

**Under the Sea:
Archaeology and Palaeolandscapes**

**Final Conference of COST Action TD0902
Submerged Prehistoric Archaeology
and Landscapes of the Continental Shelf**

**23rd–27th September 2013
Szczecin, Poland**

**Incorporating the final workshop
of the CoPaF Project:
Coastline Changes of the Southern Baltic Sea
– Past and Future Projection**

Scientific Committee

Pablo Arias, Spain
Geoff Bailey, UK
Ulrich Bathmann, Germany
Ryszard Borowka, Poland
Miquel Canals, Spain
Francesco Latino Chiocci, Italy
Katerina Dellaporta, Greece
Helen Farr, UK
Anders Fischer, Denmark
Nicholas Flemming, UK
Jan Harff, Germany
Friedrich Lueth, Germany
Tine Missiaen, Belgium
Marian Rębkowski, Poland
Dimitris Sakellariou, Greece
Julie Satchell, UK
Hans von Storch, Germany
Andrzej Witkowski, Poland

Organising Committee

Prof. Andrzej Witkowski
Prof. Jan Harff
PhD. Przemysław Krajewski
MSc. Karolina Brzozowska
Prof. Marian Rębkowski
MSc. Marcin Wroniecki
MSc. Marta Chmiel
MSc. Michał Adamczyk

Editors

Marta Chmiel, Karolina Brzozowska, Jan Harff, Marcin Wroniecki, Geoff Bailey,
Dimitris Sakellariou, Nic Flemming

Sponsors

COST – European Cooperation in Science and Technology
University of Szczecin
SEC – Szczecińska Energetyka Ciepła
HZG – Helmholtz Zentrum Geesthacht
Beta Analytic Radiocarbon Dating

ISBN 978-83-7518-607-9

Przedsiębiorstwo Produkcyjno-Handlowe
ZAPOL Dmochowski, Sobczyk Sp.j.
www.zapol.com.pl, www.e-zapol.com.pl

CONTENTS

INTRODUCTION	5
Plenary Session One SEA LEVEL, PALAEOENVIRONMENT AND CLIMATE	7
Plenary Session Two SUBMERGED LANDSCAPES AND ARCHAEOLOGY	17
Plenary Session Three SUBMERGED LANDSCAPES AND HUMAN DISPERSAL	31
Plenary Session Four UNDERWATER ARCHAEOLOGICAL SITES	43
Plenary Session Five SURVEY STRATEGIES, TECHNIQUES AND COLLABORATION WITH INDUSTRY	55
Plenary Session Six MANAGEMENT AND OUTREACH	69
Plenary Session Seven FINALE	77
Parallel Workshop Session Coastline changes of the southern Baltic Sea – past and future projection (CoPaF). Session One	81
Parallel Workshop Session Coastline changes of the southern Baltic Sea – past and future projection (CoPaF). Session Two	91
Poster Session	99
PARTICIPANTS	127
INDEX OF AUTHORS	139
PROGRAM	142

INTRODUCTION

This meeting serves a double purpose. It is in the first place the final conference of COST Action TD0902 SPLASHCOS – Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf, with the primary aim of reviewing the work of the Action over the past four years since its inception in November 2009. It is also a scientific meeting in the more conventional sense, open to all who are interested in the principal themes of the meeting, and our speakers include a mix of SPLASHCOS members and others.

COST (European Cooperation in Science and Technology) is one of the longest-running European frameworks supporting cooperation among scientists and researchers across Europe. The COST framework funds research networks called 'COST Actions' that cover the whole spectrum of scientific endeavour across the many disciplines of the humanities, social sciences and natural sciences. COST Actions have a duration of four years and are designed to foster the coordination of research and research funding across national boundaries, and, in the case of Trans-Domain (TD) Actions, across disciplinary boundaries as well.

COST provides Actions with funding for meetings to coordinate, plan and promote research, to provide short training courses and experience for Early Stage Researchers, and to disseminate the results through publications and other media. The funding provided by COST does not cover new research activity such as fieldwork, or research salaries. The objectives of the SPLASHCOS Action are set out in a publically available Memorandum of Understanding (MoU), which is available at <http://www.splashcos.org> and http://www.cost.eu/domains_actions/isch/Actions/TD0902, and are the test by which the success of the Action will ultimately be judged.

SPLASHCOS is the outcome of an earlier initiative, Project Deukalion, launched in 2008 by Nicholas Flemming of the National Oceanography Centre and Dimitris Sakellariou of the Hellenic Centre for Marine Research, to develop a large-scale research project dedicated to archaeological and scientific analysis of the European continental shelf. From initial meetings of a small group of colleagues grew the idea for a larger network, and the concept of Project Deukalion has remained a focus of attention within SPLASHCOS and a target for the future.

The COST funding formula is intergovernmental, which means that different States – and different institutions and individuals within them – can opt in or out of the Action as they wish. COST Actions are thus inclusive and open-ended networks open in principle to all who are interested, and overseen by a Management Committee with representation from all participating States. SPLASHCOS currently has 25 member States and over 100 individual members representing more than 60 institutions across Europe.

In practice the activities of the Action must necessarily focus on a core group of individuals who lead the work through formally constituted Working Groups (WGs). Ours are concerned, respectively, with Underwater Archaeological Sites (WG1), Submerged Landscapes and Palaeoenvironment (WG2), Techniques and Training (WG3), and Outreach and Collaboration with Industry (WG4). These themes provide the structuring principles around which this conference is organised.

As a multi-disciplinary group with many different disciplines represented, including many varieties of marine geoscience, archaeology and cultural heritage management, and individuals from diverse backgrounds including Universities, Research Institutions, Museums, Government Agencies, and Industry, one of our objectives and one of our great challenges has been to foster communication and to develop mutual understanding across these many boundaries, and to shift the climate of opinion towards the concept of a new and integrated discipline concerned with all aspects of the continental shelf. It is for this reason that we have placed the emphasis in this meeting on plenary sessions, in the hope that experts in one field or geographical region will listen to and learn from those in others.

We have also built into the conference timetable a workshop, in two parallel sessions, representing the final meeting of the participants in the research project: Coastline Changes of the Southern Baltic Sea – Past and Future Projection (CoPaF – <http://www.copaf.pl>). This project, running from January 2010 to September 2013, is led by the Institute of Marine and Coastal Sciences, University of Szczecin, financed by the Polish Ministry of Science and Higher Education, and coordinated by Prof. Dr. Jan Harff, University of Szczecin.

The project comprises an international network of Polish, Lithuanian, Estonian and German Universities, research institutions and State authorities, and is an outgrowth of SPLASHCOS Working Group 2, thus contributing to the wider SPLASHCOS agenda.

The CoPaF project is concerned with developing a cause-and-effect model for coastline change in the southern Baltic Sea, integrating geological conditions and meteorological/hydrographical driving forces. The aims of the model are: reconstruction of the palaeogeographic development of the southern Baltic coastal area resulting from the interplay of neotectonics, eustatic change and coastal morphogenesis during the past millennium; and projection into the future (up to AD 2100) of scenarios of coastline change. We expect the results of this project to contribute to the development of sustainable concepts for the coastal protection of the southern Baltic Sea.

In the past decade, as a result of the expanding industrial and commercial exploitation of the seabed, and our growing knowledge of the inexorable and continuous effect of sea level and climate change in human affairs, a wide range of disciplines has come to recognise the valuable archives of cultural and natural data locked up on the seabed of the continental shelf, the potential value of these archives both for illuminating our past history and for providing insights into the future survival of our society, and the high importance of collaborative ventures that seek to exploit and manage effectively the resources of the continental shelf for scientific and social purposes as well as for commercial and industrial objectives. This SPLASHCOS theme is not only of archaeological and scientific importance, but one of wide public and governmental interest as well, and we look forward to the development of new ideas and new initiatives beyond the lifetime of SPLASHCOS

Geoff Bailey
Chair of SPLASHCOS

Dimitris Sakellariou
Vice Chair of SPLASHCOS

Jan Harff
Chair of CoPaF

Andrzej Witkowski
Chair of Local Organising Committee

PLENARY SESSION ONE

SEA LEVEL, PALAEOENVIRONMENT AND CLIMATE

SEA LEVEL CHANGE AND PALAEO SHORELINES IN THE BALTIC AND EASTERN NORTH ATLANTIC DURING GLACIAL CYCLES

Kurt Lambeck

Research School of Earth Sciences, The Australian National University, and Ecole Normale Supérieure, Paris, France

The changes of sea level during glacial cycles show a particularly complex spatial pattern for areas such as the Baltic and North Seas because of their proximity to ice sheets of considerable geographic variability through time, because of the extensive shallow seas that are exposed during sea level lowstands, and because large ice-dammed lakes form at certain periods.

Observational evidence alone is too fragmentary for developing a quantitative model of these changes, but when coupled with geophysical models of the Earth's response to surface loading, models that can be tested against other observational evidence at different frequencies of the load or stress cycles, a consistent model for ice sheets, sea level and palaeo-geographic reconstructions is possible, with predictive capability of, for example, palaeo-drainage systems or migration routes.

This will be illustrated for the Baltic and North Sea areas with emphasis on the past 20,000 years and on some of the principal glacial stages between 150,000 and 20,000 years before present, together with a discussion of limitations of the model results

INTERCOMPARISON OF GIA MODEL PREDICTIONS AND PRESENT-DAY CHANGES IN RELATIVE SEA LEVEL AND CRUSTAL DEFORMATION IN THE BALTIC SEA REGION

Andreas Groh, Andreas Richter, Reinhard Dietrich

Technische Universität Dresden, Institut für Planetare Geodäsie, Germany

The deglaciation of Pleistocene ice sheets induced a visco-elastic response of the Earth which is still ongoing. The process of glacial isostatic adjustment comprises deformations of the Earth's crust and changes in relative sea level. Using a certain ice load history in combination with the corresponding visco-elastic Earth model, the present-day GIA-induced signals were modelled. For this purpose the sea-level equation was solved in a gravitational self-consistent way.

Present-day observed relative sea-level changes at tide-gauge stations and crustal deformations derived by means of GPS were used to validate the modelling results. For this purpose we derived sea-level changes relative to the Earth's crust for approximately 60 tide-gauge stations around the Baltic Sea and the adjacent North Sea. Homogeneous long-term time series provide a sound base for the determination of reliable long-term relative sea-level trends.

These trends represent the combined effect of GIA-induced crustal deformation and present-day eustatic sea-level changes. Moreover, we inferred crustal deformation for 44 stations of a dense regional GPS network. Our analysis benefits from the results of a reprocessed global GPS network and a homogeneous processing of the observations.

The combination of observed relative sea-level changes and crustal deformations allows us to solve for present-day eustatic sea-level changes. This quantity is required to correct the observed relative sea-level rates prior to comparison with the GIA modelling results.

**A MULTI-SCALE HYBRID MORPHODYNAMIC MODEL
FOR INVESTIGATION OF LONG-TERM CLIMATE IMPACTS
ON SUBMARINE AND SUBAERIAL DEPOCENTRES**

**Wenyan Zhang^{1,2}, Jan Harff³, Ralf Schneider², Michael Meyer⁴, Eduardo Zorita⁵,
Birgit Hünicke⁵**

¹ MARUM – Centre for Marine Environmental Sciences, University of Bremen, Germany

² Institute of Physics, University of Greifswald, Germany

³ Institute of Marine and Coastal Sciences, University of Szczecin, Poland

⁴ Baltic Sea Research Institute, Warnemünde, Germany

⁵ Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany

A modelling methodology based on a multi-scale hybrid morphodynamic model and representative climate driving conditions is presented to study the morphogenesis of submarine/subaerial depocentres on a centennial-to-millennial temporal scale.

The Darss-Zingst Peninsula in the southern Baltic Sea, which has been developed during the last 6000 yrs by the combined effect of eustatic sea level change, isostatic movement, meteorological forces and nearshore sediment dynamics, is selected for a case study.

A palaeo-Digital Elevation Model (DEM) serving as the initial condition is reconstructed by a compilation of recent digital elevation data sets, an eustatic sea-level curve, an isostatic map and dated sediment cores. Representative wind series are initially generated based on a statistical analysis of a palaeo-wind data set from a simulation with the coupled atmosphere-ocean general circulation model ECHO-G over the last 7000 cal yrs. These wind data were further fine-tuned using proxies from lithostratigraphic studies of sediment cores from the central Baltic Sea, and used as climate driving conditions for the model.

Based on the reconstructed palaeo-DEM and the representative climate driving conditions, the methodology is applied to reconstruct the Holocene morphogenesis of the Darss-Zingst Peninsula since 6000 cal. yr BP. Simulation results indicate that the development of the barrier system is a combination of long-term effects of climate change, isostatic crustal movement, wave dynamics, aeolian transport and short-term effects of extreme wind events, i.e. storms.

SEA LEVEL FLUCTUATIONS ON THE NORTHERN CONTINENTAL MARGIN OF THE SOUTH CHINA SEA DURING THE LAST GLACIAL CYCLE AND THE HOLOCENE

Michał Tomczak¹, Qiu Yan², Jan Harff^{1,3}, Hongjun Chen², Aleksandra Truszkowska¹,
Andrzej Witkowski¹, Ryszard Krzysztof Borówka¹, Andrzej Osadczuk¹

¹ Institute of Marine and Coastal Science, University of Szczecin, Poland

² Guangzhou Marine Geological Survey, Guangzhou, China

³ The Leibniz Institute for Baltic Sea Research Warnemünde, Germany

The northern continental margin is the widest one within the South China Sea (SCS). During the Late Quaternary its shelf area was subjected to inundation during sea level rise and widely exposed during sea level low stands. Understanding the origin of relative sea level changes completes the reconstruction of the environmental response to climate changes and monsoon variability based on proxy-data from sedimentary records sampled at the continental shelf of the SCS. Sea level fluctuations as one of the most important indicators of global climate changes are one of the central targets of the Chinese-Polish research project *Sedimentary environment and climate evolution since the Late Pleistocene in the Beibu Gulf and its adjacent area (SECEB)*.

The studies are focused on environmental changes during the Last Glacial Cycle (LGC) and Holocene at the northwestern continental margin of the SCS. For this purpose high resolution single-channel seismic sections and sediment core data have been investigated. According to radiocarbon (¹⁴C) and optically stimulated luminescence (OSL) datings, sediments of core HDQ2 (88.3 m length) cover a time span of ca. 110 kyr BP. The sedimentary facies is interpreted by multi-proxy approaches considering geological and geochemical analyses. Seismic images of the sampling site show a series of reflectors which can be correlated with coarse layers of core HDQ2. These layers are interpreted as transgression/regression horizons.

Due to the age model it is possible to correlate these horizons with the general sea level dynamics within the SCS as it is displayed in relative sea level excursions for MIS 5 to 2 from the Sunda Shelf (Hanebuth et al. 2011). Sedimentary facies reveal that sea level – and at the same time the position of shorelines on the northwestern continental margin of the SCS – changed dramatically several times during the LGC when the pattern of global sea level change was superimposed by local tectonics and climatic extremes as precipitation anomalies.

Further research will be devoted to a complex interpretation of sediment texture as well as biochemical proxies of selected sediment cores west and south of the Island of Hainan.

