

S03 Exploring maritime spaces with digital archaeology: Modelling navigation, seascapes and coastal spaces

Emma Slayton, Crystal Safadi

The use of GIS and modelling techniques for the study of maritime landscapes and seafaring is a growing theme in both maritime archaeology and in computational approaches to analyzing archaeological spaces. With the recent availability of large datasets, increasingly more detailed and accurate weather records, and advances in GIS applications and simulations, our understanding of seascapes, coastal landscapes, and navigation is expanding. Evaluating both the use of the water's surface and the interaction between seascapes and adjoining land based sites is essential for understanding the use and meaning of maritime spaces in the past. Digital archaeology is crucial to the investigation of these spaces, as the archaeological record supports the existence of sea travel without any clear evidence of the specifics of this movement and computer based analysis can be used to fill in these gaps. This session may also focus on the use of water-based navigation extending to the analysis of navigation of lakes or rivers. Similarly, coastal landscapes and harbour sites may be included as they provide essential archaeological information on the connection of seascapes and landscapes, through visibility studies, database records, or analysis of coastal mobility. This session welcomes papers on a variety of topics that make use of GIS and modelling methods to investigate these maritime spaces, e.g. seafaring and voyaging, harbour studies, coastal landscapes, seascapes and islandscapes, surveying techniques, maritime cultural landscapes, databases, web- applications, etc. Through this session we aim to share and explore different approaches to analyzing maritime spaces that would highlight their significance.

S03-01 Modeling prehistoric maritime interactions in East Polynesia

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The islands of central East Polynesia were occupied from the end of the first millennium by people who maintained connections over large distances using a predominantly Neolithic technology. Beyond linguistic and cultural affinities among present day populations, evidence for these prehistoric interactions can be found in the distributions of artifacts that can be traced between island groups separated by thousands of kilometers. But despite the extensive nature of these interactions and the corroborating archaeological evidence, studies in prehistoric Polynesian voyaging have strongly emphasized voyages of discovery and colonization over later interactions. In the absence of material evidence for watercraft, archaeologists have relied heavily on ethnohistorical sources for interpreting the seafaring capabilities of Polynesia's ancient mariners, leading to numerous debates over the timing and direction of movements. The roles of climate, geography, and navigational skill in the maintenance of these interactions beyond the settlement period remain understudied. Our research explores how these elements may have combined to influence connectivity in the islands of central East Polynesia. We employ a two-stage process to modelling interactions: first, we establish optimal spatiotemporal corridors between Aitutaki, a volcanic island in the southern Cook group, and several regional targets based on a given voyaging "strategy" (e.g. with the wind, against the wind, etc.). This is used to establish baseline expectations for accessibility between islands and island groups. Following this, we use an agent-based model to simulate navigator responses to different conditions, in order to assess potential systematic deviations from optimal paths. Both the spatial and agent- based models are driven by probabilistic climatic configurations derived from a Markov Chain process using high-resolution palaeoclimate data. The objective of this is not to mimic presumed conditions operating in the past, but to explore a range of outcomes within a constrained set of possibilities. Results are then assessed using archaeological proxy data from Aitutaki and the surrounding area, with

the aim of determining likely candidate models for the position of Aitutaki within the greater interaction sphere of central East Polynesia.

S03-02 Reconstructing and modelling the Stone Age landscape in Southeastern Norway *Gjermund Steinskog*

During 2000-2015 the Museum of Cultural History carried out several large-scale excavation projects, instigated by major infrastructure projects. Combined, these projects have excavated c. 100 Stone Age sites. Of importance are also surveyed, but unexcavated sites which are registered in Askeladden, the Directorate for Cultural Heritage's national database of archaeological sites.

The region of Southeastern Norway is one of the few places in the world that has experienced continual coastal uplift since the end of the last Ice Age. Today, the Stone Age sites are situated at different heights within the landscape, from 20 to 150 meters above the present sea level. The sites are commonly located in remote hilly and woody inland areas, but when the sites were in use, they were situated close to the contemporary shoreline, in a landscape composed of large fjords and islands.

When working with Stone Age archaeology in Southeastern Norway, it is necessary to have tools for interpretation and reconstruction of the prehistoric coastal landscape, both on a local and regional scale. As such, GIS-based landscape models are essential tools for archaeological interpretations of these sites. This presentation will focus on how to use the different types of elevation data available from the Norwegian Mapping Authority, how to make palaeo-maps and different GIS-based models of the Stone Age coastal landscape, and finally demonstrate how this is integrated into the archaeologists work with the sites.

