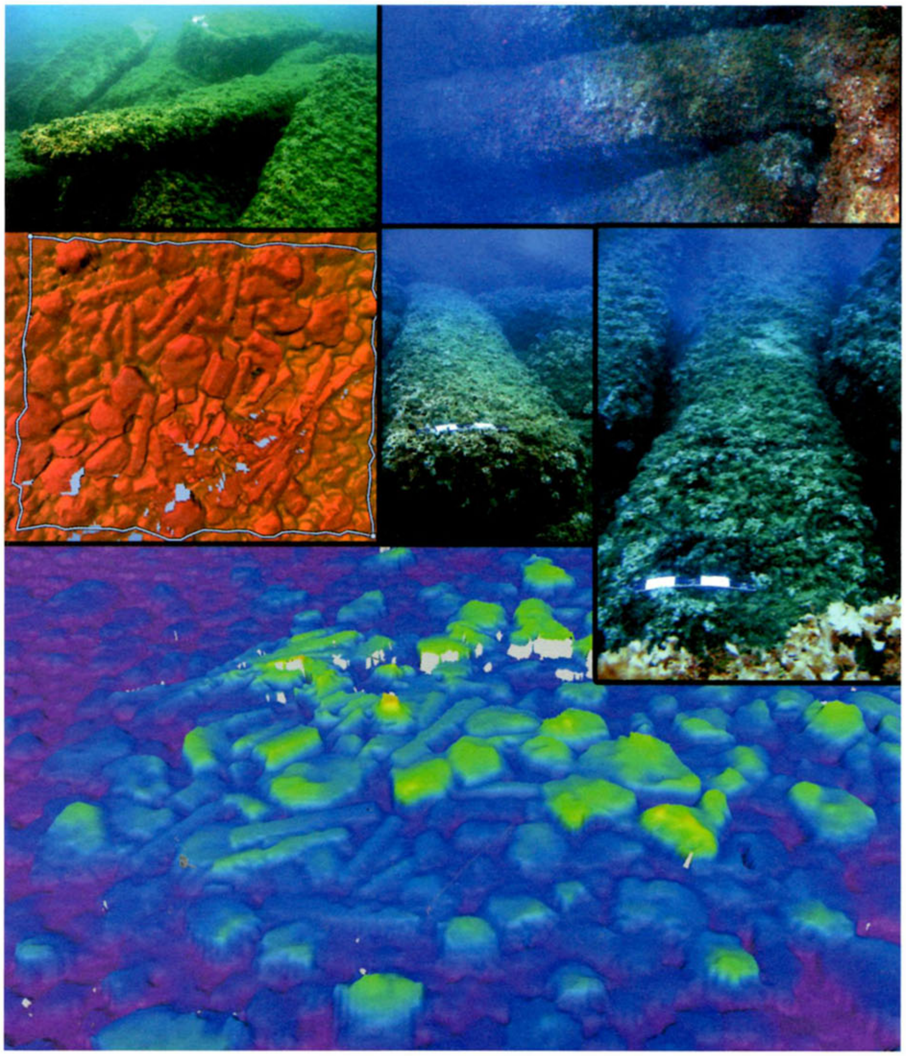

Figure 3. Site IT05-AD: this newly-produced 3-D model of the site shows the wide, square-shaped deposit of cut stones in no discernible pattern. The number of stones under those on the surface, and invisible to a dive investigation, is considerable given the height that this deposit forms compared to the surrounding sea-floor. Such large-area contextual observations are only possible through 3-D modelling. (J. Royal and G. Nickerson)

modules of the multibeam data deviated by less than 5 cm from direct measurements; the majority of the difference is due to the marine growth on the stones. This is unremarkable, as highly-precise 3-D measurement of objects is a fundamental element of shallow-water multibeam survey in many industries.