Reference

Hanebuth, T.J.J., Voris, H.K., Yokoyama, Y., Saito, Y. & Okuno, J., 2011. Formation and fate of sedimentary depocentres on Southeast Asia's Sunda Shelf over the past sea-level cycle and biogeographic implications. *Earth-Science Reviews* 10: 92–110

UNDERSTANDING THE DRIVERS OF ENVIRONMENTAL CHANGES IN WEST AFRICA FROM SEDIMENTARY DEEP-SEA RECORDS

Gerold Wefer

MARUM – Centre for Marine Environmental Sciences, University of Bremen, Germany

Ocean circulation plays an important role for terrestrial climates including the tropical monsoonal belt. Information about continental climate as well as the state of the ocean is continuously recorded in marine hemipelagic sediments which offer the opportunity to study relationships between terrestrial and marine climates at various time scales.

Here, I review the history of African vegetation and precipitation during the past ~200 kyrs and its relation to changes in the Atlantic meridional overturning circulation. Stable isotopic composition of benthic foraminifera are used as a proxy for ocean ventilation. Information about continental climate has been derived from bulk geochemistry and grain size (as a proxy for dust input), the carbon isotopic composition of plant leaf wax (as a proxy for the composition of vegetation) and the hydrogen isotopic composition of plant leaf wax (as proxy for the amount of precipitation).

The data show that changes in both ocean circulation and Earth's orbit are important modulators of African precipitation on the orbital to centennial time scale. A strong anthropogenic overprint is observed since the beginning of the nineteenth century, when a sharp increase in dust deposition accompanies the advent of commercial agriculture in the Sahel region.

INCORPORATING HIGH PRECISION DETAILED LIDAR DATA IN 3D MODELLING AND ANALYSING FORMATION MECHANISMS OF WAVE CUT NOTCHES

Paweł Terefenko, Dagmara Wziątek

University of Szczecin, Poland

Notch generation is presumably one of the most crucial aspects of the rocky-cliff erosion process. Erosion of the coastline contributes to loss of land area and to cliff collapse or landslides due to sudden cliff changes, which directly endanger human lives. The present contribution aims to study the characteristics of notch shapes and their genetic type using high precision laser scanning data.

The aim of this project is to check whether terrestrial LiDAR (Light Detection And Ranging) data can incorporate recognition of the mechanisms that generate notches. For that reason, a methodology using interpolation, raster analysis and morphological parameterization of the notch profiles was developed and a workflow of LiDAR data used to detect and define notches.

In this work, the shape of the notches has been defined based on the analysis of geometric parameters derived from notch topographic profiles. Among three notches analysed, two were characterized as U-shaped and one as V-shaped. Notch surface-roughness has been classified based on the standard deviation value of the curvature plan-profile raster, as moderately smooth, smooth and moderately porous. According to genetic notch type characteristics, notches have been defined as structural and tidal. One notch (nb. 1) appeared to be a feature of anthropogenic origin.

Terrestrial LiDAR data provides a very detailed and exhaustive source for the detection of the mechanisms that generate notches. However, further examination of the assumptions for the shape recognition threshold values as well as for the surface roughness criteria need to be introduced into the proposed research methodology.

DIATOM-BASED CONTRIBUTION TO THE INUNDATION HISTORY AND SALINITY CHANGES OF THE WISMAR BAY DURING THE LATE MESOLITHIC

Andrzej Witkowski, Sławomir Dobosz, Agnieszka Kierzek, Diana Krawczyk, Jan Harff

University of Szczecin, Poland

Results of diatomological studies on sediment cores retrieved from two submerged archaeological sites close to Poel Island in the western Baltic Sea are presented. Three sediment cores were studied and in each of them abundant diatom assemblages occurred.

The aim of the diatomological analysis was to reconstruct the inundation history of a settlement area inhabited by Late Mesolithic human communities. Differences in species composition and in the distribution of diatom ecological groups enabled us to distinguish local diatom assemblage zones (LDAZ). In each core studied, several LDAZ were distinguished. The following criteria were used to distinguish the LDAZ: salinity, life form (habitat), pH, saprobity and trophy.

The distribution of diatom ecological groups in the sediment profile indicated that the key driver in palaeoenvironmental change was salinity as a result of sea level rise. For quantitative surface water salinity reconstructions, a diatom-based transfer function method has been applied. As a result, a change in salinity from slightly exceeding 2 psu to slightly less than 10 psu of the transgressing waters has been inferred. The inundation of the study area took place ca. 5400 cal. BC and the rate of sea level rise varied between the sites studied. The local palaeo-inhabitants were forced to move their settlements due to the development of the Littorina transgression.

SOUTHERN DOBROGEA COASTAL POTABLE WATER SOURCES AND UPPER QUATERNARY BLACK SEA LEVEL CHANGES

Glicherie Caraivan¹, Valentina Voinea², Diana Stefanescu¹

¹ National Research and Development Institute for Marine Geology and Geocology, Constanta Branch, Romania

² Museum of National History and Archaeology, Constanta, Romania

Southern Dobrogea is a typical geological platform unit, located in the southeastern part of Romania, bordered to the north by the Capidava-Ovidiu fault and by the Black Sea to the east.

Four drinking water sources have been identified: surface water, phreatic water, medium depth Sarmatian aquifer water, and deep Upper Jurassic-Lower Cretaceous aquifer water. The discharge system is strictly dependent on the drainage base line, represented here by the Black Sea level. The natural boundary of the Upper Jurassic-Lower Cretaceous aquifer is the Capidava-Ovidiu Fault. The piezometric heads show that the Upper Jurassic-Lower Cretaceous aquifer is supplied from Bulgarian territory, where the Upper Jurassic deposits crop out. The aquifer discharges into the Black Sea to the east and into Lake Siutghiol to the northeast.

The cyclic Upper Quaternary climate changes induced drastic remodelling of the Black Sea level and the corresponding shorelines. During the **Last Glacial Maximum (MIS 2)**, the shoreline retreated eastwards, reaching the 100–120 m isobath. In these conditions, the surface drainage base level was very low. The phreatic nappe closely followed the river valley dynamics. The mean depth of aquifer discharge was on the inner shelf, where Sarmatian limestones outcrop. This process enabled the dispersal of prehistoric human communities, from Asia to Europe, who established settlements on the newly created alluvial plain on the western Black Sea shelf.

The **Holocene Transgression (MIS 1)** involved a sea level rise up to the modern level, and probably higher. Under the pressure of these environmental changes, the Neolithic settlements slowly retreated upstream. During the Greek colonization, the rising sea level caused the salinisation of the previous available sources of phreatic drinking water. In these conditions, in the Roman Age, a new hydraulic infrastructure had to be developed, using aqueducts for available inland water delivery.

PLENARY SESSION TWO

SUBMERGED LANDSCAPES AND ARCHAEOLOGY

SEA LEVEL AND CLIMATE (SPLASHCOS WORKING GROUP 2)

**Jan Harff¹, Nicholas Flemming², Kurt Lambeck³, Gilles Lericolais⁴,
Tine Missiaen⁵, Alar Rosentau⁶, Dimitris Sakellariou⁷**

¹ Institute of Marine and Coastal Sciences, University of Szczecin, Poland

² National Oceanography Centre, Southampton, UK

³ Research School of Earth Sciences, The Australian National University, and Ecole Normale Supérieure, Paris, France

⁴ Institut français de recherche pour l'exploitation de la mer (IFREMER), Paris, France

⁵ Department of Geology and Soil Science, University of Ghent

⁶ Department of Geology, University of Tartu, Estonia

⁷ Hellenic Centre for Marine Research, 19013 Anavyssos, Greece

After two decades of research on the archaeology, climate and environment of the drowned landscapes of local and regional areas of the European continental shelf, the SPLASHCOS Action has attempted for the first time a comprehensive view of the shelf and its marginal seas as a whole. This view is possible due to the integration of numerous sources of research data and the development and application of models describing the action of driving forces shaping the drowned palaeolandscapes of the continental shelf.

This shelf experienced dramatic environmental changes after the last glaciation: Continental Ice sheets disappeared; the drainage of meltwater shaped the periglacial landscape; dammed melt-water lakes filled morphological depressions; globally sea-level rose and the transgression flooded large parts of the continental shelf, turning former freshwater lakes into brackish-marine ones; closer to the ice margins the land rose at faster rates than the sea level rise, such that there the sea was in retreat. On steep rocky coastlines, incised river valleys and karstic areas were inundated, and cliffs, caves and speleothems were flooded with salt water.

The driving forces of this environmental change are complex, and have to be considered in their interdependence. The most important drivers are climatically controlled eustatic sea-level change and the vertical movements of the Earth's crust, primarily in response to glacial unloading and meltwater loading.

In view of relative sea-level change, according to the tectonic setting, but also to geographic position, three subregions can be distinguished for Europe: the Baltic Basin; the North Sea and the open Atlantic shelf; and the Mediterranean Basin together with the Black Sea. Where the land is subsiding or the rate of eustatic sea-level rise exceeds crustal uplift, the continental shelf and its palaeolandscapes are continuously inundated. Here, the migrating highly dynamic shoreline reworks the surface of the palaeolandscape.

Any palaeogeographic reconstructions rely on proxy-interpretation and models of relative sea-level change resulting from interactions between eustasy, glacial-isostasy, tectonics and hydrographic forces. This work requires integration of vast quantities of existing data, combined with new high-resolution surveys in high priority areas.

**EARLY HOLOCENE LANDSCAPE DEVELOPMENT, CLIMATE EVENTS
AND BALTIC SEA HISTORY BASED ON SUBMARINE WOOD REMAINS,
HIGH-RESOLUTION BATHYMETRY AND LAGOONAL SEDIMENTS
IN THE HANÖ BAY, SOUTHERN SWEDEN**

**Dan Hammarlund¹, Svante Björck¹, Hans Linderson¹, Mats Rundgren¹, Björn Nilsson²,
Arne Sjöström²**

¹ Department of Geology, Lund University, Sweden

² Maritime Archaeological Research Institute, Södertörn University, Sweden

Remains of a submerged pine forest along the Hanö Bay coast in south-eastern Sweden have been a well-known phenomenon since the 19th century. Radiocarbon dates obtained on rooted stumps occurring down to at least 15 m below the present-day sea level have yielded ages in the range of 11,000–10,600 cal. yr BP, i.e. the end of the Yoldia Sea stage and the onset of the Ancylus Lake stage. These tree remains are associated with up to several metres thick deposits of gyttja, presumably representing lagoonal basins along the former coastline and the lower reaches of a small river.

This submerged coastal environment with wetlands and pine-dominated woodland was exploited by early Mesolithic hunter-gatherer populations as evidenced by frequent finds of wooden artefacts, animal bones and constructions such as fish traps.

An integrated palaeoecological, archaeological and geophysical project based at Lund and Södertörn Universities has now been initiated in order to provide increased knowledge about the landscape and ecosystems that existed along the coastline of south-eastern Sweden during the early Holocene. Multi-disciplinary investigations of this unique and largely unexplored material will be based on radiocarbon dating, dendrochronology, multi-proxy stratigraphy and high-resolution bathymetry (LIDAR and multi-beam SONAR surveying). We envisage addressing a number of important questions within several scientific disciplines:

1. Shore-level displacement and Baltic Sea history: To what level below the present-day sea level did the Yoldia Sea regression reach, and how rapid was the subsequent Ancylus Lake transgression?
2. Dendrochronology and dendroclimatology: For how many years lasted the Yoldia Sea low-stand, and how did climatic and environmental conditions change during this dynamic part of the early Holocene?
3. Early Mesolithic archaeology: How was the landscape exploited by hunter gatherers, how large was the population, and what was the character of their seasonal (or even permanent) settlements in this fertile area?

**SUBFOSSIL FORESTS UNDER THE SEA:
POTENTIAL FOR PALEOENVIRONMENTAL AND HUMAN CHANGE
IN NORTH-WESTERN FRANCE**

Elise Werthe, Bernard Vincent

Centre de Recherche en Archéologie, Archéosciences, Histoire (CRéAAH (UMR 6566), University Rennes 1, France.

Following a severe erosive phase during the last decade, the casual discoveries of coastal peat bogs along the Norman and Breton coasts (North-western France) have become more common. These levels have preserved subfossil oak trunks, which correspond to ancient forests submerged by the sea, accessible today only with the lowest tidal ranges. A root system is often associated with these oak trees showing that they collapsed where they died.

With a tidal range of about 12 m and a 240 km² foreshore, the Mont-Saint-Michel Bay, located between Normandy and Brittany, is an ideal field study area (Morzadec-Kerfourn, 2002, Tessier *et al.*, 2012).

Radiocarbon dating shows a discontinuous range extending from 5300 to 1000 cal BC with a few late Mesolithic samples (around 7500 cal BC). It is therefore an invaluable body of material to establish a precise time scale thanks to dendrochronology. However, these trees have a very disturbed dendrochronological signal during flood phases. That is the reason why absolute dating of these floating chronologies is very difficult. To overcome this obstacle, it is necessary to enrich our corpus with less disturbed contemporaneous wood specimens found in archaeological sites, bogs and inland valley bottoms.

Combining elements of relative and absolute chronology from dendrochronology and radiocarbon dating (Wiggle-Matching), we can show that the sites like Lillemer (Brittany), Saint-Pair-sur-Mer and Gorges (Normandy) present synchronous phases (Werthe). Environmental changes implied by these floods, but also anthropogenic activities such as fish weirs, can be closely tracked at different spatio-temporal scales. This will allow us to determine the impact of sea-level changes on the nature and development of human activities in coastal and wetland areas.

**LATE PLEISTOCENE ENVIRONMENTAL FACTORS DEFINING THE BLACK SEA,
AND THE IDENTIFICATION OF POTENTIAL EXAMPLE AREAS
FOR SEABED PREHISTORIC SITES AND LANDSCAPES
ON THE BLACK SEA CONTINENTAL SHELF**

Valentina Yanko

Department of Physical and Marine Geology, Odessa I.I. Mechnikov National University, 2, Shampansky Per., Odessa 65058, Ukraine

A few tens of millions of years ago, the giant Paratethys Ocean covered the region north of the Alps across Central Europe as far as the Aral Sea in Western Asia. At present, only the Black Sea, Caspian Sea and Aral Sea are its remnants. During glacial times of low global sea level, the Black and Marmara seas were isolated from the Mediterranean, becoming inland lakes comparable to the present Caspian Sea. This predetermined their hydrologic regime and impacted diverse biological populations, including humans.

The collection of earth-science and archaeological data in the Black Sea region goes back to the end of the 19th century. Despite over 150 years of intensive field studies and interpretative research, many aspects of the geological history as well as human responses to environmental changes in the region since the LGM remain disputed. Obtained material is studied by different teams of scientists who apply different methodological approaches leading to contradiction in understanding of the last pages of the geological history of the basin.

Despite decades of searching for submerged prehistoric habitations on the previously subaerially exposed shelves of the Black Sea, there have been no definite finds below a water depth of –10 m, and all reports of Neolithic settlements are based on debatable Early Holocene sea-level estimates (Yanko-Hombach et al., 2011). However, Stanko (2007, 374) reported several flint tools retrieved from boreholes in various places on the NW shelf and wrote "...archaeological surveys targeted at final Palaeolithic and Mesolithic sites on the NW Black Sea shelf and along the submerged river valleys might be deemed promising".

The main goal of this presentation is to provide a review of the late Pleistocene environmental factors defining the Black Sea, with identification of potential example areas for seabed prehistoric sites and landscapes on the Black Sea continental shelf.