S03-03 Uncovering routes to Grenada: Exploring possible routes between mainland South America and the Southern Lesser Antilles

Emma Slayton, Jan Christoph Athenstädt, Jan Hildenbrand

Archaeologists have been attempting to uncover past sea routes through computer analysis since the early 1990s. Though the trend did not carry over into the Caribbean sphere until the turn of the century, many of the themes that had been established by the study of seafaring in the Pacific were applied to this region as well. One of these themes is the focus on the colonization of islands by early seafarers. While it is important to focus on initial connections, those voyages were only one way in which the sea was crossed by early seafarers. Reciprocal voyaging, or the process through which communities kept in contact over time through the act of canoeing, is equally as important, as it allows us to evaluate ongoing interactions that we see reflected in archaeological assemblages throughout the Caribbean. The interruption or adaption of these established reciprocal networks take are also of interest to archaeologists, to determine the affect Europeans on local social rhythms. From the time Grenada was first sighted by Columbus in 1498, the structure of social networks in Antilles had already begun to change due to the influx of new peoples, new technology, and new materials. To determine the effects on the relationship between mainland South America, in particular Guyana and Venezuela, and the Southern islands of the Lesser Antilles, in particular Grenada, pathways will be modelled to determine the ease of movement between these areas. This paper proposes to test links between sites using a new method of calculating isochrones taking into account both current and wind data. Through the use of this method, we will try to evaluate the effect of seasonal fluctuations on the model from a new perspective. Through this case study we hope to establish the benefits of using a directed ischrone method to understand and explore sea based pathways and uncovering the layout of past links between inter- island and inter-mainland communities.

S03-04 Looking for the lost harbor. Role of non-invasive archaeological methods in the reconstruction of the seascape of an ancient city Paphos

Paweł Ćwiakala, Kasper Jan Hanus, Karolina Matwij, Wojciech Matwij, Łukasz Miszk, Wojciech Ostrowski

Paphos, Hellenistic-Roman capital of Cyprus, was one of the most important trade centers in the East Mediterranean. Until recently, it was believed that only a singular harbor was located in Paphos in the east-south part of the city, the same place where the modern haven is now situated. When research on the Agora of the city has begun, the hypothesis about existence of the another harbor was formulated. It was primarily based on the analysis of the spatial organization of the city. Investigation of the layout of the city walls and gates gave assumptions that such hypothesis could be positively verified. The broad spectrum of non-invasive methods was implemented for reconstruction of the seascape of north-west part of the city where the harbor was expected to be found. At first, geoarchaeological research has proved that terrain behind the north-west wall had been silted by geologic material transported by Koskinas river after deforestation of the Troodos Mountains during the ancient times. It explains why there are no visible remains of the ancient harbor infrastructure. As the next step aerial prospection was conducted. The orthophotoplan and DTM of the Nea Paphos Archaeological Park was created using UAV. Obtained data were post-processed using Agisoft software. DTM allowed to register remains of the dock or shipyard outside the wall. 3D model of the research area was also created using TLS. The model was used to simulate sea level in ancient era which was two and a half meters higher than presently. All data gave a strong proves to confirm existing of the harbor in the north-west part of Paphos and allowed to reconstruct seascape of this part of the city. To final confirm these arrangements geophysical and archaeological research will be also conducted. In this paper, the role of integrated approach in extension of the range of digital tools for modelling and reconstruction of the past seascapes will be shown.

S03-05 Simulating Pre-Hispanic canoe navigation in Lake Cocibolca, Nicaragua

Adam Kevin Benfer

While the earliest computational method for modeling prehistoric human movement was developed during the late 1960s to simulate maritime voyages, other navigable bodies of water (e.g., lakes and rivers) have received very little attention in computational archaeology. Just as with the sea, the archaeological record supports the existence of travel on inland water bodies often without clear evidence of the specifics of this movement. Since the same environmental variables of surface current and wind patterns and cultural variables of navigator skill, vessel shape, and propulsion method are crucial to all aquatic travel simulations, the computational methods that were developed for simulating voyages in the open sea can be modified for lacustrine environments. As a case study, I focus on the largest lake in Central America, Nicaragua's Lake Cocibolca, which covers an area of about 8,264 square kilometers, but remains surprisingly shallow, with an average depth of 12.5 meters. Because the lake is subject to persistent, strong northeasterly winds, some archaeologists have claimed that pre-Hispanic navigation was infrequent due to rough waters. However, archaeological studies in the Lake Cocibolca region have documented an abundance of ceramics and worked stone that the past inhabitants produced and traded widely during the later pre-Hispanic periods (AD 300- 1550). This lake also features two large volcanic islands and hundreds of small islands, most of which contain archaeological sites with petroglyphs, monumental statuary, and mound architecture. Combined with the ethnohistoric record, it is clear that the pre-Hispanic inhabitants of the Lake Cocibolca region regularly navigated these waters using paddle-propelled dugout canoes. Computer- based voyage simulations in this

windy lacustrine environment reveal the actual navigability of Lake Cocibolca during the later pre-Hispanic periods.