The multibeam system used in the shallow waters off Capo Colonna was a Reson Inc. SeaBat 8125 system which emits 240 per discrete beams at a rate of up to 40 times per second on a frequency of 455 MHz. With a dynamic 120° swath, resolution accuracy has been tested to 6 mm. 3-D models of the sea-floor can also provide perspective views and reveal objects with relief which are obscured by a thin cover of sediment and so not detectable by divers or cameras. For example, such models of the stone-pile sites designated IT05-AB and -AD (Figs 1–3) illuminate additional stones not noted in Bartoli's analysis based on the plan-view image. Hence sites IT05-AB and -AD cover a total area on the current sea-floor of *c*.28 × 21 m and 21 × 20 m respectively; larger and less ideally boat-shaped than Bartoli's estimates of 24 × 15 and 15 × 12 m (2010: 402–04). The extent of additional stones not taken into account by Bartoli may be due to sand and/or *posidonia* cover. The highest remaining feature on site IT05-AB was a cut-stone stack upwards of 2 m off the current sea-floor (Bartoli, 2010: 404). Additionally, more stones are noted extending into the sediment and increase the number of stacked layers to 5 or possibly 6. Stones extending below the current sea-floor are evident throughout the site (Fig. 2), and as a result the piles exceed current visible dimensions; consequently the total height of the pile at IT05-AB may reach well over 3–4 m.

Bartoli's estimate of 350 tons of marble for site IT05-AB, again located in the surf-zone during the Roman

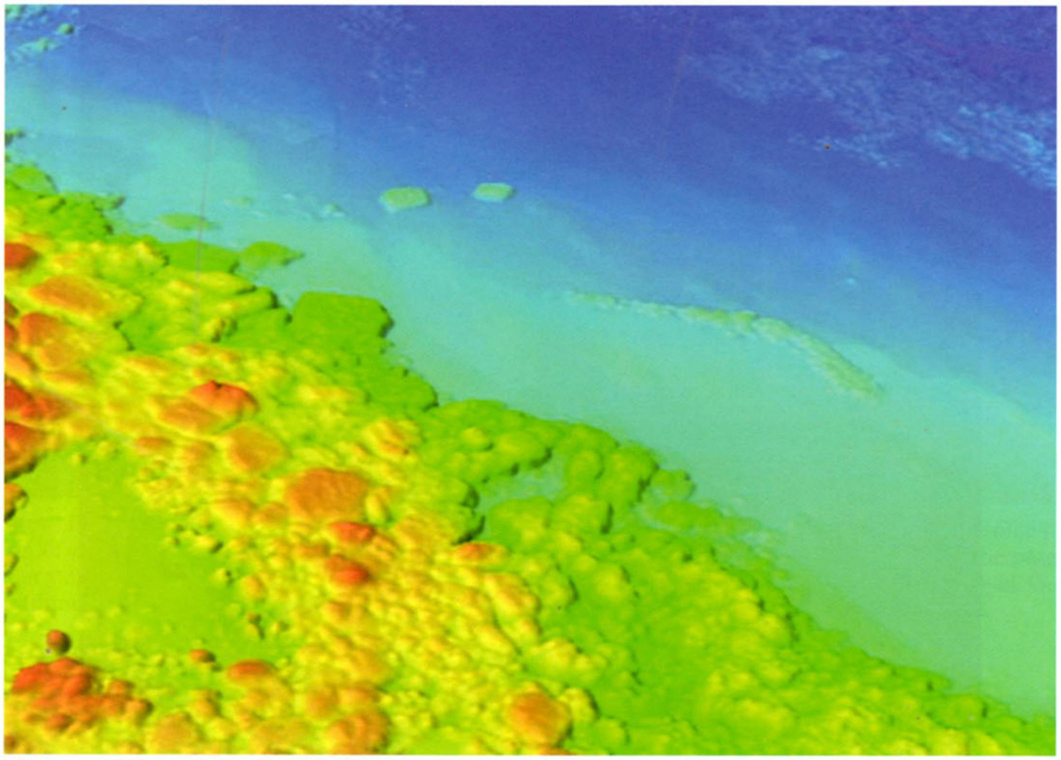

Figure 4. Sites IT05-AE and -AF: this 3-D model of the possible breakwater structures shows additional features protruding from the sea-floor and extending along the line of the two square structures forming site IT05-AF. (J. Royal and M. Weirathmueller)