A PRACTICAL APPROACH TO FIELD INVESTIGATION AND PROSPECTION FOR SUBMERGED PREHISTORIC ARCHAEOLOGY

Louise Tizzard¹, Andrew Bicket², Jonathan Benjamin²

¹ Wessex Archaeology, UK

² Wessex Archaeology Coastal & Marine, UK

Over the last 15 years, significant progress has been made on the investigation of submerged prehistory in the British Isles, spanning the last 1 million years. Through collaboration with industry, substantial areas of the east and south coasts of England have been assessed for the preservation of inundated palaeolandscapes. This has been supplemented by development-led investigations of the seabed in support of offshore windfarms around much of the English and Welsh coasts, providing a rich archive of data.

The potential for Middle Palaeolithic sites to survive beneath the sea in northern latitudes has been established by intensive investigation within Area 240, a marine aggregate licence area situated in the North Sea, some 11 km off the coast of Norfolk, England. The fortuitous discovery of bifacial handaxes, and Levallois flakes and cores, led to a major programme of fieldwork and analysis. Based on the typology of the artefact assemblage, taphonomic considerations and the geological context of the artefacts it is considered that the materials discovered, including Acheulean handaxes and Levallois products, are contemporaneous in Pleistocene terms, as observed in a number of northwest European sites.

The Early Middle Palaeolithic assemblage from Area 240 has survived multiple phases of glaciation and marine transgression showing that submerged landscapes can contain preserved, *in situ* Palaeolithic artefacts. Looking forward, one of the key questions scientists continue to ask around the SPLASHCOS community (and globally), is *how do we locate submerged sites*? Are we reliant on fortuitous discoveries or it is possible to predict and target high potential areas? Are hot-spot predictive models inherently flawed, useful (or both)? How do we deal with difficult practical and environmental conditions associated with submerged sites? This paper takes a practical approach to address some of these issues and look to the future.

**INVESTIGATING SUBMERGED ARCHAEOLOGICAL LANDSCAPES
OFF THE NORTH COAST OF IRELAND
– CURRENT PROGRESS AND RECENT RESULTS**

Kieran Westley, Rory Quinn, Ruth Plets

Centre for Maritime Archaeology, University of Ulster, Northern Ireland, UK

Relative sea-level change around Ireland was spatially and temporally complex during its earliest phase of occupation, a result of isostatic adjustment following melting of the ice sheet that covered the island during the Last Glacial period. Consequently, coastal areas favoured by its Mesolithic inhabitants are now submerged by anywhere between 5 to 40 metres below present sea-level depending on local patterns of isostatic rebound.

Over the last three years, systematic research has been undertaken to reconstruct these submerged archaeological landscapes off the north coast of Ireland. The initial stages of this project utilized a variety of marine geophysical data (principally high resolution multibeam echosounder supplemented by seismic profiles) to search for evidence of past sea-level change and submerged landscapes on the continental shelf, produce palaeo-geographic reconstructions of the former landscape and identify areas of high potential for the preservation of archaeological and palaeo-environmental remains.

A programme of diving fieldwork is now underway to ground truth the conclusions of the initial stage. This paper will provide an overview of the research done to date, focusing in particular on the most recent results of the ground-truthing phase.

STONE AGE SETTLEMENT AND HOLOCENE SHORE DISPLACEMENT IN THE NARVA-LUGA KLINT BAY AREA, EASTERN GULF OF FINLAND

**Alar Rosentau^{1,2}, Aivar Kriiska², Merle Muru³, Hanna Raig¹, Dmitry Subetto⁴,
Dmitry Gerasimov⁵**

¹ Department of Geology, University of Tartu, Estonia

² Institute of History and Archaeology, University of Tartu, Estonia

³ Department of Geography, University of Tartu, Estonia

⁴ Department of Geography, Herzen State Pedagogical University of Russia

⁵ Institute of History and Material Culture, Russian Academy of Sciences

Based on geological and archaeological proxies from NW Russia and NE Estonia and on GIS-based modelling, shore displacement during the Stone Age in the Narva-Luga Klint Bay area in the eastern Gulf of Finland was reconstructed. The reconstructed shore displacement curve displays three regressive phases in Baltic Sea history, interrupted by the rapid Ancylus Lake and Litorina Sea transgressions c. 10.9–10.2 cal. ka BP and c. 8.5–7.3 cal. ka BP, respectively.

During the Ancylus transgression the lake level rose 9 m at an average rate of about 13 mm per year, while during the Litorina transgression the sea level rose 8 m at an average rate of about 7 mm per year. The results show that the highest shoreline of the Ancylus Lake at an altitude of 8–17 m a.s.l. was formed c. 10.2 cal. ka BP and that of the Litorina Sea at an altitude of 6–14 m a.s.l., c. 7.3 cal. ka BP.

The oldest traces of human activity dated to 8.5–7.9 cal. ka BP are associated with the palaeo-Narva River in the period of low water level in the Baltic basin at the beginning of the Litorina Sea transgression. During the rapid phase of the Litorina transgression c. 7.8–7.6 cal. ka BP, which is probably related to the final decay of the Labrador sector of the Laurentide Ice Sheet, some of the early settlements became eroded and buried under the Litorina deposits.

The coastal settlement associated with the Litorina Sea lagoon, presently represented by 33 Stone Age sites, developed in the area c. 7.1 cal. ka BP and existed there for more than 2000 years. Transformation from coastal settlement back to riverine settlement indicates a change from a fishing-and-hunting economy to farming and animal husbandry c. 4.4 cal. ka BP, coinciding with the time of the overgrowing of the lagoon in the Narva-Luga Klint Bay area (Rosentau et al., 2013).

ARCHAEOLOGICAL POTENTIAL OF ANCHIALINE CAVES IN CROATIA

Irena Radić Rossi¹, Neven Cukrov²

¹ University of Zadar, Croatia

² Ruđer Bošković Institute, Croatia

Anchialine caves are a common phenomenon in Mediterranean karstic areas. Their entrances are situated above the sea level, and underground fresh water percolating through the porous carbonate rock accumulates in their interior to form a layer floating above the sea water. This fresh water layer represented a significant resource of drinking water for the ancient inhabitants of the eastern Adriatic coast.

Due to the systematic work of a group of Croatian speleologists with geological and paleontological expertise, 87 anchialine caves have been registered along the Croatian coast and on the numerous islands.

Submerged speleothems from two caves, situated on the islands of Krk and Lošinj, have been used for reconstructing the Late Pleistocene and Holocene sea level changes in the northern part of the eastern Adriatic.

Archaeological finds have been recovered in at least 10 caves, but only the cave Vodeni Rat on the Pakleni Islands near the island of Hvar has been archaeologically researched. As in many other similar caves, human intervention on the rock walls has been identified, and from the bottom of the cave some Roman amphorae were recovered.

Another cave named Živa Voda, situated on the other extremity of the island of Hvar, revealed the presence of a great quantity of Bronze Age underwater finds, testifying to the intensive use of the fresh water from its interior.

Considering their distribution, accessibility, depths and location in relation to other well-known prehistoric settlements, we can assume that the anchialine caves of Croatia have a high archaeological potential that should be protected and researched. The lack of archaeological interest has already resulted in disturbance of some of the most interesting archaeological contexts.

**THE STUDY OF PALAEOGEOGRAPHIC EVOLUTION OF CASKA BAY
(PAG ISLAND, CROATIA) THE LAST 10 KYRS USING MARINE REMOTE
SENSING TECHNIQUES**

**Konstantina Soura¹, Maria Geraga¹, George Papatheodorou¹, Dimitris Christodoulou¹,
Kalliopi Baika², Stavroula Kordella¹, Elias Fakiris¹, Irena Radić Rossi³, Giulia Boetto⁴,
Kruno Zubčić⁵**

¹ Laboratory of Marine Geology and Physical Oceanography, Department of Geology, University of Patras, Greece

² Ephorate of Underwater Antiquities, Hellenic Ministry of Culture, Greece

³ University of Zadar, Croatia

⁴ Centre Camille Jullian (UMR 6573, Aix-en Provence), France

⁵ Croatian Conservation Institute, Croatia

In the framework of the international interdisciplinary research project *Cissa antiqua*, directed by the University of Zadar (Croatia) and Centre Camille Jullian, CNRS (France), a detailed marine remote sensing survey was carried out in the semi enclosed and elongated shallow bay of Caska, located in the central part of the island of Pag (Croatia). The survey was carried out by the Laboratory of Marine Geology and Physical Oceanography of the University of Patras (Greece).

The objective of the research is twofold: 1) the examination of the palaeogeographic evolution of the bay during the last 10 kyrs based on the seismic stratigraphy; and 2) the detection of surface and subsurface targets of potential archaeological significance.

In order to meet the objective three acoustic systems were used: Elac Nautic Hydrostat 4300 echo sounder, high resolution 3.5 kHz subbottom profiling system and towed E.G&G dual frequency (100, 500 kHz) side scan sonar system. Positioning data were obtained by a Hemisphere V100 GPS with an R.M.S. accuracy of 2 m.

The 3.5 kHz profiles showed that the upper 15 m consists of three distinct seismic sequences overlapping the gentle folded acoustic basement. The upper seismic sequence (0–3.5 m) is an almost acoustically transparent horizon with a few weak internal reflectors. The two lower sequences are characterized by stronger internal reflectors, whose amplitude appears stronger at the base of each sequence. The results of the seismic data in correlation with the present coastal geomorphology of the area suggest that these sequences correspond to phases of inundation by brackish water before seawater flooded the gulf, as a consequence of the sea-level rise. The side scan sonar survey revealed a large number of targets of potential archaeological interest. Moreover, the TARGAN software was used for selecting the most important targets.

SUBMERGED ATTICA: ARCHAEOLOGICAL AND MARINE GEOLOGICAL RESEARCH FOR THE LANDSCAPE RECONSTRUCTION OF SOUTH ATTICA, GREECE

Kalliopi Baika¹, Maria Geraga², George Papatheodorou², Christodoulou Dimitris², Elias Fakiris², Margarita Iatrou²

¹ Ephorate of Underwater Antiquities, Hellenic Ministry of Culture, Athens, Greece

² Laboratory of Marine Geology and Physical Oceanography, Department of Geology, University of Patras, Greece

Recent geoarchaeological research undertaken in South Attica on the palaeogeographic evolution of the area of Cape Sounion revealed extended submerged remains of ancient settlement. These are part of a considerable number of submerged coastal sites located on the coasts of Attica and on the Southern and Northern Euboean Gulf, including prehistoric settlements, sanctuary areas, ancient harbour-works, and remains of ancient industrial activities. The submerged archaeological record indicates severe relative sea level and geological changes since prehistory, yet it remains practically unexplored.

At Cape Sounion, an interdisciplinary study carried out from 2004–2006 included underwater archaeological and topographic investigations and marine geophysical surveys, undertaken by the Laboratory of Marine Geology and Physical Oceanography of the University of Patras (Greece) using marine remote-sensing techniques in shallow-water environments. The main objective was to reconstruct the diachronic palaeogeographical evolution of the extended area. Therefore, the study took into consideration a variety of archaeological RSL markers around the coasts of Attica, coastal and submerged sites on the South Euboean Gulf, as well as submerged settlements in the archipelago of the Cyclades. The evidence was correlated with geological information and archaeoseismology data of local tectonics.

The results provide new elements for the landscape reconstruction of South Attica and the study of the migration of the coastlines in Euboea and the central Aegean, as derived from geoarchaeological data.

Finally, the study revealed the urgency of adopting a sustainable coastal management policy, focusing on the protection and preservation of this rich submerged cultural heritage lying at several meters of depth and its potential for future exploration. This is especially the case for Attica, where the presence of human activity is attested on the current shoreline since early prehistory, which is the most populated area of Greece, today threatened by modern large-scale industrial projects in the coastal sector; and where, hence, there is a need for solid and efficient coastal management policies.

**SACRED LANDSCAPE ALONG THE SEA:
NEW INTERDISCIPLINARY DATA
FROM THE BRONZE AGE SOUTH-EASTERN SICILY**

Gianfranco Scicchitano¹, Elena Flavia Castagnino Berlinghieri², Antonioli Fabrizio³

¹ Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Università di Catania, Italy and Studio Geologi Associati T.S.T., Misterbianco (CT), Italy

² Soprintendenza Beni Culturali e Ambientali di Siracusa, Siracusa, Italy

³ ENEA e National Agency for New Technologies, Energy and Environment, Rome, Italy

Sacred landscape is a highly complex term that carries many meanings, beliefs and shapes, where any relationships or actions have different values in different settings. New studies have focused on the nature of coastal environments as characterised by significant heterogeneity and instability on a number of spatiotemporal scales, and have introduced notions of 'sea-level changes' or 'submerged landscapes'. Meanwhile increasing attention has been paid to the role of coastal landscape as an essential component of relationships associated to maritime activity, and also to the creation of ritual beliefs and social identity.

Through the analysis of two selected BA sites, Thapsos and Ognina, this poster will examine the geomorphological processes coupled to archaeological markers in order to offer some explanations on relative sea-level changes and on ritual practices in the use of sacred sea-shore rock-cut tombs.

Marine and terrestrial Geophysical data (Multi Beam Echo Sounder, LIDAR) have been collected to reconstruct the emerged and submerged topography of the studied areas. Moreover, accurate geological analyses and ¹⁴C AMS dating have been carried out in order to better define the ancient coastal landscape.

The interdisciplinary approach adopted in this research provides new data on relative sea-level change during the late Holocene, while at the same time it would bring together diverse approaches and methods for the analysis of nowadays submerged landscapes, as well as setting an outline for future directions in this specific field.

PLENARY SESSION THREE

SUBMERGED LANDSCAPES AND HUMAN DISPERSAL

THE ROLE OF SUBMERGED PREHISTORIC LANDSCAPES IN GROUND-TRUTHING MODELS OF HUMAN DISPERSAL

Nicholas Flemming

National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, UK

Analysis of both modern human DNA and fossil DNA provides the basis for innovative and plausible models of global hominin dispersal from Africa (e.g. Forster 2004; Genographic project). Recent discoveries in South Africa and elsewhere are increasing the scope for early developments and multiple early dispersals. However, the date scale of such analyses is uncertain, and has been revised at times by significant factors (Scally and Durbin 2012). While all prehistorians recognise that the continental shelf was exposed as terrestrial landscape for much of the Pleistocene, and played a key role as a route of migration and longer-term coastal settlement, the assumption that anthropogenic signals have been destroyed by marine transgression is still widespread (e.g. Klein 1999: 566; Mithen 2003: 24; Apenzeller 2012: 24–26).

Submerged prehistoric sites in primary or secondary condition have been found off a wide range of coastal types including rocky deglaciated coasts, alluvial depositional, deltaic and estuarine environments, circum-glacial low gradient plains, limestone karstic cliffs, low-gradient sandy beaches, sub-tropical sandy coasts, submerged caves, fossil beaches, peat marshes, alluvial and wetland archipelago, submerged river gravels, and in varied oceanographic conditions from sheltered lagoons to exposed oceanic coasts (Stright 1990; Benjamin *et al.* 2011; Faught and Gusick 2011). Conditions which preclude discovery include regions of massive seabed erosion, and those where modern reef-building corals have built over the original sites, but there are often extensive areas of non-reef-growth even in tropical coral-growing zones. Mangrove forests and tropical wetlands are probably another environment which will be unproductive for prehistoric remains.