S03-06 Evocative virtual exploration of underwater sites: Issues and approaches

Manuela Ritondale, Gaia Pavoni, Roberto Scopigno, Marco Callieri, Matteo Dellepiane

The preservation in-situ and the use of non-intrusive technologies are prior principles in the UNESCO Convention on the Protection of the Underwater Cultural Heritage of 2001, thus introducing new challenges for the management of the underwater sites. The latter include the need to reach a high quality level in the documentation using remote sensing techniques and the need to protect the sites although ensuring their full accessibility. Digital technologies have provided several solutions for the documentation, the visualization, the monitoring and the predictive analysis of CH sites. Nonetheless, a real time effective visualization of an underwater scene is much more complex than the navigation on the ground, due to the presence of all the light effects introduced by water as a transmission medium (absorption, turbidity, caustics, scattering...). The aforementioned technical constraints might affect the perception of the public. This work aims to summarize the main issues and directions for an effective (not necessarily naturalistic) virtual exploration of underwater sites, and to propose further options for a successful storytelling. In order to reach the goal, a number of aspects must be redesigned, thus taking also into account two different pivotal concepts which imply rather different approaches and solutions: that of immateriality and that of intangibility. Which kind of intangible relations are hidden behind archaeological objects? How can we display them? Is it possible to enable a material experience through virtual technologies? We try to face these issues and to propose solutions on a case-study related to a deep-water site.

S03-07 A space and time analysis of the Early Bronze Age Levantine Littoral

Crystal Safadi

Maritime spaces are endowed with a set of natural characteristics acting upon and beneath the water surface. They foster a home for the movement of winds, of water, of ships, and of people. Movement through these spaces is a function of a complex system of interaction between humans, the environment, and humans' perception of the environment. Yet Maritime spaces are not present in isolation or within demarcations. In fact, land and sea seamlessly merge shaping waterfronts and shores marked by human activities. The importance of these coastlines and their imbued heritage, is well paramount in maritime cultural landscapes studies. They form a substantial heritage record, a place of archaeological signature, and specialization. However, though our knowledge of maritime spaces is growing, much of their potential and affordances remain concealed. Through reconstructing, testing, and analysing, experimentally or digitally, we can reach a step closer to lived maritime spaces. The Early Bronze Age (EBA) in the Levant is recognised for marking the first urban period in the southern Levant, and the 'second urban revolution' in the northern Levant. It is characterised by significant changes, primarily a shift from village-like communities towards an urban mode of life. The Levantine littoral, particularly in the north, is known to have played a major role during the mid-third millennium, when maritime connections mainly with Egypt became vital. This has been considered one of the instigators of urban development. However, numerous hypotheses have attempted to explain the rise of social complexity and urbanism, yet most of these failed to consider the totality of the space over which change is occurring, and appraise the Levantine littoral in its full potentiality, as a seamless space of sea and land. This paper aims to study and analyse the littoral Levant during the EBA as a space of affordances, accessibility, and connectivity. It builds on a time-space analysis of traveling by sea and by land, and attempts to move beyond the representation of space towards spaces of representations which incorporates at its foundation social activities.

S03-P1 Changing coasts, changing worlds. A preliminary approach to the evolution of coastal landscapes at the Asón river basin (Cantabria, northern Spain) during the Pleistocene–Holocene transition

Alejandro García-Moreno, Manuel R. González-Morales, Igor Gutiérrez-Zugasti, Alejandro Cearreta, David Cuenca-Solana

The Late Pleistocene - Early Holocene transition changed the climate more profoundly than at any time in human history. This change was especially evident at coastal areas, due to a significant sea level rise. The influence of that environmental change on human societies has been largely addressed from an economic point of view, mainly related to changes in the availability of resources. However, little attention has been paid to how these changes transformed the landscape. By modelling changes in the landscape we can evaluate not only how coastal and maritime resources availability changed during the Pleistocene-Holocene transition, but also how the landscape evolved, due to the appearance of coastal environments such as marshes, estuaries, etc. In this paper, we present a case study from the Asón river mouth, in the Cantabrian coast (northern Iberia). Using GIS modelling, we analyse the evolution of this coastal area. Sea level rise was reconstructed, leading to the definition of past shorelines and coastal topography, while tree vegetation predictive models allow for the reconstruction of coastal forests. Modelling these two elements allows approaching the evolution of coastal landscapes during the Early Holocene, mainly by changes in coastal topography, the appearance and disappearance of coastal features (islands, bays, etc.), and the development of coastal environments, notably salt marshes and killing zones. The reconstruction of coastal landscapes is key to approach the historical dynamics of Late Palaeolithic - Early Mesolithic coastal hunter-gatherer societies, and allows for a better understanding on how environmental changes related to economic, social and cultural transformations.

