

Institution: University of Nottingham, Archaeology
Unit of Assessment: Sub-panel 17, Geography, Environmental studies and Archaeology
Title of case study: Pavlopetri: Improving the public presentation, management and conservation of submerged cultural heritage
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Research at the submerged town of Pavlopetri in Greece has stimulated improved management and conservation of a key site of marine cultural heritage. It helped to forge a new policy against uncontrolled industrialisation of the Vatika bay, reducing potential environmental damage, and has informed the development of national governmental policy on the protection and presentation of submerged sites in Greece.</p> <p>Utilising pioneering technological advancements in underwater scanning and improved visualisation processes, the research also helped an offshore engineering company to improve its product development and changed the way archaeologists and the public visualise, interpret and understand marine cultural heritage.</p> <p>Through an internationally successful documentary (viewed by approximately 15 million people) that used state-of-the-art CGI technology, public awareness and policy engagement with underwater archaeology (and the environmental issues related to its preservation) have been enhanced and, locally, Vatika and the Laconia region have seen increased tourism and transformed community involvement.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>Dr Jon Henderson (Nottingham 2000- Associate Professor from 2007) began a 5-year project in 2009, in collaboration with the Hellenic Ministry of Culture (Ephorate of Underwater Antiquities), and the Hellenic Centre for Marine Research, to outline the history and development of Pavlopetri. The site, located off the coast of Laconia, Greece, is the oldest submerged town in the world with remains dating from at least 3500 BC through to the end of the Mycenaean period c.1100 BC. Through the development of new digital underwater archaeological survey techniques (2009-2011) followed by targeted underwater excavations (2011), the Pavlopetri Underwater Archaeology Project has established the full extent of the site, when it was occupied, what it was used for and, through a systematic study of the geomorphology of the area, how the town became submerged (3.3). Fieldwork in May 2009 and June 2010 consisted of detailed digital underwater survey of the structural remains (utilising sonar technology never before applied on an archaeological site as well as revolutionary robotic stereo photogrammetry) alongside sampling of the artefactual material across the site. In addition to the digital recording of the 30,000 square metres of previously known buildings, over 50,000 square metres of new buildings and occupation have been discovered. These discoveries, in tandem with the finds recovered, have fundamentally changed academic understanding of the chronology and importance of Pavlopetri in the Bronze Age. The ceramics (recorded by Dr Chrysanthi Gallou, UoN, while a PDF from 2009-2011 and a Lecturer from 2012), have confirmed the Bronze Age occupation of the site but significantly have also revealed substantial evidence for earlier occupation beginning in the Final Neolithic as early as 3,500 BC and continuing throughout the Bronze Age (3.2).</p> <p>Underwater excavation in June 2011 identified stratified in-situ deposits clearly associated with structural remains and individual buildings. On the basis of the finds these deposits date to the Neopalatial period (c.1700-1425 BC) and demonstrate that the people of Pavlopetri had close trading contacts with Minoan Crete. The results suggest that Pavlopetri may have been either a Minoan trading colony (if so the first identified on the Greek mainland) or an indigenous port with strong Minoan influence - the production of Minoan forms in local pottery fabrics supports the latter view. In addition to the excavation work the whole site was surveyed in three-dimensions using a stereo-photogrammetric diver-rig system developed and built especially for the project (3.4). Referred to as the 'diver rig' the unit consists of the cameras, lighting, sensors, instrumentation, and power source needed to take high resolution images of the seabed arranged inside a highly portable carbon fibre and balsa wood frame. The images are then post-processed using a 3D mapping algorithm to produce geometrically accurate 3D photo-realistic models. Essentially the 'diver rig' is an adaptation of existing stereo-vision mapping technology currently used in deep water autonomous underwater vehicles (AUV), simplified and deployed in a system designed for use by individual divers in shallow water. It can achieve a higher resolution than existing AUV</p>

Impact case study (REF3b)

approaches and, importantly, can be carried out at a fraction of the cost involved in operating and deploying AUV systems. This system allowed the creation of a full photo-realistic three dimensional model of the submerged remains at Pavlopetri which proved of use not only to the archaeologists for interpretation and recording but also to the Greek government (in terms of the management of the site) as well as providing an effective means of presenting and displaying the site to the public resulting in extensive national and international public engagement (3.1).