Submerged sites have been found in both the northern and southern hemispheres. (Werz and Flemming 2001; Cartajena *et al.* 2011). The DNA-based models which refer to shelf-wise migration or residence on the shelf are valuable as postulates (e.g. Apenzeller 2012; Genographic project; Soares *et al.* 2008), but they require ground-truthing, and the evidence from SPLASHCOS and other projects outside Europe indicates that significant advances of this kind can be achieved in the next decade. This paper analyses the taphonomic evidence for the link between conditions and survival, with examples, and relates discoveries to key regional questions. The logical strategy for the future is to collaborate between DNA modelling and seabed site data analysis such as SPLASHCOS, Deukalion, and SUBLAND.

References

- Apenzeller, T., 2012: Eastern Odyssey, *Nature* 485 (7536) 24–26.
- Benjamin, J., Bonsall, C., Pickard, C. & Fischer, A. (eds). *Submerged Prehistory*, Oxbow Books.
- Cartajena, I., et al., 2011: Arqueología subacuática y Tafonomía: *Recientes avances en el estudio de sitios Finipleistocénicos*.
- Forster, P., 2004: Ice Ages and the mitochondrial DNA chronology of human dispersals. *Phil. Trans. Roy. Soc. London. B*. 358: 255–264.
- Genographic Project: <https://genographic.nationalgeographic.com>.

- Klein, R.G., 1999: *The Human Career*. University of Chicago Press, Chicago & London. Mithen, S. 2003. *After the Ice*. Weidenfeld and Nicolson. London.
- Scally, A. & Durbin, R., 2012: Revising the human mutation rate: implications for understanding human evolution. *Nature Reviews Genetics*. 13, 745–753.
- Soares, P., et al., 2008: Climate Change and post-glacial human dispersals in Southeast Asia. *Molecular Biology and Evolution* 25 (6): 1209–1218.
- Stright, M.J., 1990: Archaeological sites on the North American continental shelf. *Geological Society of America* 4: 439–465.
- Werz, B. & Flemming, N.C., 2001: Discovery in Table Bay of the oldest handaxes yet found underwater demonstrates preservation of hominid artefacts on the continental shelf. *South African Journal of Science* 97, 183–185.

FLOODED LANDSCAPES, HUMAN CULTURAL DIVERGENCE AND THE NORTH SEA BASIN

Garry Momber¹, Hans Peeters²

¹ Maritime Archaeology Trust, National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, UK; email: garry.momber@hwtma.org.uk

² Groningen Institute of Archaeology, University of Groningen, Poststraat 6, 9712 ER Groningen, The Netherlands; email: j.h.m.peeters@rug.nl

Assessment of the coastlines along the North Sea basin and Channel as part of the SPLASHCOS review demonstrates that they are rich in prehistoric archaeological and palaeo-environmental material. The finds are primarily recorded in palaeo-channel infill deposits and following erosion of soft cliffs. However, archaeological material recovered from the relict landscapes that are now submerged is comparatively limited.

This has proven problematic when interpreting the cultural and technological divergence between Britain and Continental Europe that is witnessed during the early Holocene. This was the time when sea levels rose to form islands, separate populations and remove access to vast tracts of land. Indeed, it can be argued that the focal point from which human populations dispersed is centred in the areas of the north-west continental shelf that are now submerged.

This paper will look at how the limited number of isolated finds from the North Sea contrasts with the numerous coastal discoveries and the discovery of rich deposits of archaeological material following targeted inspection at La Mondrée near Cherbourg (FR), Maasvlakte-Rotterdam (NL) and Bouldnor Cliff (UK).

These sites demonstrate the potential of archaeological material within drowned and buried environments. They also suggest that similar deposits remain within palaeolandscapes. If so, it is here we need to look to address the lacuna that is restricting our understanding of human dispersal and colonization as Europe took shape.

LANDSCAPES LOST: NEW ARCHAEOLOGICAL/GEOLOGICAL EXPLORATIONS OF THE FLOODED LANDSCAPES OF THE EARLY HOLOCENE IN THE SOUTHERN BALTIC

**Björn Nilsson¹, Svante Björck², Dan Hammarlund², Joakim Holmlund³,
Martin Jakobsson⁴, Johan Rönnbj¹, Arne Sjöström¹, Oscar Törnqvist¹**

¹ MARIS, Södertörn University, Sweden

² Quaternary Sciences, Department of Geology, Lund University, Sweden

³ MMT AB, Sweden

⁴ Department of Geological Sciences, Stockholm University, Sweden

In 2012 MARIS (Maritime Archaeological Research Institute at Södertörn University, Stockholm, Sweden) launched an ambitious research project: *Landscapes Lost. Exploring the Early Holocene Sub-Marine Landscapes in Southern Baltic Sea*. The goal is to archaeologically survey, examine and discuss the sunken landscapes of the early Holocene in the southern Baltic Sea.

The project concentrates on the postglacial river mouth of the Verkeån, South East Scania and the Blekinge archipelago. Another interest is the unknown archaeological potential of the more distant shallow banks of the southern Baltic such as Södra Midsjöbanken.

The aim is to bring together archaeology and several other landscape disciplines, from the fields of geology, geography and biology. Hence, the project is a collaboration between several institutes and companies. The project has resulted in several new findings and significant sites that yield new information on both the cultural and natural processes at hand during the very beginning of the Holocene.

The paper discusses the results achieved from an archaeological interpretative perspective, and focuses on how such research can stimulate truly humanistic perspectives within the realm of technology and natural sciences.

PLEISTOCENE SUBMERGED LANDSCAPES AND PALAEOLITHIC ARCHAEOLOGY IN THE TECTONICALLY ACTIVE AEGEAN REGION

Dimitris Sakellariou¹, Nena Galanidou²

¹ Institute of Oceanography, Hellenic Centre for Marine Research, 19013 Anavyssos, Greece

² Department of History and Archaeology, University of Crete, Rethymnon, Crete, Greece

In this paper we review the main geological and tectonic processes which have controlled the evolution of the submerged Pleistocene landscapes in the Aegean Region and discuss the potential for the survival of Palaeolithic remains on the seafloor of the continental shelf.

The Aegean Region is a land-locked sea that has repeatedly become an archipelago when sea levels rise. During Pleistocene low sea level stands many of its present islands were connected to the Eurasian mainland, so offering to hominins a much larger area of land to live in than the one seen today. Part of this landmass now lies beneath the sea; it carries the potential to yield precious palaeogeographic and archaeological material for research into the origins of humanity. It holds many clues to the study of hominin dispersals from Africa into Eurasia and vice versa and to hominin adaptations, mobility and settlement patterns.

The Aegean Region is a unique environment in terms of active geodynamics, plate movements, on-going geological processes, formation of new relief and dynamically changing landscapes. Long-term geodynamic and geotectonic processes along with short-term geological phenomena are the driving mechanisms for the evolution and continuous change of the landscape, both above and below sea level. The geodynamic outline and morpho-tectonic structure of the Aegean provide the frame for discussion of the morphological evolution of the continental shelf and reconstruction of the submerged landscapes. The geological, tectonic and hydrological background provides information for the assessment of the natural resources available to hominins.

Geological, morphological and hydrogeological data along with the palaeogeographical evolution of the shallow coastal and shelf areas are examined in parallel with the terrestrial archaeological record to open windows to future research.

**TO THE ISLANDS: THE ARCHAEOLOGY OF BARROW, MONTEBELLO
AND DAMPIER ARCHIPELAGO ISLANDS, NORTH-WEST AUSTRALIA
AND ITS IMPLICATIONS FOR DROWNED CULTURAL LANDSCAPES**

Peter Veth

School of Social and Cultural Studies, University of Western Australia

This talk will profile 'deep-time' human occupation of Barrow and Montebello Islands; and then draw lines over the submerged north-west shelf to the 42 islands of the Dampier Archipelago which host some 2M petroglyphs. These islands are 'time capsules' of information about the nature and antiquity of Indigenous occupation of the now-drowned coastal landscapes of the northwest shelf of Australia.

For the first time the rich occupation records of the relatively well-dated limestone islands, with evidence for emergent maritime economies, will be linked to the poorly dated, but globally significant, rock art corpus engraved into the jagged volcanic rocks of the Dampier Archipelago. In concert, these records speak to a fecund drowned cultural landscape which now awaits (re)discovery.

This 'window' into a drowned landscape off northern Australia speaks to the larger issue of the role of submerged landscapes in understanding the southern dispersal of anatomically modern humans from Africa through southern Asia, SE Asia, the Wallacean islands and finally into Australia and New Guinea.

New evidence for maritime competencies comes from excavations within caves in uplifted coralline terraces in East Timor. These occupations date to before 40,000 years ago and raise the high likelihood of early drowned sites containing similarly rich maritime assemblages. Clearly the ethnographically documented maritime craft for Australasia were recent regional adaptations and unlike those used in the original diaspora.

DROWNED QUATERNARY ENVIRONMENTS AND THE SIGNIFICANCE FOR THE SOUTH AFRICAN SOUTHERN CAPE ARCHAEOLOGICAL RECORD

Hayley C. Cawthra^{1,2}, Erich C. Fisher³, John S. Compton², Curtis W. Marean³

¹ Marine Geoscience Unit, Council for Geoscience, South Africa

² Department of Geological Sciences, University of Cape Town, South Africa

³ Institute of Human Origins, School of Human Evolution and Social Change, Arizona State University, USA

Archaeological results in the southern Cape, South Africa, suggest that early modern humans focused their occupation on the coastline and thus would have followed it out onto the now submerged continental shelf in response to retreating Quaternary sea-levels. A high-resolution model of these sea-level and coastline fluctuations in the vicinity of Mossel Bay, offshore of the Pinnacle Point site, shows that during most of this time the shoreline was positioned between several kilometres and up to 95 km away from the current coastal caves.

The contemporary Mossel Bay shoreline is a geologically, sedimentologically, climatically and biologically complex zone. This relatively narrow band migrates with falling sea levels onto the continental shelf. Although the rate of erosion in the marine environment is typically high, preservation of fragments of palaeoshorelines in the offshore record has allowed a window of opportunity to map and unravel the sequence of events associated with sea-level regressions and subsequent transgressions.

Here, we discuss well preserved submerged Quaternary palaeocoastlines, which consist of numerous stacked geomorphic features (seafloor caves, clastic facies of dunes and beaches, and lower energy back-barrier deposits, lacustrine deposits and estuarine deposits). These features were mapped from present Mean Sea Level to a depth of –55 m using ultra-high resolution marine geophysical instruments. In addition to deposits of remnant coastlines, we will also present evidence for three significant fluvial systems that have incised the inner- to mid-shelf in this region.

**AFRICA-ARABIA CONNECTIONS: EARLIEST HUMAN DISPERSALS
AND GEO-ARCHAEOLOGICAL EXPLORATION OF THE CONTINENTAL SHELF
OF THE RED SEA, SAUDI ARABIA**

**Geoff Bailey¹, Dimitris Sakellariou², Abdullah Alsharekh³, Salem Al Nomani⁴,
Panos Georgiou², Manolis Kallergis², Stefanos Kalogirou², Lionidas Manousakis²,
Prokopis Mantopoulos², Matthew Meredith-Williams¹, Garry Momber¹,
Ioannis Morfis², Ioannis Pampidis², Ioannis Panagiotopoulos², Panagiotis Renieris²,
Grigoris Rousakis², Vasileios Stasinou², Spyros Stavrakakis²**

¹ Department of Archaeology, University of York, York, YO1 7EP, UK; email: geoff.bailey@york.ac.uk

² Hellenic Centre for Marine Research, 19013 Anavyssos, Greece

³ Department of Archaeology, King Saud University, P.O. Box 2627, Riyadh, 7524-12372, Kingdom of Saudi Arabia

⁴ Saudi Geological Survey, P.O. Box 54141, Jeddah, 21514, Kingdom of Saudi Arabia

In the past decade, genetic, archaeological and human fossil evidence has increasingly pointed to the southern crossing of the Red Sea as a major dispersal pathway for the exit of anatomically modern humans from Africa after about 150,000 years ago, and quite possibly for archaic hominins earlier in the Pleistocene. During low sea-level stands, the sea crossing was relatively narrow, and extensive areas of the continental shelf were exposed as potentially attractive landscapes for human settlement. The Red Sea region is thus of high interest both for archaeologists because of its key role in the global picture of human evolutionary origins and dispersal, and for marine geoscientists because it offers unusual opportunities as a 'laboratory' for investigating Pleistocene sea-level change (Lambeck et al., 2011, *Quaternary Science Reviews* 30 (25–26): 3542–74).

Here, we report on a preliminary exploration of the submerged landscapes of the southern Red Sea by the HCMR Research Vessel, R/V AEGAEON, in May–June 2013. The project has been developed as an international and interdisciplinary collaboration arising directly out of the SPLASHCOS initiative, and is nested within the wider ERC-funded project DISPERSE (Bailey et al. 2012).

This is one of very few examples anywhere in the world of an underwater project informed by joint archaeological and marine-geoscientific thinking with the aim of exploring systematically the submerged landscapes of the continental shelf down to the shelf margin at ~130 m depth, and targeting features of significance in relation to the archaeological potential of the submerged landscape including geological structure, palaeoenvironment, and sea-level change.

The project has incorporated strategic features and faced challenges that provide a template for such investigations, and lessons for the future. These include the importance of combining offshore work with investigation of the archaeology on land; the deployment of a variety of underwater technologies including bathymetry, acoustic imaging, seismics, sediment-coring, ROVs and diving; investigation of the underlying geological structure of the shelf, which is especially complex because of combined rifting and salt tectonics; and targeting of features of the submerged topography that might have served both as attractors of human settlement and as locations for the preservation of archaeological evidence.

References

- Bailey, G.N., King, G.C.P., Devčs, M., Hausmann, N., Inglis, R., Laurie, E., Meredith-Williams, M., Momber, G., Winder, I., Alsharekh, A. & Sakellariou, D., 2012: DISPERSE: dynamic landscapes, coastal environments and human dispersals. *Antiquity* 86 (334). <http://antiquity.ac.uk/projgall/bailey334>.
- Lambeck, K., Purcell, A., Flemming, N., Vita-Finzi, C., Alsharekh, A. & Bailey, G.N., 2011: Sea level and shoreline reconstructions for the Red Sea: isostatic and tectonic considerations and implications for hominin migration out of Africa. *Quaternary Science Reviews* 30 (25–26): 3542–74, 2011.

THE SOCIAL AND ECONOMIC IMPORTANCE OF THE SUBMERGED COASTS OF EUROPE – HOW TO BEAT AROUND THE BUSH AND STILL GET SOME RESULTS

Håkon Glorstad

Museum of Cultural History, University of Oslo, Norway

Scholars of the French epistemological tradition have demonstrated that key issues in philosophy can be analysed in completely new and thought provoking manner by investigating topics so far deemed to be of peripheral importance to philosophy. For instance, rationality has been investigated through the history of madness; aesthetics through research in popular taste. This perspective on research is of importance to archaeology, and in particular to the present state of research on submerged landscapes, since technical and economical obstacles obstruct a direct empirical approach to sites in deep water.

This methodological point is illustrated by a case study of the earliest settlement structures of Scandinavia, where a marine economy and way of life is demonstrated from the beginning of the Holocene. The main argument, as recently discussed by several scholars, is that the long-lived and distinct marine adaptations documented in Scandinavia, could be representative of the rest of Europe. The relatively slow adoption of agrarian economies throughout the European continent will also be discussed with reference to the Scandinavian data sets.