S03-P2 Exploitation of prevailing winds and currents by the earliest known seafarers, reaching and colonizing Australasia c 50 000 years ago

Eveline Kiki Kuijjer, Rosemary Helen Farr, Robert Marsh, Ivan David Haigh, Erik van Sebille

Long-distance maritime migration can be seen as early as 60–50,000 years ago, with the movement of Anatomically Modern Humans from the Sunda basin (southeast Asia) to Sahul (Australasia). The archaeological record of early settlement is limited, but evidence suggests short crossings from southeast Asia to Papua New Guinea and northern Australia at a time when sea levels reached c.60 - 80 m lower than today.

The effects of the maritime environment and ocean drift on early seafaring is addressed with computer models and novel drift calculations. To demonstrate this method, a particle-tracking algorithm is used with high-resolution ocean model current data, to explore modern-day ocean drift between southeast Asia and Australia. The tracking algorithm is progressively developed to account for the "windage" effects of prevailing winds on a drifting body, such as a raft. Large ensembles of simulated drifts are thus calculated and further analysed to determine the most probable timescale and trajectory of drift between coastal departure and arrival points in present-day circumstances, and these will be assessed against observations of drifting buoy trajectories. The approach will ultimately be applied to ocean currents in simulations for the time-slices during the period of early migration.

S03-P3 Using GIS modeling to reconstruct the urban landscape of the Roman city of Ossonoba

Cátia Sofia Machado Teixeira, João Pedro Pereira da Costa Bernardes, Célia Maria Alves Gonçalves

The Algarve region in Portugal is an individualized and diverse geographical landscape, well defined by the sea to the south and the mountains to the north. The coastline is a key element that defines the region, not only for the resources available but also for shipping and maritime trade. It was not by chance that the structures in the city of Ossonoba were affected by the strategic position between the maritime routes of the Mediterranean and the Atlantic Ocean, which yielded several benefits, especially after the conquest of Britain in the mid-first century AD. This particular Roman city had an intense and dynamic economic system, promoted by the maritime trade in the Mediterranean during the Roman Empire. The archaeological findings, inscriptions and various field works carried out in the urban area of the city of Faro over more than a century, allow us to have an idea (albeit scarce), of the extent and topography of the Roman city of Ossonoba. This poster presents the first approach to the use of a digital support for spatial information, namely a GIS (Geographic Information System), specifically directed to the ancient Roman city in the current territory of Faro, in which the primary goal was to obtain a circuit of the former city of Ossonoba, by defining the city limits as well as the organization of Roman structures over time.

S03-P4 The first web based viewer for archaeological underwater sites in Europe: The Splashcos—Viewer

Moritz Mennenga, Hauke Jöns

During the last 6 years the EU-funded SPLASHCOS network has shed light on the discipline of 'Continental Shelf Prehistoric Research'. It is based on an interdisciplinary research approach combining archaeological, geophysical, geological, oceanographic and biological methods. Investigations so far have already enormously expanded the available knowledge about prehistoric life, especially the economic conditions and environments that these communities had to face. In many cases the excellent preservation conditions in waterlogged sediments for everyday objects, tools and structures made of organic materials have provided completely new insights into prehistoric life. The 25 member countries started to collect archaeological data from all over Europe in their national databases or publications and brought the data together. But not only the presence of archaeological sites is reported, also additional information like the type and dating of sites or the presence of organic material and the water depth is mentioned. The data gave first opportunities to compare the preservation and state of research in different European regions and to observe the distribution of sites in time, space and depth. Permanent access to the collected data is essential for safeguarding, investigating and researching these sites and landscapes, as well as for communicating and visualising results. The archaeological data is now accessible for free in the web viewer or as WMS via the Marine Information Service (Maris). Additional to this Maris is hosting bathymetrical, chemical, geological and a lot more data of the seas. Therefore the Splashcos-Viewer is not only a tool for the public to view the data, but a handy instrument to investigate the sites. Due to the WMS it is possible to combine it with external data and support the own research. The poster will present the project, the data range, the possibilities of access and first results of the evaluation of the data.