3. References to the research (indicative maximum of six references)

Publications

3.1 HENDERSON, J. C., PIZARRO, O., JOHNSON-ROBERSON, M. and MAHON, I. 2013. Mapping submerged archaeological sites using stereovision photogrammetry. *International Journal of Nautical Archaeology* 42.2. 243-256. (Listed in REF 2; lead article in the leading international journal for underwater archaeology).

3.2 GALLOU, C. and HENDERSON, J.C., 2012. Pavlopetri, an Early Bronze Age Early harbour town in south-east Laconia. *Pharos* 18(1): Journal of the Netherlands Institute in Athens. 79-104. (Listed in REF 2; one of the major peer-reviewed journals for Greek archaeology).

3.3 HENDERSON, J. C., GALLOU, C., FLEMMING, N. AND SPONDYLIS, E., 2011. The Pavlopetri Underwater Archaeology Project; Investigating an ancient submerged town. In: J. BENJAMIN, C. BONSALE, C. PICKARD AND A. FISCHER, ed., *Underwater Archaeology and the Submerged Prehistory of Europe* Oxbow Books. 207-218. (Listed in REF 2; peer reviewed and the current benchmark overview of submerged settlement archaeology in Europe).

3.4 MAHON, I., PIZARRO, O., JOHNSON-ROBERSON, M., FRIEDMAN, A., WILLIAMS, S. AND J. C. HENDERSON, J.C., 2011. Reconstructing Pavlopetri – Mapping the World’s Oldest Submerged Town Using Stereo Vision. In: *Robotics and Automation, (ICRA) IEEE International Conference, Shanghai 2011*. 2315-2321. (http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5980536&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D5980536; the leading international conference for robotic science).

4. Details of the impact (indicative maximum 750 words)

The pathway that Henderson and Gallou’s research has taken to achieve its ultimate impact (the conservation of a key element of ancient Greek marine culture) has multiple interlinking strands: A developmental relationship with on offshore engineering company improved the accuracy of underwater scanning; further technological developments facilitated detailed visualisations of the remains and CGI images of what the original city might have looked like engaged a global public with the site through an internationally-popular documentary. This had concomitant effects at a local level in Pavlopetri and its region, both on tourism and eventually, on the government’s marine protection strategy for future conservation of the site. This section describes each link in this chain in more detail and draws out how each constituency benefitted along the way.

Helping an offshore engineering company to improve its operating practices and identify a new market

A developmental relationship was established between Henderson and Nautilus Marine Group International (NMGI), a North American offshore engineering company associated with Kongsberg Mesotech, to test the accuracy of a new acoustic scanner (the MS 1000 Sector Scan Sonar) in recording submerged features. Pavlopetri offered an unparalleled opportunity to test the accuracy of the scanner as it sits in shallow water (less than 4 metres), has clear structural remains across a seabed area of 8ha and, most crucially, has been surveyed using a Total Station in millimetre accuracy – this accurate survey data provided a baseline template against which the scans from the MS 1000 could be compared. The results of this work allowed NMGI to improve its product by refining the use of the scanner particularly in regard to methods of deployment and the effects of different frequencies on resulting geometric accuracy (5.1). The collaboration has been described by HEFCE as an ‘exemplary example of Knowledge Transfer’ (5.2) and was initially pump-primed by a University of Nottingham Knowledge Transfer grant which allowed NMGI to take part in the

2009 Pavlopetri season. They returned in 2010 and 2011 using their own funds to further develop the scanner and field-test a range of other technologies such as swath bathymetry, side-scan sonar, echo-sounding and sub-bottom profiling. The work has also been beneficial to NGMI in identifying a new market as following the work at Pavlopetri NMGI they have carried out commercial archaeological work using the scanner. In September 2013 Nautilus Marine Group donated an MS Sector Scan Sonar to the University and entered into a long term collaboration to offer the equipment and training in its use to the UK maritime heritage sector.