By enhanced focus on the peripheral or indirect data sets available for research on early European coastal societies, the scene can be prepared for new and more focused research strategies for identifying and investigating sites in submerged landscapes. This “beating around the bush” perspective could thus facilitate a more firm grip on the core problem of the SPLASHCOS, that is, how to analyse directly prehistoric settlement and subsistence on the Continental Shelf. Finally, plans for such an interdisciplinary, multinational project are briefly presented.

PLENARY SESSION FOUR

UNDERWATER ARCHAEOLOGICAL SITES

EVALUATING THE ARCHAEOLOGICAL RECORD FROM THE CONTINENTAL SHELF – A SUMMARY OF FACTS AND POTENTIAL

(SPLASHCOS Working Group 1)

Anders Fischer

The Danish Agency for Culture, H.C. Andersens Boulevard 2, DK-1553 Copenhagen V, Denmark

This paper summarizes the prehistoric archaeology of the continental shelf of Europe and neighbouring regions. It presents research questions, actions, results and experiences relating to the pan-European activities of the archaeology group of SPLASHCOS.

An overview is given of the archaeological sources presently known: settlements, burials, sacrificial sites, art items, boats, stationary fishing structures, megalithic structures, bone 'fossil' sites, etc.

Examples of the special preservation quality of the archaeological record from the seabed are given, and the reasons for the extremely uneven distribution of known sites across the European continental shelf are discussed.

Finally, suggestions for future pan-European initiatives pertaining to the archaeological record of submerged prehistory are proposed.

SUBMERGED SETTLEMENT IN THE ÖRESUND STRAIT, SOUTHERN SWEDEN

Lars Olof Georg Larsson

Institute of Archaeology and Ancient History, Lund University, Sweden

In order to obtain information on coastal settlement during the Early Mesolithic, marine archaeological investigations on the Swedish side of the strait Öresund have been carried out since the 1970s.

At least four Early Mesolithic sites were registered, the depth of which varied between –20 and –6 m. One of these sites is layered in peat and situated at a depth of –7 to –8 m and has been dated to 6000 cal. BC. Finds of bones and worked wood make this a very important find location.

Finds from different activities along the southern coast line of Öresund have revealed a number of submerged sites from the Early Mesolithic. These sites and their distribution are compared to the location of sites from the Late Mesolithic.

TUDSE HAGE – UPDATE ON A 7000-YEAR-OLD SUBMERGED STONE AGE SETTLEMENT WITH UNIQUE PRESERVATION CONDITIONS AND POTENTIAL FOR LOCATING OLDER PHASES IN DEEPER WATER

Jørgen Dencker

The Viking Ship Museum, Roskilde, Denmark; email: jd@vikingeskibsmuseet.dk

One of the best preserved known submerged Stone Age settlements in the world is Tudse Hage situated at the mouth of Skaelskoer Fjord on the west coast of Zealand. For many years it has been well known that the preservation conditions at Tudse Hage are excellent. Investigation during recent years has shown that the potential of the location in many ways is much greater than expected. The site, which is dated to around 5000 BC is not only important because of its preservation conditions, but also because it opens up the possibility of mapping older coastlines and locating settlements down to 10 meters water depth that might be 2000 years older than the known site.

Excavation in 2010 along a former coast line showed extremely well preserved materials, and even green leaves were found. The recent investigations have unfortunately shown a severe erosion of the shallowest part of the settlement and in some areas the culture layers have already been eroded away. Only the vertical posts from up-standing fishing gear are left.

A rescue excavation of the shallower parts of this unique settlement is needed and in the EU-funded SASMAP project artificial sea grass mats will be tested in different water depths, and new tools for recovery and stabilization of soft wooden artefacts will be developed.

HJARNØ: AN ERODING MESOLITHIC SITE WITH ORGANIC MATERIALS

Claus Skriver

Moesgård Museum, Denmark

In 2009 it was realized that a submerged settlement in Horsens Fjord, Denmark was rapidly eroding. Since then the site has been surveyed and test excavated by underwater archaeologists.

In connection with these investigations, there are, among other artefacts found, objects of organic material like antler and wood. The artefacts are preserved in anaerobic gyttja and give us a rare glimpse into the Late Mesolithic Ertebølle Culture tool inventory beyond the usual flints. Several of the objects are ornamented and in light of this we can, by comparison with contemporaneous Danish findings, begin to make interpretations in terms of regional identity and ethnicity within the Ertebølle Culture.

FISHED UP FROM THE BALTIC SEA – A NEW ERTEBØLLE SITE NEAR STOHL CLIFF LINE (BAY OF KIEL)

Julia Goldhammer¹, Sönke Hartz²

¹ Niedersächsisches Institut für historische Küstenforschung (Lower Saxony Institute for Historical Coastal Research), Wilhelmshaven, Germany

² Archäologisches Landesmuseum der Stiftung Schleswig-Holsteinische Landesmuseen (State Archaeological Museum of Schleswig-Holstein), Schleswig, Germany

In June 2012 scientific divers and students from Kiel University supported by the State Archaeological Department of Schleswig-Holstein excavated test trenches on a new Mesolithic site named "Strande". Prior to this, two professional divers had found tree trunks and flint artefacts six metres below the surface.

The site is characterised by different peat and organic silt layers, containing a large number of lithics as well as organic finds. These include wooden objects, botanical remains, bones of different marine and freshwater fish, as well as sea and land mammals. Notably, fragmented human bones were also found. Tree ring dating, radiocarbon dates of leister prongs, human bones and the inventory of artefacts pinpoint the site to the older pre-pottery Ertebølle phase (5400–5000 BC). Sites of this time period are rare in the Southwestern Baltic Sea area. Only very few sites, for example, Jäckelberg-Nord and Rosenfelde, have been examined in detail.

Further investigations at Strande are planned. They could give additional insights into the way of life during a time of rapid environmental changes. The inundation of land in the Baltic Sea area changed the habitat of humans within a few generations. The Strande site illustrates, on the one hand, how humans kept their traditional way of living by hunting land mammals and, on the other hand, adapted to the new circumstances by using marine resources such as catching marine fish in the shallow waters, building log boats, and hunting seals.

**SUBMERGED LATE MESOLITHIC SITES ON THE JÄCKELBERG,
NORTH OFF POEL ISLAND, WISMAR BAY.
MECKLENBURG-VORPOMMERN, GERMANY – AN UPDATE**

Harald Lübke, John Meadows, Ulrich Schmölcke

Centre of Baltic and Scandinavian Archaeology, Schleswig-Holstein State Museums Foundation, Schloss Gottorf, Germany

In the 7th and 6th millennium BC the hunter-gatherer populations of the North European plain were confronted by massive changes to their environment, not only by the increasing reforestation of the landscape but also by the rapid sea-level rise of the world ocean. This process led to the final flooding of the Baltic basin and to the origin of the present Baltic Sea.

The investigation of the human reaction to this fundamental environmental change was a main task of the geoarchaeological work group of the interdisciplinary DFG Research Unit *SINCOS* (www.sincos.org) from 2002 until 2009. One of the main regions of investigation was Wismar Bay in western Mecklenburg-Vorpommern.

Several Stone Age sites were located during surveys with research vessels using geoscientific equipment, such as side-scan sonar, multi-beam and sediment echo sounder, and remotely controlled underwater video camera, in water 6.5 to 11 m deep, north of Poel Island. The sites belong to different phases of the Late Mesolithic and the early Terminal Mesolithic, between 8500 and 7000 cal BP. The best preserved sites were further investigated by underwater archaeological excavations.

The paper will give a brief overview of the most important and newest archaeological and archaeozoological results of the ZBSA's investigations after the end of the *SINCOS* project in 2009.

SUBMERGED NEOLITHIC SETTLEMENTS OFF THE CARMEL COAST AND THE TRANSITION FROM PRE-POTTERY TO POTTERY NEOLITHIC CULTURES ON THE LEVANT COAST

Ehud Galili¹, Vered Eshed², Baruch Rosen²

¹ Israel Antiquities Authority; Zinman Institute of Archaeology, University of Haifa, P.O.B 180, Atlit 30350, Israel, email: udi@israntique.org.il

² Israel Antiquities Authority

Submerged settlements off the Israeli Carmel coast demonstrate important aspects of Neolithic cultures. These sites (9200 to 8000 cal BP) were exposed underwater as a result of anthropogenic erosion. The Pre-Pottery Neolithic C (PPNC) site of Atlit-Yam included rectangular stone buildings, megalithic structures, stone-built water wells and human burials. The economy was based on agro-pastoral and marine resources. Herding of domesticated ungulates was accompanied by hunting. Water wells enabled permanent coastal habitation for the first time in this area.

Later Pottery Neolithic (PN) Wadi Rabah culture sites included water wells constructed of wood and stone as well as installations for extracting olive oil. At the Neve-Yam PN site, human skeletons were interned in stone graves. The PN sites revealed a fully agricultural subsistence economy. The sites exhibit the emergence of the Mediterranean fishing village on the south Levant coast and the beginning of olive oil extraction, a major component of Mediterranean subsistence.

The transition to farming and sedentarism modified land-uses, including changes in burial practices. The submerged sites demonstrated significant changes in burial practices and contributed to understanding the evolution of such practices in the Levant: In PPN Atlit Yam site burials were in un-built pits dug in open spaces and near dwellings all over the site, while in Neve-Yam PN site, burials were in stone-built cist graves concentrated in an organized burial ground, separated from the dwelling area. The organized intramural burial ground identified in Neve Yam is one of the oldest known of its kind. This type of burial became a common practice during the following Chalcolithic period and in most modern human societies.

SUBMERGED PREHISTORIC SITES FROM POLISH INLAND AND COASTAL WATERS

Andrzej Pydyn, Mateusz Popek

Department of Underwater Archaeology, Nicolaus Copernicus University, Toruń, Poland

Submerged late prehistoric and Medieval sites are relatively well known from Polish inland waters. Sites of earlier chronology dated to the Mesolithic, Neolithic and Early Bronze Age are less frequent, nevertheless a few examples of them have been found. The best known are Klasztorne Lake and Kurka Peninsula on Mamry Lake, where remains of Neolithic settlements were found. Also on lakes Radomno and Cieśle, Stone Age tools and pottery were discovered. Furthermore, on the Plotki Lake a so called votive deposit of the Corded Ware Culture was found. There are no Mesolithic settlements known from inland waters but there are a few single finds from lakes: Gil Wielki, Mausz, Kopań and Miedwie. There are also a few Stone Age finds from Wisła and Odra rivers.

A high potential for underwater archaeological research is also in coastal areas of the Baltic Sea. It is unrealistic that well known submerged sites of Denmark and Germany stop suddenly on the Oder river. In the central part of the Polish Baltic coast, not far from the well known Mesolithic site Dąbki, stone axes, bone tools, and amber pieces were discovered on a beach near Lake Kopań and Bukowo. Also in the Gdańsk Bay and particularly Puck Bay stone tools, probably dated to the Neolithic or Early Bronze Age were found.

Submerged prehistoric sites known from Polish inland and coastal waters have a significant value. These sites often provide numerous organic artefacts unknown from other settlements. They are also sources of information about postglacial and early Holocene environment and landscape changes

THE LOWER SAXONY WADDEN SEA: A MARINE LANDSCAPE WITH HIGH RESEARCH POTENTIAL

Julia Goldhammer¹, Martina Karle¹, Sunhild Kleingärtner²

¹ Niedersächsisches Institut für historische Küstenforschung, Wilhelmshaven

² Deutsches Schiffahrtsmuseum, Bremerhaven

The Wadden Sea area is characterized by strong tidal changes and sediment movements. Since the end of the last glacial period this marine landscape has gone through innumerable changes, and is still undergoing change. It was used by humans until the Holocene inundation took place. Contemporary sediment shifts give the opportunity to gain insight into sunken settlements and palaeolandscapes but may also destroy the rich geological and archaeological record. In recent years, increasing coastal protection and offshore industries threaten the cultural heritage more than ever.

There is evidence of artefacts and records from the Stone Age. Most of the artefacts are single finds found without any context, such as a bell beaker, located in the very Western part of the Lower Saxony Wadden Sea area. But there is also proof of in-situ-records, including sacrificial pits and submerged wood from the then Schleswig-Holstein Wadden Sea area.

The project *Settlement and Cultural History of the Wadden Sea Area in Lower Saxony* aims to document the cultural heritage of the Lower Saxony Wadden Sea, which covers a territory of 3,525 km². By analysing a variety of basic geological data, palaeogeographical changes of the modern coastal area will be reconstructed in order to identify zones of particular archaeological interest. The recording of known sites, prospecting for new sites and the investigation and subsequent monitoring of both will show the research potential of this tidal region and will help to preserve the cultural archive before erosion destroys it. By this means the project aims to get new insights into the development and anthropogenic use of the Wadden Sea area.

DISCOVERING THE SUBMERGED SITES OF EUROPE – THE SPLASHCOS-VIEWER

Hauke Jöns

Lower Saxony Institute for Historical Coastal Research, Viktoriastr. 26/28, 26382, Wilhelmshaven, Germany

The SPLASHCOS project aims to provide a forum for exchange of information about finds, sites and research strategies, and to inform the general public about submerged landscapes and sites in European waters and to raise awareness of them as important sources for the reconstruction of climate, landscape and settlement history. Therefore after long and intensive discussion within the SPLASHCOS community, it was agreed that it would be important to have a web-based and easily accessible tool that could serve both purposes.

This system was developed with the support of representatives from all SPLASHCOS member States – so it is a collaborative outcome of the SPLASHCOS network. At the moment the SPLASHCOS viewer is still work in progress, and this paper will present the actual state of the project rather than the final version

The viewing component of the SPLASHCOS viewer is planned to be a simple GIS-based application that makes it possible to visualise the position of all known prehistoric submerged sites of Europe as locations on the GeoSeas-website (<http://www.geo-seas.eu/>). In addition the SPLASHCOS viewer offers basic data about these sites such as type of site, age, method of dating, preservation of organic material or water depth. So it will not only show the different state of research in the different European regions and States but also the high scientific potential that sites may offer.

The viewer will also facilitate searches on an European scale for sites e.g. of a special chronological phase, for sites with preserved organic material or for sites that are dated with ¹⁴C. In addition the viewer offers further information and references; for sites from some countries it may also provide weblinks to national databases of heritage agencies or research institutions. Summarising the viewer will hopefully be an important link between citizens, stake-holders and researchers, interested and engaged in the submerged prehistory of Europe.

PLENARY SESSION FIVE

**SURVEY STRATEGIES, TECHNIQUES AND COLLABORATION
WITH INDUSTRY**

A REVIEW OF ACOUSTIC SURVEY STRATEGIES IN MARITIME ARCHAEOLOGY

(SPLASHCOS Working Group 3)

Ole Grøn^{1,2}, Tine Missiaen³

¹ Culture & Preservation, Denmark

² Strandingsmuseum St. George, Denmark

³ Ghent University, Renard Centre of Marine Geology, Krijgslaan 281 – S8, B-9000 Ghent, Belgium

This presentation provides an overview of acoustic techniques used in underwater archaeological survey in recent years, and assesses the results, with a particular focus on the use of high resolution penetration systems for mapping Stone Age sites under water.