era or on land in earlier periods, is laudable as a follow-up exercise to measure the accessible blocks sitting atop the current sea-floor (though incomplete, such investigations are the next step called for in the original publication; preferably full excavation around each deposit). However, it fails to account for those blocks which are mostly or completely buried in the sand, due to high sedimentation rates over the intervening millennia, those missed due to being obscured by *posidonia*, or those located in inaccessible parts at the centre of the stack. A conservative additional 50–100 tons of stone, probably much more given that stacks tend to expand not narrow at their lowest levels, places the total tonnage and height of stacks even further outside reasonable totals for transport by ancient wooden ships. Undoubtedly this misunderstanding of the principle and underlying attributes of the data-set, as well as not taking the area's geological history into account, contribute to Bartoli's flawed proposals.

In regard to Bartoli's claim (2010: 405) that the hypothesized breakwater (site IT05-AE and -AF) (Figs 1, 4–5) (Royal, 2008, figs. 2, 9–10) was 'ancient submerged beach-rock', an assessment by Dr Stanley and Dr M. P. Bernasconi of the Department of Geology, University of Calabria, Cosenza, identifies the structure as an unnatural formation and unlike beach-rock. Rather, it is observed to be comprised of irregular and similarly-sized individual stacked stones. Dr Bernasconi also made several investigations during autumn 2010 to record further geological structures, and effects of recent physical processes on the coastal margin in the area. An additional recent examination of the potential harbour structure in relation to local geology by these two geologists, and their comparison of it with well-defined beach-rock strata on the Ionian coastal margin of Calabria, further substantiates this as an unnatural feature and probably of human construction (Stanley, 2007; Stanley *et al.*, 2011).

Notice the sedimentation thickness shoreward of the structure (Fig. 1, height profile inset), one of numerous sedimentation features in the area. The high sedimentation rates, established by Stanley's and previous geological research, would have long buried any artefacts around this structure, so traces of human occupation would not be visible to a casual diver search. Conspicuously, the shallow sites IT05-AA, -AB, and -AK also lie in this heavy sediment area, directly shoreward of the possible breakwater (Fig. 1, right). Their full extent remains unknown, as well as other potential areas of buried material revealed in the multibeam data, many of which lie between sites IT05-AB and -AK (Fig. 1, left). These sites were in the general area of the surf-zone, or on the shore near the surf-zone, *c.*2500 years BP; so the protected area behind the possible breakwater would have extended *c.*100–125 m shoreward.