Enhancing heritage preservation and presentation through public and media engagement

An innovative diver propelled unit was designed and built for use at Pavlopetri through a collaboration between Nottingham and the Australian Centre for Field Robotics, University of Sydney, facilitating the production of accurate photo-realistic models of submerged features which can be easily interpreted by both archaeologists and the public. The unit is able to collect geo-referenced stereo digital imagery and has signalled a step-change in the presentation of underwater archaeological data (3.1). During the 2011 field season at Pavlopetri, a movie industry CGI graphics team was embedded as part of the archaeological field team to construct digital visualizations directly on to the actual archaeological survey data as it was collected in the field. The CGI was developed through a unique collaboration between the University of Nottingham, BBC and Prime Focus Graphics.

The effect of this combination of geo-referenced stereo digital imagery with CGI was harnessed in a one hour documentary: *Pavlopetri: City Beneath the Waves* which aired on BBC 2 on October 9th 2011 achieving viewing figures of 2.03 million. The documentary (for which Henderson successfully obtained a commission with BBC 2 and the Discovery Channel and for which he was the Academic Consultant and Principal Contributor) used the state-of-the-art CGI technology (describe above) to raise the city from the seabed revealing, for the first time in 3,500 years, how Pavlopetri would once have looked and operated. It has since been repeated 18 times on BBC 2, BBC 4 and the Yesterday channel. A North American version of the documentary debuted on the Discovery Channel on June 2nd 2012 and it has so far been shown in a further 20 countries with estimated consolidated viewing figures of 15 million worldwide (5.3). The documentary set out to cover, for a mainstream prime time TV audience, how underwater archaeological survey and excavation is carried out as well as documenting the use of the cutting-edge new marine survey equipment described above. The degree of interest in and uptake of the documentary represents a significant contribution to changes in public awareness of underwater archaeology and related environmental issues relevant to its preservation. (5.4).

In addition to the new knowledge made available to the public through the documentary, Henderson and Gallou's research and excavation work at Pavlopetri created (sustained) engagement through other broadcast, print and online media: **television** coverage has included BBC Breakfast, BBC National News, BBC East Midlands, BBC World, CNN, the Discovery Channel (North America) and Greek and Spanish national TV stations (including live interviews with Jon Henderson on BBC Breakfast Oct 9th 2011 and CNN News 2nd June 2012); **radio** coverage includes BBC Radio 4 (The Today Show and Leading Edge) as well as live interviews on national Irish stations; In terms of **printed media**, articles have appeared in New Scientist, the Guardian, the Independent, the Scotsman, DIVE magazine, The Week, the German weekly der Freitag, the Sydney Morning Herald, and various periodicals in throughout Europe (including Greece, Italy, France, Norway, Sweden, Poland), Asia (including Japan and Pakistan) and North America; Extensive **online content** includes significant coverage in Nature, New Scientist and Scientific American. In addition three UoN podcasts on the project have together amassed 221,885 views, a BBC History Magazine podcast on the project has obtained over 150,000 downloads, while a BBC News article written by Jon Henderson has received over 450,000 views to date with 229,040 on day of publication (Oct 8th 2011) making it 16th in the 50 most read items on the BBC News website around the world on the day (5.5). This degree of engagement with the project (at a detailed and sophisticated level) demonstrates a significant contribution to shaping public understanding of marine cultural heritage and contemporary scholarship in this area, and to changes in public awareness and behaviours (see below) relevant to the environment.