We will also discuss the relationship between traditional methods of exploration using survey methods designed for geological purposes and survey strategies and techniques optimised for research on submerged archaeological landscapes.

**RESOLUTION OF SEISMICS USED FOR UNDERWATER ARCHAEOLOGY
AND A POSSIBLE NEW TECHNIQUE
FOR ACHAEOLOGICAL UNDERWATER SURVEY**

Ole Grøn^{1,2}, Jean-Pierre Hermand³

¹ Culture & Preservation, Denmark

² Strandingsmuseum St. George, Denmark

³ Université libre de Bruxelles (U.L.B.), av. F.-D. Roosevelt 50, CP194/051050 Bruxelles, Belgium

Acoustic technologies are well established in underwater work and have been widely used in all types of underwater archaeology. However one has to be aware of the relationship between the dimensions of the features one wishes to observe and the resolution (frequency/wavelength) of the equipment one uses, if one is to be successful in identifying new finds. Acoustic technology and techniques are constantly undergoing new developments, and this offers new opportunities for archaeologists posed with the challenge of finding submerged Stone Age materials, often quite small and indistinguishable from the seabed background, to develop new methods of detection in collaboration with the latest developments in acoustic science.

We will discuss a new method that has been inspired by the need for the discovery of underwater archaeological remains, often in relatively small concentrations that are typical of Stone Age archaeological signatures, and which has the potential to detect some types of artefacts even when buried beneath a covering layer of sediment.

Tests have shown that different types of materials such as sediments and stone artefacts have distinctive acoustic signatures that can, in principle, be detected by high-resolution acoustic techniques. The viability of this method is still undergoing tests, and we will present here an outline of the techniques and our preliminary results.

INTEGRATION OF SEAFLOOR AND SUBSEAFLOOR ACOUSTIC SURVEY TECHNIQUES IN UNDERWATER GEOARCHAEOLOGICAL RESEARCH

Dimitris Sakellariou

Institute of Oceanography, Hellenic Centre for Marine Research, 19013 Anavyssos, Greece

Remote sensing seafloor mapping techniques, like multi beam echosounders and side scan sonar systems, are powerful tools in seabed mapping. Their use in applications for shallow and deep-water geoarchaeological research has increased steadily during recent decades and they have proved their efficiency on many occasions.

In many (more) other cases these techniques have shown their limitations in providing the user with sufficient data for a geologically and physically correct interpretation of the nature of the seafloor and the recognition of archaeological remains.

Here, we present some clues and suggestions for methodological schemes and best use of side scan sonar in seabed mapping surveys. A considerable part of this paper is devoted to the usefulness and in many cases necessity of integrating more than one data set in order to achieve best results in the interpretation of the nature of the seabed and the sub-seafloor structure.

Advantages and disadvantages of side scan sonar and multi beam systems are discussed. Integrated use of sub-bottom profilers in parallel with side scan sonar and or multi beam survey provides information on the geological and sedimentological structure of the seafloor's shallow substrate and contributes towards a more precise and geologically consistent interpretation of the acoustic character of the seafloor. The advantages of using various types of high resolution sub-bottom profilers in parallel with side scan sonar prospecting and swath bathymetry is described.

The aim of this contribution is to assist users of remote sensing techniques to obtain best results during seabed mapping for geoarchaeological surveys, particularly for the reconstruction of submerged landscapes and mapping of prehistoric remains.

BEYOND DOGGERLAND: OPPORTUNITIES AND RECENT WORK IN THE NORTH SEA

Simon Fitch, Vincent Gaffney, Eleanor Ramsey

University of Birmingham, UK

The Mesolithic Landscape of the North Sea has long been considered as *terra incognita* by archaeologists prior to the North Sea Palaeolandscape Project. Building upon the success of that project, new research has been carried out beyond the English national boundary to extend the Palaeolandscape mapping to some 48,000 square kilometres of Holocene land surfaces submerged in the North Sea. This paper will present the atlas of the most recent data and associated analysis that may now allow us to consider the scale and scope of the landscape change in the North Sea during the Mesolithic. The results of this recent work illustrate many new features that demonstrate the diversity of the landscapes present and the environments that would have supported a vibrant Mesolithic community.

SUBMERGED DEPOSITIONAL TERRACES AS A TOOL TO RECONSTRUCT SEALEVEL FLUCTUATIONS IN INSULAR VOLCANIC ISLANDS: EXAMPLES FROM THE ITALIAN SEAS

Francesco Latino Chiocci¹, Claudia Romagnoli², Daniele Casalbore³

¹ Sapienza, Università di Roma, Italy

² Università di Bologna, Italy

³ CNR-IGAG, Roma, Italy

Submerged depositional terraces (SDT) are small prograding sedimentary bodies found on the upper slopes of Italian volcanic islands and tectonically-controlled coasts (generally within 150 m water depth). Their formation is thought to be completely subaqueous, with their upper boundary close to the sea-level and their outer edge matching the storm-wave base level. It is noteworthy that different orders of terraces have been recognized and possibly related to different stillstands during the glacial maximum and successive sea-level rise.

However, until now the study of these bodies was based only on a set of high-resolution seismic profiles, a very useful tool to reconstruct their inner geometry but not able to depict the lateral continuity of these bodies. This problem was solved by recent advances in multibeam bathymetry, enabling a detailed seafloor mapping, with the spatial reconstruction of these sedimentary bodies.

For the first time, this dataset offers a unique opportunity to better understand which factors control the SDT formation, and consequently to define their possible use as a proxy to reconstruct sea-level fluctuations. These data can also provide useful insights to discriminate between eustatic and tectonic contributions, especially in very active settings as in the case of volcanic islands. The aim of this work is to show some examples of such an approach, recently carried out in the Pontine and Aeolian Archipelago (Italy).

THE CHALLENGE OF DETECTING AND ATTRIBUTING SEA LEVEL CHANGE – THE CASE OF THE BALTIC SEA

Hans von Storch, Eduardo Zorita

Institute of Coastal Research, Helmholtz Zentrum Geesthacht, Germany

Changing sea level represents a significant challenge for climate science – both because of the societal relevance of such changes and because of the range of causes leading to such changes.

In the talk the available evidence for the change in the past centuries is reviewed, and the different drivers which may be used to explain such changes – and thus allow prediction of future changes – will be discussed.

The contribution will focus on the Baltic Sea, and make use of the BACC assessment of contemporary scientific knowledge about ongoing and possible future climate change.

SASMAP: GEOLOGICAL MODELING AND DOWNSCALING CONCEPT FOR LOCATING POSSIBLE SUBMERGED ARCHAEOLOGICAL SITES

Jørn Bo Jensen, Zyad Al-Hamdani

Geological Survey of Denmark and Greenland (GEUS), Denmark

One major objective of the SASMAP project is to build a geological model of palaeo coastal changes, based on existing data (seismics, core sample dating etc.) for two pre-designated pilot areas in Denmark (Tudse Hage) and Greece (Cape Sounion), from which potential submerged archaeological sites can be delineated.

The downscaling concept being developed in this project reduces the time (and budget) for conducting actual survey of the areas with archaeological potential. This is performed by analyzing satellite and orthophoto images where a seamless continuum of on-shore to off shore-morphology and sediment distribution can be deduced and used to decide on the potential areas that require further investigation. The delineated areas are uploaded to a GIS system where they are compared with existing archaeological databases for calibration. Areas of high potential will be surveyed in detail using a suite of geophysical systems such as sub-bottom profilers and multibeam. All datasets will be incorporated in a GIS to find locations for ground truth sampling and archaeological diver investigation.

REMOTE SENSING SURVEYS AND THE MANAGEMENT OF UNDERWATER CULTURAL HERITAGE

Timmy Gambin

University of Malta

To date, the majority of shipwrecks and other underwater archaeological sites that have been discovered and documented in the Mediterranean are situated in waters shallower than the 50 meter contour. With an increase in technical diving and deep water exploration, this is a statistic that is rapidly changing and will continue to change in the near future.

Given that the UNESCO convention on the protection of underwater cultural heritage puts emphasis on preservation of submerged sites in-situ, it is imperative to look at ways in which such a directive can be implemented.

This talk will highlight the potential synergies between existing remote technologies and the management of underwater cultural heritage as well as between the interdisciplinary uses of remote sensing data. Using examples from on-going research projects, I intend to demonstrate how, large-scale remote sensing surveys, if planned and managed properly, can make a major contribution to site management, which in turn facilitates decision making by various stakeholders.

CONSTRUCTION OF THE MAASVLAKTE 2 HARBOUR AND DROWNED PREHISTORIC LANDSCAPES AND ARCHAEOLOGY; LESSONS LEARNED

**Andrea Otte¹, Ellen Vreenegoor¹, Gilles Erkens², Henk Weerts¹, Hans Peeters³,
Laura Vonhögen-Peeters², Sytze van Heteren⁴**

¹ Cultural Heritage Agency, Ministry of Education, Culture and Science, Amersfoort, the Netherland

² Deltares, Utrecht, the Netherlands

³ Groningen University, Groningen, the Netherlands

⁴ TNO | Geological Survey of the Netherlands, Utrecht, the Netherlands

The presence of drowned prehistoric archaeology on the North Sea floor has long been known. For decades, trawler fishers have found artefacts in their nets. As it became clear that dredging and construction activities would be necessary for the construction of the new Maasvlakte 2 harbour into the North Sea, PoR, BOOR and RCE have worked together to prevent possible drowned Palaeolithic and Mesolithic sites getting lost without knowing. From early on and from offshore geological and archaeological research it was known that such sites might be present in the areas at stake.

For the construction of the new harbour, 240 million m³ of sand had to be dredged from two areas in the southern North Sea. In the harbour itself, dredging to 20 m depth was necessary to be able to permit access for the largest container-ships. In all cases, destruction of possible sites present at the locations was inevitable. To be able to anticipate this, an interdisciplinary Working Group Archaeology, Maasvlakte 2, was established and the PoR allocated a budget for the research. The Working Group comprised archaeologists, engineers, decision makers, and a quaternary geologist.

Because no experience existed that we could use in the planning process, we decided to follow a step-by-step tailor made approach in the three areas at stake. In this approach, Maritime Archaeology was also included (ship wrecks, airplane wrecks). For the possible presence of Palaeolithic and Mesolithic sites, research focused on landscape reconstruction to pinpoint possible sites.

In all cases, the first step was a simple desktop-research of the existing data. Depending on these first results, decisions were made if field research was necessary. In one case we concluded from the desktop-research that no further investigations were necessary, while at the other extreme the research ultimately resulted in a logistically complex and expensive underwater excavation. The third case was intermediate, with a complete landscape reconstruction based on fieldwork.

Because the exact areas and time of the dredging operations were well known ahead of time, all the necessary research was carried out without hampering the dredging and construction works. Furthermore, the research stayed well within budget.

Lessons learned? It is possible to incorporate drowned prehistoric archaeology research in complex construction works, if planned properly. Secondly, the approach we followed will probably serve as a template for future research of this kind in the Dutch sector of the North Sea.

**EFFICIENT STEPPED APPROACH TO SITE INVESTIGATION
FOR UNDERWATER ARCHAEOLOGICAL STUDIES, A CASE STUDY:
YANGTZEHAVEN – PORT OF ROTTERDAM, THE NETHERLANDS**

Peter C. Vos

Deltares, PO Box 85467, 3508 AL Utrecht, The Netherlands; email: peter.vos@deltares.nl

The Port of Rotterdam (PoR) is expanding the Maasvlakte harbour area into the sea. A new channel, the Yangtze harbor, will be dug out to connect the Maasvlakte area with the harbour area under construction. The new channel of the Yangtze harbor will be dredged out to a depth of 20 m below sea level. The upper part of the sediments, which was dredged out to create the new channel, consists primarily of marine offshore sands. In the lower part at about a depth of 17–22 m below the Dutch Ordnance Level (DOL), Late Weichselian fluvial and aeolian sands and early Holocene deltaic deposits of the Rhine–Meuse were present. From earlier dredging activities in the Maasvlakte area it was known that the late Weichselian /early Holocene deposits contain late Palaeolithic and Early Mesolithic artefacts. The deepening of the Yangtze harbour will affect the Late-Weichselian / early Holocene deposits and destroy the archaeology in these layers.

The aim of the archaeological Yangtze harbour project was to predict the locations where Stone Age archaeology could be found. A geological-geogenetic approach has been applied to determine the optimal palaeo-environmental locations. A 3D palaeolandscape model was constructed of the harbour area, which was 0.4 km wide and 3 km long. On the basis of the palaeolandscape model, the areas with potential for archaeological sites were selected.

The multidisciplinary prospection research has been carried out in several steps. After each research step the strategy of the following research phase was determined. The first step was to make a primarily 3D lithological model of the harbour area from the existing data of soundings and bore hole information; data which was generated for the construction of the harbour. The next step was a seismic field survey (side scan sonar, Xstar-chirp) in the harbour area which was already dredged to a depth of 17 m –DOL. Based on the seismic data, locations were selected for vibro-core drillings and soundings to verify the interpretations of the seismic measurements. After this step two promising archaeological areas (river dunes) were selected (200 ha) for further detailed seismic and drilling research. In the sediments of the bore holes small artefacts and bones were found which proved that the selected dune was a Mesolithic site. In November 2011, an underwater excavation was carried out using an accurate dredging crane on a pontoon, which was normally used to remove polluted underwater soils. The soil samples taken from the crane were recorded carefully (position and stratigraphy), put in large bags and then sieved for further archaeological investigation. The results will be shown in the presentation.

**EXCHANGING KNOWLEDGE BETWEEN INDUSTRY AND ACADEMIA
FROM A SCANDINAVIAN STANDPOINT:
THE MMT AND MARIS COLLABORATION**

Johan Rönaby¹, Joakim Holmlund², Björn Nilsson¹

¹ MARIS, Södertörn University, Sweden,

² MMT AB, Sweden

The Institute for Maritime Archaeology at Södertörn University (MARIS) aims to contribute to the development of maritime archaeology through an active theoretical discussion of research directions and through initiatives to stimulate new maritime archaeological research.

A part of this is to be involved in multidisciplinary collaboration with other fields, community organizations and the commercial world. An important part of the subject is also the development of new methods involving search, mapping and underwater excavation, all of which require special techniques and skills. This is particularly evident in the case of examining archaeological remains at great depths.

Underwater robotics, multibeam bathymetric systems and other subsea survey technologies are increasingly indispensable. Since 2008 MARIS have cooperated closely with the survey company Marin Mätteknik AB (MMT) regarding improvement of technologies and methods.

An important part of this joint work is also the development of new standards for documentation and evaluation of archaeological material on the sea floor. Our presentation will summarize some of the results and experience from this cooperation.

PLENARY SESSION SIX

MANAGEMENT AND OUTREACH

**EDUCATION AND ENGAGEMENT: DEVELOPING UNDERSTANDING
AND APPRECIATION OF SUBMERGED PREHISTORIC LANDSCAPES
(SPLASHCOS Working Group 4)**

Julie Satchell

Maritime Archaeology Trust, National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, United Kingdom

The position of submerged prehistoric landscapes beneath the water and beneath the seabed makes them difficult to access. Scientific investigation and research are providing data on prehistoric peoples and the associated drowned landscapes, which is important for illuminating aspects of the past at all levels. Development of academic study and management approaches for the resource are vital for professional growth and appropriate protection. Alongside this there is a large public fascination with past landscape change which provides an important route for engaging people with this otherwise hidden aspect of the past.