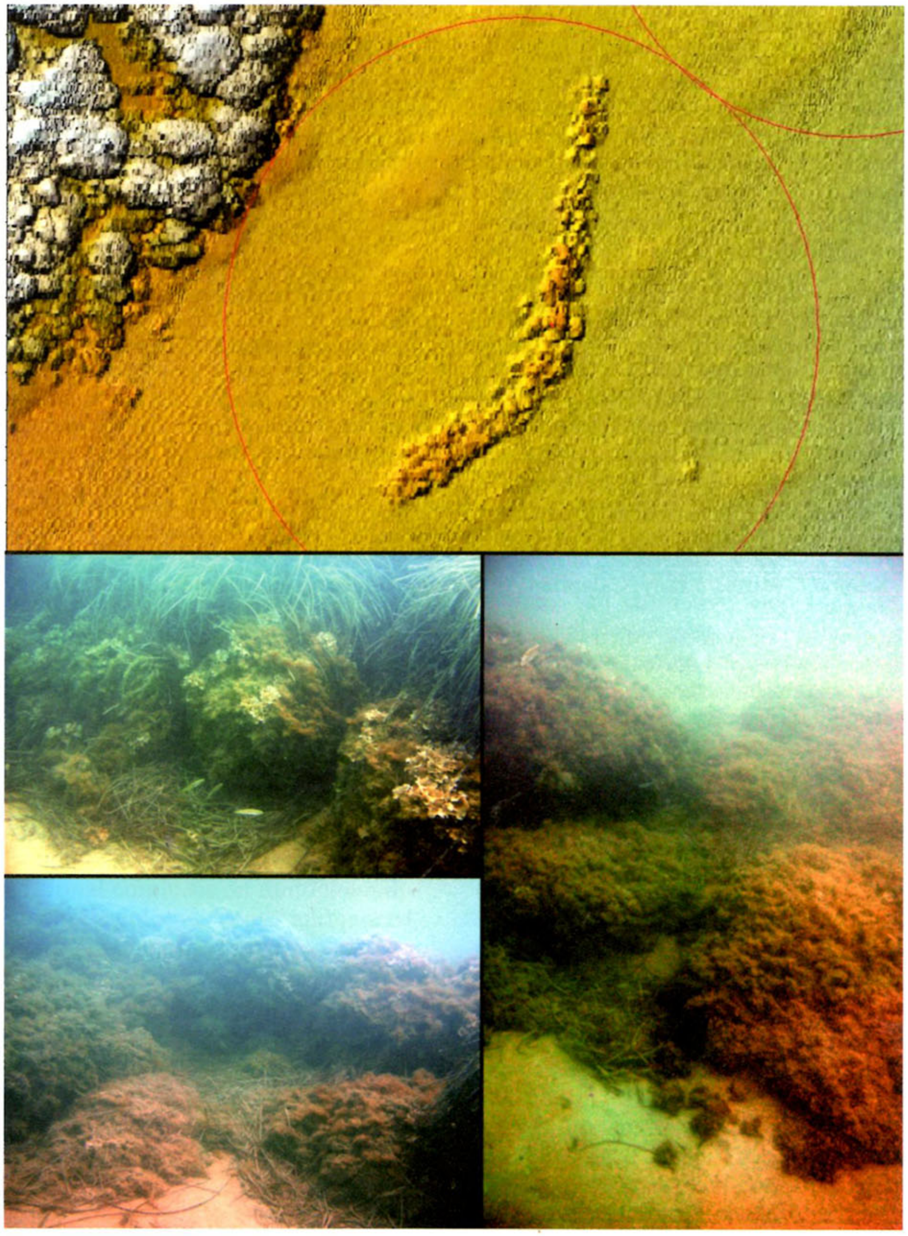

Figure 5. Site IT05-AE: the individual stacked stones from which the possible breakwater is constructed, shown in the photographs, are also discernible in the high-resolution 3-D model (top). (J. Royal and M. Weirathmueller)

Ultimately, the relative sea-level changes for this seismically active section of coast are inescapable. Stone piles near the shore around Capo Colonna were either on land (sites IT05-AA and -AK) or in extremely shallow surf (IT05-AB and -AD) during the later Roman era. If these sites were formed during the Roman Republican period or earlier, then they were probably all on land. Moreover the extensive size, excessive number of stacked stones, and magnitude of the deposits at sites IT05-AB and -AD remain uncharacteristic of all known stone-carriers; again such stone-carriers would be by far the largest ever known and an astonishing find, particularly as they were beached. Likewise, with a confirmed significant rise in relative sea-level the hypothesis of an ancient harbour site remains viable and awaits testing by excavation. The real import of such study is the value of interdisciplinary research and the contributions that disparate and independent lines of scientific inquiry can provide, as well as the dangers of ignoring such research for archaeological interpretation.

Jeffrey G. Royal
Archaeological Director, RPM Nautical Foundation, 7009 Shrimp Road, Old Island Harbor #3, Key West, FL 33040, USA

Acknowledgments

I would like to thank Dr Stanley for his expert consultation and review of geological evidence, provision of references, and insights in regards to the data gathered around the area of discussion. Much appreciation to G. Nickerson, President and Senior Surveyor of Highland GeoSolutions Inc. for his review and analysis of the multibeam data, creation of 3-D models, as well as consultation on multibeam reference material. I would also like to extent gratitude to Dr Bernasconi for her additional fieldwork and expert analysis.