This national and international engagement has been complemented by Henderson and Gallou's active involvement in local outreach leading to a transformation in terms of community awareness of and engagement with Pavlopetri: Gallou has delivered public lectures throughout

Vatika and Sparti and has organised local school programmes and trips to the site since 2009. In 2013 Gallou implemented a primary school programme at the local school of Kampos Voion involving 92 school children (5.6). The raised public profile of Pavlopetri has also served to bring in new tourism to the area (evidence by organised tourist trips from the UK to visit the site, the inclusion of Pavlopetri in official tourism literature produced by the Municipalities of Monemvasia and Elafonisos, and, for example, the renaming of a local business to 'Pavlopetri Rooms') (5.7).

Informing the development of Greek governmental policy on the protection and presentation (sustainability) of submerged sites

The increased interest in the site generated by the local outreach and international media interest described above catalysed local public and political awareness of the environmental issues that might affect the future preservation of the site. In 2011 (30 April-1 May) an International Symposium (organised by C. Gallou, the local Association of Velanidiotes and the Municipality of Monemvasia, in collaboration with the Mediterranean Institute for Nature and Anthropos (Med-Ina) and the Aikaterini Laskaridis Foundation, under the auspices of the Region of the Peloponnese) on the environmental and cultural heritage of the local area was held in which the Pavlopetri project formed one of the main points of reference. Local governmental authorities, 40 local and regional associations, and individuals signed the Cape Malea Declaration for the protection and promotion of the local area as a World Heritage Site of Cultural and National Significance (5.8). As a consequence of all the above, a management strategy for the site has been developed in collaboration with Henderson & Gallou, the Municipalities of Elafonisos and Monemvasia, the Coastguard, and local NGOs. A developmental plan for presenting the site and its findings to the public is in progress with the Municipalities of Elafonisos and Monemvasia. Meetings to date with the Mayors of Elafonisos and Monemvasia have directly influenced local governmental policy on the protection and presentation of the submerged site helping to forge a new policy against the uncontrolled industrialisation of the Vatika bay.(5.9 & 5.10). The increased profile of the site has also led to more protection of the site by the local Coastguard, promotion of the site in local public fora and media (e.g. VisitVatika.gr), the organisation of events by local associations and NGOs (e.g. organised visits at the site by the NGO "Toulipa Goulimi") and in May 2013 cleaning of rubbish from the environs of the archaeological site by the "Philopatris Association" of Elafonisos (5.11).

5. Sources to corroborate the impact (indicative maximum of 10 references)

- 5.1. Factual statement from NMGI.
- 5.2 <http://www.hefce.ac.uk/news/newsarchive/2011/name,62294,en.html> 26th May 2011.
- 5.3 Viewing figures and territories for BBC Programme page City Beneath the Waves <http://www.bbc.co.uk/programmes/b015yh6f> (available on file).
- 5.4 BBC audience reaction email 8th April 2011.
- 5.5 Media coverage dossier including UoN Marketing Office stats, Nature, 18 May 2009 <http://www.nature.com/news/2009/180509/full/news.2009.484.html>, New Scientist, 25 Nov 2009 <http://www.newscientist.com/article/mg20427361.700-pavlopetri-greece.html>, Podcasts (figures on 25 March 2013 www.nottingham.ac.uk/archaeology/videos), BBC History programme (<http://www.historyextra.com/podcast-page>) & (<http://www.bbc.co.uk/news/magazine-15191614>) BBC News Programmes Interactive 'Jon's feature did spectacularly well on the website' email 24th Nov 2011 (with metrics).
- 5.6 Community and School feedback dossier (comprising PDFs of proof for public lectures and educational programmes, email from local school at Kampos Voion (email 29/9/13)).
- 5.7 PDFs of tourist website of Monemvasia, Elafonisos Municipality tourist brochure, pdf of "Pavlopetri Rooms" business website.
- 5.8 Cape Malea Declaration and signatures (available on file); http://www.capemalea.eu/english/en_index_files/symposium.htm.
- 5.9 Factual Statement from the Mayor of Monemvasia.
- 5.10 Factual Statement from the Mayor of Elafonisos.
- 5.11 Dossier on local activity related to protection and promotion of the site and its environs (including a letter from the local Coastguard Chief, proceedings of the 9/2-7-2013 town council of Elafonisos and a pdf of community activities).