The Maritime Archaeology Trust (HWTMA) has been undertaking research-led investigation of submerged prehistoric landscapes in a range of locations. Experience gained in the UK has focused on the submerged Mesolithic site at Bouldnor Cliff, the drowned Western Solent and Langstone Harbour. As an organisation, the Trust is involved with data gathering, analysis, dissemination and promotion to a very wide range of audiences from school children through to marine managers and planners. The development of innovative approaches to involvement, education and dissemination makes it possible to reach and engage at all levels.

The MAT has brought this experience to the SPLASHCOS project where it has been used to develop the work of Working Group 4. A communications strategy was established that targeted a range of audiences alongside targeted events and documents to reach specific sectors.

This paper will explore the wider MAT experience of delivering education and awareness-raising programs working with a wide variety of sectors and audiences in addition to reviewing the outcomes of Working Group 4. This will include:

1. Formal and informal education and learning opportunities
2. Volunteer involvement
3. Marine and coastal management
4. Marine Industry
5. Professional colleagues

Experience from this work will be drawn upon to consider future challenges for further expanding understanding and appreciation of submerged prehistoric landscapes.

ARCH-MANCHE: ARCHAEOLOGY, ART, COASTAL CHANGE AND MANAGEMENT

**Lauren Victoria Tidbury¹, Julie Satchell¹, Garry Momber¹, Marie-Yvane Daire²,
Tine Missiaen³, Peter C. Vos⁴**

¹ Maritime Archaeology Trust, National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, United Kingdom

² Centre National de la Recherche Scientifique, France

³ Ghent University, Renard Centre of Marine Geology, Krijgslaan 281 – S8, B-9000 Ghent, Belgium

⁴ Deltares, PO Box 85467, 3508 AL Utrecht, the Netherlands

The submerged prehistoric landscapes along the coastlines and sub-tidal fringes of the European Continental Shelf were covered and protected when sea level rose. Archaeological and palaeo-environmental evidence preserved when the waterborne sediments first covered them can be dated. When the depth and location of the material is known, index points can be provided for sea level change.

The Arch-Manche project is demonstrating how submerged and coastal maritime heritage can be used to show long-term patterns of coastal change and the impact on human settlement. Shifting coastlines and intertidal features are often recorded by artists, photographers and cartographers. Accordingly, art, photographs and historic charts are also being used as resources to document change.

These data are being tested in a system of modelling, quantifying and scoring to document their value when assessing coastal adaptations. The visual nature of the tools applied aid the dissemination of the results to coastal managers and professionals. The results are providing an understanding of the impacts of past reactions to climate change along the coastlines of France, Belgium, the Netherlands and the UK. The results produced will be presented to inform the development of sustainable policies for adapting to coastal and climate change.

DROWNED PREHISTORIC LANDSCAPES AND ARCHAEOLOGY IN THE DUTCH SECTOR OF THE NORTH-SEA: TRYING TO GET THE PICTURE

**Henk Weerts¹, Andrea Otte¹, Ellen Vreenegoor¹, Gilles Erkens², Hans Peeters³,
Laura Vonhögen-Peeters², Sytze van Heteren⁴**

¹ Cultural Heritage Agency, Ministry of Education, Culture and Science, Amersfoort, the Netherlands

² Deltares, Utrecht, the Netherlands

³ Groningen University, Groningen, the Netherlands

⁴ TNO | Geological Survey of the Netherlands, Utrecht, the Netherlands

The presence of drowned prehistoric archaeology on the North Sea floor has long been known. For decades, trawler fishers have found artefacts in their nets. Unfortunately, for the Dutch sector none of these finds has been carefully documented – yet. Since the work of Gaffney et al. (2007), it is clear that some of this archaeology is present in situ in drowned landscapes, especially around Doggerland. Weerts et al. (2012) described an in situ Mesolithic case-study from the southern North Sea just offshore the Dutch coast. Already in 2009, Peeters et al. (eds) noted that future legislation will be necessary to preserve the archaeological heritage.

One of the results of the 2012 evaluation of the La Valetta treaty in Dutch legislation was that knowledge of underwater prehistory in the Dutch part of the North Sea was insufficient and had to be increased. This is necessary because of the large number of activities that threaten the archaeological heritage (e.g. oil and gas, sand extraction, offshore wind farms etc.). The notion that these activities can destroy possible archaeological heritage has unfortunately not yet dawned on everyone.

One of the projects was a data-inventory of all relevant coring and seismic data that are present in the Dutch sector of the North Sea (Erkens et al., 2013). The idea was to get a picture of how many useful data are out there and how they can be interpreted in terms of predictive archaeological maps for the Late Palaeolithic and Mesolithic on the North Sea floor. The picture that emerged was that (1) very many data are available, (2) but of often unknown quality and (3) not evenly distributed over the sector. (4) Therefore, making a detailed predictive map that covers the entire sector is still far off. (5) Making such a map for the areas with enough good data would be very expensive. So the picture we now have is that we are going to have to look for alternative solutions.

References

- Erkens, G., Peeters, J.M., van Heteren, S., Marges, V.C., Vonhögen-Peeters, L.M. & de Kleine M.P.E., 2013: *Proef Indicatieve Kaart Archeologische Waarden (IKAW) Noordzee*, Deltares, Utrecht.
- Weerts, H.J.T., Otte, A., Smit, B., Vos, P., Schiltmans, D., Waldus, W. & Borst, W., 2012: Finding the Needle in the Haystack by Using Knowledge of Mesolithic Human Adaptation in a Drowning Delta. In: W. Bebermeier, H. Hebenstreit, E. Kaiser & J. Krause (eds), *Landscape Archaeology. Proceedings of the International Conference Held in Berlin, 6th-8th June 2012. eTopoi Journal for Ancient Studies, Special Volume 3*, 17–24.
- Peeters, J.M., Murphy, P. & Flemming N., 2009: *North Sea Prehistory Research and Management Framework (NSPRMF) 2009*. Cultural Heritage Agency, Amersfoort.
- Gaffney, V.L., Thomson K. & Fitch S., 2007: *Mapping Doggerland. The Mesolithic Landscapes of the Southern North Sea*. Archaeopress, Oxford.

**THE SEARCH PROJECT: ARCHAEOLOGICAL HERITAGE
IN THE NORTH SEA: DEVELOPMENT OF AN EFFICIENT ASSESSMENT
METHODOLOGY AND APPROACH TOWARDS A SUSTAINABLE MANAGEMENT
POLICY AND LEGAL FRAMEWORK IN BELGIUM**

**Tine Missiaen¹, Marnix Pieters², Sven Van Haelst², Frank Maes³, Bob Hoogendoorn⁴,
Philippe De Maeyer⁵, Jan Mees⁶**

¹ Ghent University, Renard Centre of Marine Geology, Krijgslaan 281 – S8, B-9000 Ghent, Belgium

² Flemish Heritage Agency, Koning Albert II-laan 19 bus 5, B-1210 Brussels, Belgium

³ Ghent University, Dept. of Public International Law / Maritime Institute, Universiteitsstraat 6, B-9000 Ghent, Belgium

⁴ Deltares, Dept of Geology, Princetonlaan 6, 3584CB Utrecht, The Netherlands

⁵ Ghent University, Dept. of Geography, Krijgslaan 281 – S8, B-9000 Ghent, Belgium

⁶ J. Mees: Flanders Marine Institute (VLIZ), InnovOcean site, Wandelaarkaai 7, B-8400 Oostende, Belgium

Large parts of the Belgian continental shelf are affected by commercial activities such as aggregate extraction, wind farms, dredging, cable/pipeline projects, intensive fishing, etc. Closer to the shore major infrastructural works for harbour extension and coastal protection are envisaged for the near future. All these activities constitute a serious threat for the underwater cultural heritage (UCH). However a solid regulation regarding UCH is still lacking, notwithstanding the increasing awareness at the political and administrative levels of the need to take responsibility for this heritage.

The SeArch project will offer solutions to these challenges through the realization of three objectives:

1. To develop a reliable survey methodology based on geophysical and remote sensing techniques that allows accurate and cost-effective evaluation of the archaeological potential of marine areas (offshore, nearshore, intertidal). This will avoid costly damage and loosing valuable time during the preparatory and operational phase of the works.
2. To prepare a correct implementation of the commitments imposed by international conventions with regard to UCH, and work out comprehensive proposals for a transparent and sustainable management policy and for the further development and implementation of a legal framework related to UCH in Belgium. This legislative framework should protect the marine historic environment but at the same time allow the necessary marine exploitation.
3. To offer guidance for the stakeholders (marine industry, government agencies, fisheries, harbor authorities, and the public/social sector), on how to implement the new methodology and management approach, and to increase the general awareness with regards to UCH.
4. The 4-year project started in January 2013 and is funded by the Flanders Agency for Innovation by Science and Technology (IWT). It involves a multidisciplinary consortium between Ghent University, Flanders Heritage Agency, Deltares (The Netherlands) and Flanders Marine Institute (VLIZ).

THREATENED PALAEOLANDSCAPE IN THE GERMAN BIGHT, NORTH SEA

Daniel A. Hepp¹, Ursula Warnke², Tobias Mörz^{1, 3}

¹ MARUM – Centre for Marine Environmental Sciences, University of Bremen, Germany

² Deutsches Schiffahrtsmuseum, Bremerhaven, Germany

³ Geo-Engineering.org GmbH, Bremen, Germany

The German North Sea is part of a marginal sea under high utilization pressure. There are only a few areas that have not been exploited by fishery, maritime traffic, wind energy, pipelines etc. These interferences are threatening to destroy our cultural wealth preserved on the seabed of the North Sea. German state heritage legislations are only valid within a 12-mile-zone. Beyond that zone in the German Exclusive Economic Zone (EEZ) no heritage authority has responsibility. Accordingly, underwater cultural heritage outside the twelve-mile zone cannot be placed under monument protection.

To produce a basis for future protection and archaeological research the Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung) is financing a three year (2011–2014) pilot project at the National Maritime Museum of Germany (Deutsches Schiffahrtsmuseum). This project is carried out in close cooperation with the Federal Department for Shipping and Hydrography (Bundesamt für Seeschifffahrt und Hydrographie). The evaluation of their database is one important part of this pilot project.

The aim is to collect substantial data on palaeo-landscapes for a research database and to develop appropriate methods for the evaluation of the underwater cultural heritage in the German EEZ. The postglacial reorganization of the drainage system in the southern North Sea shelf area is the focus of geological investigations at the research centre MARUM. In the course of this project two fluvial features within the EEZ, which are part of the tributary system of the major receiving stream «Elbe-Urstromtal» (Elbe Paleovalley), were investigated with seismic surveys, sediment cores and geotechnical methods. These investigations provide useful data to locate potential areas of human settlement and to find suitable sites for systematic archaeological investigations.

**SUBMERGED PREHISTORIC LANDSCAPES:
AN EMERGING EUROPEAN HERITAGE RESOURCE
IN NEED OF PROTECTION AND MANAGEMENT**

Katerina Dellaporta¹, Nena Galanidou²

¹ Hellenic Ministry of Culture, Athens

² Department of History and Archaeology, University of Crete, Rethymnon, Crete

The European Union (EU) is currently developing its policy on marine economy for 2014–2020 under the heading of 'Blue Growth'. Our paper addresses the emerging field of mapping submerged prehistoric landscapes, bringing together archaeologists, oceanographers and other scientists, from a legal and protection point of view. We see these landscapes of the continental shelf as a heritage, which is both cultural and natural, and which ought to be recognized as such, declared and protected.

We argue that the development of our interdisciplinary agenda of research ought to go hand-in-hand not only with refining methods and techniques of exploration but also with developing legislation and strategies of management. Exploring the landscapes of the shallow coastal and continental shelf ought to be coupled with acts to protect them. All these ought to be in a dialogue with the EU's developing policies.

We draw examples from the NE Mediterranean, where human activity has in recent years been intensive, altering coastal landscapes dramatically. In addition, the exploration of the diverse resources that lie on and below the seabed of the NE Mediterranean Sea is often seen as an answer to the Greek or the Cypriot financial crises. Thus far the NE Mediterranean shelf is the focus of various different and often conflicting interests: at one extreme are those who see the opportunity for a complete transformation to a sea of petrol and gas extraction or for cargo transit stations; at the other end of the spectrum are those who argue for a purely conservationist stand.

The submerged prehistoric landscapes of Europe are a resource with the same potential as the cultural heritage found on land. Yet they have different properties and needs. To this end a new legal frame ought to be developed to protect this heritage.

PLENARY SESSION SEVEN

FINALE

FIGURES IN AN UNDERWATER LANDSCAPE: THE EVOLUTION AND FUTURE OF CONTINENTAL SHELF PREHISTORY

Nicholas Flemming

National Oceanography Centre, Southampton, UK

A well-established genre of classical painting is sometimes entitled “Figures in a Landscape” or alternatively “Landscape with Figures”. The ambiguity is significant, showing the grandeur of nature overwhelming diminutive humans, while suggesting that nature means nothing until observed, understood, and even conquered by humans. The realisation over 100 years ago that humans had lived on the seabed during the ice ages was precipitated by the chance finds of peat, bones, fossils, and prehistoric ceramics by fishermen. The explanation of this phenomenon has required a century of scientific study of the continental shelf, and the parallel study of prehistoric relics in their seabed context. We have started the logical integration of this research at a European scale and the sea basin scale. We now need a research strategy for sustained and integrated study of the hominin figures and how they lived in that drowned landscape over a timescale of almost 1 million years.

Early publications on submerged prehistory described scattered short-lived projects, often forgotten or published in obscure local journals and regional newssheets. The situation was summarised by Masters and Flemming (1983). Such discoveries continue today, and are still disappearing into the forgotten grey literature. Studies after the mid-20th century such as those from the Gulf of Mexico (Gagliano 1977; Clausen *et al.* 1979; Dunbar *et al.* 1988), North Sea (Louwe Kooijmans 1970–71) and Baltic (Skaarup 1980) showed that a small number of research groups could maintain a steady effort over the years, albeit restricted by minimal funding. Papers were published in small workshops and conferences, or side-sessions in major conferences, without continuity. In the late 20th–early 21st century, several regional projects had achieved more sustained support (Fischer and Sorensen 1983; Fischer 1995; Galili *et al.* 1993; Harff *et al.* 2007). But much depended upon a small number of highly committed individuals.

In 2008 the Deukalion Planning Group was launched at the IKUWA3 Conference, leading to an application to the COST Action Office of the EU, and the 4-year SPLASHCOS project (COST TD0902). SPLASHCOS has raised the visibility of continental shelf prehistoric research both in Europe and globally (Benjamin *et al.* 2011), but it receives funding for co-ordination and promotion of research, not new research activity. During the SPLASHCOS project co-ordination has been developed with the three EC Directorates responsible for Maritime Affairs, Culture, and Research. A pan-European effort to synthesise existing data to provide high resolution Quaternary maps of the seabed, with integrated data management, will provide the framework for understanding drowned river patterns and submerged coastlines. National agencies and major universities are sharing data and reports on submerged prehistoric sites, enabling the improved production of regional models.

Continuity and cohesion in this pioneering area of multi-disciplinary research now depends on the creation of structures and systems which support multi-agency collaboration, high level training courses, project funding, access to advanced technology, regular publications, access to large data sets, and institutional consistency across borders. The SUBLAND Working Group, initiated by the European Marine Board (EMB) in correspondence with the European Archaeological Council (EAC), will consider these issues, and publish a position

paper with recommendations on the way forward. It will draw on the information available through the EMB, EAC, SPLASHCOS and Deukalion.