References

Bartoli, D., 2008, Marble Transport in the Time of the Severans: a New Analysis of the Punta Scifo A Shipwreck at Croton, Italy, unpublished dissertation, Texas A&M University, College Station.
Bartoli, D., 2010, Ancient Harbour Structures in Croton, Italy: a reappraisal of the evidence, *The International Journal of Nautical Archaeology* **39**.2, 399–406.
Hughes Clarke, J. E., Mayer, L. A. and Wells, D. E., 1996, Shallow-water imaging multibeam sonars: a new tool for investigating seafloor processes in the coastal zone and on the continental shelf, *Marine Geophysical Research* **18**, 607–29.
Le Bas, T. P. and Huvenne, V. A., 2009, Acquisition and processing of backscatter data for habitat mapping—comparison of multibeam and sidescan systems, *Applied Acoustics* **70**.10, 1248–57.
Lurton, X., 2002, *Underwater Acoustics: an Introduction*. Chichester.
Royal, J., 2008, Discovery of Ancient Harbour Structures in Calabria, Italy, and Implications for the Interpretation of Nearby Sites, *The International Journal of Nautical Archaeology* **37**.1, 49–66.
Stanley, J-D., 2007, Kaulonia, southern Italy: Calabrian Arc tectonics inducing Holocene transgressive and regressive coastline shifts, *Méditerranée* **108**, 7–15.
Stanley, J-D., Nickerson, G., Bernasconi, M., Fischer, S., McClure, N., Segal, T. and Royal, J., 2011, Multibeam sonar technology and geology to interpret ancient harbor subsidence off Crotone Peninsula, Italy, *Méditerranée* **114**.
Van Dijk, J. P., 1991, Basin dynamics and sequence stratigraphy in the Calabrian Arc (Central Mediterranean); records and pathways of the Crotone Basin, *Geologie en Mijnbouw* **70**, 187–201.
Zecchin, M., Massari, F., Mellere, D. and Prosser, G., 2003, Architectural styles of prograding wedges in a tectonically active setting, Crotone Basin, southern Italy, *Journal of the Geological Society* **160**, 863–80.

Balancing Sailing Rigs

Julian Whitewright, whose work I very much respect, includes Tilley (1994) among those who 'have concluded that the single-masted square-rigged vessel, such as those of the Roman period, had some ability to sail above 90° to the wind' (Whitewright, 2011: 7). I would like to clarify my actual published views on the subject. I think the Roman merchant ship had a foremast (or bowsprit) carrying a head-sail, and that that was essential to balance the rig and allow sailing to windward. A single square sail on a mast stepped amidships would not generally have allowed a ship to make any ground at all up-wind, as was found in the voyage of the modern *Argo* (Severin, 1985: 168–9). Brailing up the after part of the sail may have given a little windward ability in favourable conditions, but the technique would not have been in use for long. Once it was realised that the need was to move the centre of sail area further forward, it was superseded by the more efficient solution of using a head-sail.

The ability to sail to windward well enough to keep off a lee shore was what allowed the use of round ships as opposed to galleys (Tilley, 2004: 85–98; Palmer, 2009). Once that had been achieved, further improvements in windward performance were of only secondary importance. To refer to Whitewright's Figure 5, it was the existence or absence of the sailing ability represented by his small red triangles that transformed seafaring. The size and shape of the green and yellow sectors are of only secondary importance.

Alec Tilley
Fieldfare, Hambledon, Hampshire, PO7 4RX, UK

References

Palmer, C., 2009, Reflections on the Balance of Traditional Sailing Vessels, *The International Journal of Nautical Archaeology* **38**.1, 90–96.
Severin, Tim, 1985, *The Jason Voyage*. London.
Tilley, Alec., 1994, Sailing to Windward in the Ancient Mediterranean, *The International Journal of Nautical Archaeology* **23**.4, 309–13.
Tilley, Alec., 2004, *Seafaring on the Ancient Mediterranean*. Oxford.
Whitewright, J., 2011, The Potential Performance of Ancient Mediterranean Sailing Rigs, *The International Journal of Nautical Archaeology* **40**.1, 2–17.