References

- Benjamin, J., Bonsall, C., Pickard, C. & Fischer, A. (ed.). *Submerged Prehistory*, papers presented at the 2009 Conference of the European Archaeologists' Association. Oxbow Books, 352p. ISBN-13:978-1-84217-418-0.
- Clausen, C.J., Cohen, A.D., Emiliani, C., Holman, J. & Stipp, J.J., 1979: Little Salt Spring, Florida: A Unique Underwater Site. *Science*, 203: 609–614.
- Dunbar, J.S., Faught, M.K. & Webb, S.D., 1988: An Underwater Paleo-Indian Site in Northwestern Florida. *The Florida Anthropologist* 41: 442–453.
- Gagliano, S.W., 1977: Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf, vol. 1. Interagency Archeological Services, National Park Service, Washington, D.C.
- Fischer, A., 1995: *Man and the sea in the Mesolithic*. Oxbow Monographs number 53, Oxbow Books. Oxford.
- Harff, J., Lemke, W., Lampe, R., Lüth, F., Lubke, H., Meyer, M., Tauber, F. & Schmölcke, U., 2007: The Baltic Sea coast- A model of interrelations among geosphere, climate, and anthroposphere. *Geol. Soc. Am. Special Paper* 426.
- Gallili, E., Weinstein-Evron, M., Hershkovitz, I., Gopher, A., Kislev, M., Lernau, O., Lolska-Horwitz, L. & Lernau, H., 1993: Atlit-Yam. A prehistoric site on the sea floor off the Israeli coast. *Journal of Field Archaeology*. 20, 133–157.
- Louwe Kooijmans, L.P., 1970-71: Mesolithic bone and antler implements from the North Sea and from the Netherlands. *Ber. Rijksdienst oudheidk. bodemonderz.* 22, 21.
- Masters, P.M. & Flemming, N.C. (eds.), 1983: *Quaternary Coastlines and Marine Archaeology*. Academic Press, London and New York, 641 pp.
- Skaarup, J., 1980: Undersoisk stenhalder. *Tidsskriftet Skalk*, 1: 3–8.
- SPLASHCOS. www.splashcos.org.

PARALLEL WORKSHOP SESSION
COASTLINE CHANGES OF THE SOUTHERN BALTIC SEA
– PAST AND FUTURE PROJECTION (COPAF)

SESSION ONE

THE COASTS AT THE SOUTHERN BALTIC SEA – INTERFERENCE OF GEOLOGICAL PROCESSES AND CHANGING CLIMATE

Jan Harff, Junjie Deng, Kazimierz Furmańczyk

Institute of Marine Sciences, University of Szczecin, Poland

The Baltic Sea Basin serves as a natural laboratory for the investigation of topographic change in particular of the coastal zones. This is particularly due to the converse sense in which vertical crustal movement ranges from 9 mm/y uplift in the Bothnian Bay to 2 mm/y subsidence at the southern Baltic coast. This vertical crustal movement pattern is superimposed by climatically driven eustatic change, which amplifies along the subsiding southern Baltic even the local relative sea level rise.

The southern and south-eastern Baltic Sea coast was shaped during the Early to Mid-Holocene mainly by a rapidly rising sea level leading to inundated palaeolandscapes. During the younger Holocene, when the sea level rise slowed down, the coastal morphogenesis was determined increasingly by wind (and wave) driven coastal erosion and sediment transport and re-deposition. Numerical models are important for historical reconstruction, but also for future projection of coastal processes, and this becomes increasingly important within the frame of the protection of coasts and their natural environment. These models have to integrate the vertical crustal displacement as well as the atmospheric and hydrographical forces (including extreme events) driving the sediment dynamics in the coastal zone. The decadal to centennial (even millennial) time scale requires the analysis of natural and anthropogenic changes of the regional climate based on proxy-data interpretation and climate modelling.

For the southern Baltic Sea, modelling approaches on the regional and local scale confirm the value of numerical simulation for basic research and the solution of applied tasks in coastal sciences. Within a frame of an international and interdisciplinary project CoPaF (Coastline changes of the southern Baltic Sea – past and future projection) co-ordinated at the University of Szczecin, Poland, from 2010 to 2013, numerical models have been developed and applied to selected key areas at the southern Baltic coast. The models are designed in a general mode in order to enable also an application to coasts of transgressive seas outside the Baltic.

SEA LEVEL AND COAST CHANGES OF THE SOUTHERN BALTIC SEA DURING THE HOLOCENE

Karol Rotnicki

Institute of Marine Sciences, Szczecin University, Poland; email: rotnicki@amu.edu.pl

Glacio-isostasy and deglaciation influenced sea level changes during the Early Holocene. For the past 9000 calendar years the level of southern Baltic was mainly controlled by climatic factors, which were responsible for:

1. Two highstands during the Atlantic Climate Optimum: H1 and H2 at 9000–8000 cal. BP and 7000–6100 cal BP, respectively.
2. The post-Atlantic sea regression and the long period of its lowstand, which showed a slight rising tendency (between 6000 and 1800 cal. BP) with a short higher sea level H3 (between 3900 and 3100 cal. BP). The H3 was marked by high sea level at the southern North Sea Coast (Behre 2007). The long period of this lowstand ended at the beginning of the Middle Subatlantic (2750 cal. BP, i.e. A.D. 150 BP).
3. The higher sea level around 2000 cal. BP.
4. The Middle Subatlantic ingression and the highstand H4. covering the period between A.D. 850 and 1200 BP (Little Climatic Optimum). At the Polish Middle Coast the sea level, which was higher than present sea level by 0.5 m, corresponded to the detritus lacustrine gyttja, and this is proved by three radiocarbon dates from the top of the gyttja deposits.
5. Very distinct sea level lowering – exceeding 1 m – during the Little Ice Age. The rate of this process is estimated at 4 mm r-1.
6. The sea level rise after the Little Ice Age and its further rise due to recent global climate warming.

The above-mentioned sea level changes influenced the formation and evolution of barrier coasts and cliff erosion. Among others factors controlling the development of the southern Baltic Sea coast during the Holocene are

1. Compaction of lagoon-lacustrine-swampy deposits, which is significant in some cases
2. Frequency and intensity of storm surges, particularly important during the Younger Holocene. Extreme storm surges, the origin of which is not well known, caused serious changes in coastal morphology and environment.

RECONSTRUCTION OF SEA LEVEL CHANGES IN THE SOUTH EASTERN BALTIC DURING THE LATE GLACIAL AND HOLOCENE: METHODOLOGICAL APPROACH

Albertas Bitinas², Aldona Damušytė³, Simona Vaičiulytė², Viacheslav Jurkin¹

¹ Coastal Research and Planning Institute, Klaipėda University, Lithuania

² Department of Geophysical Sciences, Faculty of Natural Sciences and Mathematics, Klaipėda University, Lithuania

³ Lithuanian Geological Survey

Reconstruction of eustatic sea level fluctuations in the different Baltic Sea palaeobasins during the Late Glacial and Holocene is one of the most problematic procedures of palaeogeographic reconstruction. This issue is especially complicated in the South-Eastern Baltic – there are several factors that should be considered:

1. Unequal glacioisostatic rebound, recent tectonic subsidence and oscillatory movements of the Earth's crustal blocks have to be included in the palaeotectonic model of the investigated area. The positions of reliable indicators of sea level fluctuations have to be re-calculated according to this model. These indicators are features dated by ¹⁴C, OSL, ESR, etc., such as organic sediments (peat, gyttja), brackish or freshwater molluscs, sediments of ancient terraces in the recent onshore and offshore environment.
2. The remnants of well-preserved tree stumps (*in situ*) offshore of the Lithuanian coast, recently discovered and dated by ¹⁴C during underwater archaeological investigations, indicate that the sea level after drowning of the ancient forest did not drop lower – otherwise the wood remains would not have survived.
3. The recent radiocarbon (¹⁴C) dating (bulk samples, AMS) of organic sediments, mollusc shells and fish bones in the lagoons of the the South-Eastern Baltic (Curonian, Vistulian) show an extremely high reservoir effect (up to two thousand years and more), resulting from old carbonates that enter into the basins from the main tributaries. As a result, most of the radiocarbon data is impossible to use for stratigraphic purposes and palaeogeographic reconstructions.
4. The majority of the published curves of relative or eustatic sea level fluctuation contradict the eustatic curve of the World Ocean; theses curves must be logically consistent with each other.

The research was funded by the grant of national project Nr.VP1-3.1-ŠMM-08-K-01-019.

POST-GLACIAL EVOLUTION OF THE Odra RIVER MOUTH AREA, POLAND-GERMANY

**Ryszard Krzysztof Borówka, Andrzej Witkowski, Andrzej Osadczuk,
Krzyszyna Osadczuk**

Institute of Marine Sciences, Faculty of Geosciences, University of Szczecin, Poland

Multidisciplinary studies, including sedimentological, geochemical, diatomological, palynological and malacological analyses of sediment cores and supported by seismo-acoustic surveys, have allowed reconstruction of the postglacial evolution of the area of the Odra River mouth. Studies reveal that during the Late Glacial and Holocene this area developed in several stages: glaciofluvial, fluvial, swampy-limnic, marine and lagoonal (Borówka *et al.* 2002, 2005, Duda & Borówka 2007, Osadczuk 2004).

The first stage is connected with deglaciation of this area, ca. 16 ka BP. During the Late Glacial, the whole study area constituted a low alluvial plain. The pre-Odra flowed westward along the Toruń-Eberswalde ice-marginal valley, and farther away, together with the Elbe and Rhine rivers, discharged into the Atlantic. When the ice sheet retreated (ca. 14.5 ka BP) to the area of the present-day Szczecin Lagoon, the pre-Odra changed its course and turned to the north-east. The pre-Odra discharged into the Baltic most probably near the eastern part of Rügen Island.

Initially, the Odra was most likely a braided river, with its waters flowing along numerous channels. In the early Holocene it changed to a meandering river. During the middle Holocene, the Odra became an anastomosing river flowing among swamps and bogs – similar to today's Lower Odra south of Szczecin. This stage is documented by three erosion/deposition terraces buried under recent Holocene sediments.

During the late Atlantic period, while the Littorina transgression was in progress, ca. 6.1 ka (¹⁴C) years BP, the Odra River valley was flooded by sea water. The valley transformed into a marine embayment extending southward up to today's Szczecin town, and the Odra River mouth became an estuary (Osadczuk, Musielak & Borówka 2007).

The next stage began ca. 3.1–3.4 ka BP. Intensified abrasion processes on the high moraine shores of the Uznam and Wolin Islands caused rapid growth of two spits, progressively enclosing an embayment and turning it into a lagoon that today is called the Szczecin Lagoon (Zalew Szczeciński in Polish, Stettiner Haff in German). Simultaneously to the isolation of this area from marine influences, the Świna back-delta began to develop behind the barrier system. The lagoonal stage of the Odra River mouth still persists.

However, the last geological stage of the Odra mouth development is under strong anthropogenic influences which began in the Early Middle Ages, together with extension of colonization and shipping trade. The biggest transformations of the Odra River mouth landscape were initiated in the 18th century. The development of modern shipping trade and harbours caused changes in the hydrological system and natural landscape of that region (Osadczuk K. & Osadczuk A. 2007).

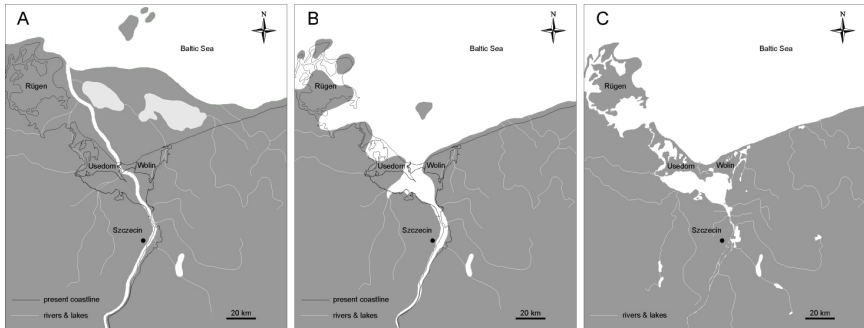


Figure. Simplified scheme of the Odra River mouth evolution. A – before Littorina transgression, B – maximum Littorina transgression, C – present day

References

- Borówka, R.K., Latałowa, M., Osadczuk, A., Święta, J. & Witkowski, A., 2002: Palaeography and palaeoecology of Szczecin Lagoon. In: R. Lampe (ed.) Holocene evolution of the South-Western Baltic Coast – Geological, Archaeological and Palaeo-environmental Aspects. *Greifswalder Geographische Arbeiten*, Bd. 27, Greifswald, 107–113.
- Borówka, R.K., Osadczuk, A., Witkowski, A., Wawrzyniak-Wydrowska, B. & Duda, T., 2005: Late Glacial and Holocene depositional history in the eastern part of the Szczecin Lagoon (Great Lagoon) basin – NW Poland. *Quaternary International* 130, 87–96.
- Duda, T. & Borówka, R.K., 2007: Landscape changes in the lower Odra valley on the background of its palaeogeographical development [in Polish, English summary]. In: U. Myga-Piątek (ed.), Doliny rzeczne. Przyroda – Krajobraz – Człowiek. *Prace Komisji Krajobrazu Kulturowego PTG*, nr 7.
- Osadczuk, A., Musielak, S. & Borówka, R.K., 2007: Why should the River Odra mouth area not be regarded as an estuary? A geologist's point of view. *Oceanological and Hydrobiological Studies*, Vol. XXXVI, No. 2: 87–99.
- Osadczuk, K., 2004: Origin and evolution of the Świna barrier spit in the light of morphometric and sedimentological research. [in Polish, English summary]. *Wydział Nauk Geograficznych Uniwersytetu Szczecińskiego, Rozprawy i studia* Vol. (DCXXVI) 552: 209 pp.
- Osadczuk, K. & Osadczuk, A., 2007: Landscape transformation of the Odra River mouth area on the background of palaeogeographical evolution of the region. [in Polish, English summary]. In: U. Myga-Piątek (ed.), Doliny rzeczne. Przyroda – Krajobraz – Człowiek. *Prace Komisji Krajobrazu Kulturowego PTG*, nr 7: 91–102.

POSTGLACIAL REBOUND AND RELATIVE SEA LEVEL CHANGES IN THE BALTIC SEA SINCE THE LITORINA TRANSGRESSION

Alar Rosentau^{1,2}, Jan Harff^{3,4}, Tõnis Oja⁵, Michael Meyer³

¹ University of Tartu, Department of Geology, Estonia

² University of Tartu, Institute of History and Archaeology, Estonia

³ Leibniz-Institute for Baltic Sea Research Warnemünde, Estonia

⁴ Institute of Marine and Coastal Sciences, University of Szczecin, Poland

⁵ Estonian Land Board, Estonia

Based on geostatistical modelling, the authors have compared relative sea level records for the Litorina and post-Litorina Sea with tide gauge and GPS derived crustal velocity measurements in Fennoscandia and in the Baltic region.

The results show a good fit between the geological record and GPS derived crustal velocity measurements, indicating that the postglacial rebound (PGR) centre on the northwest coast of the Bothnian Sea and the isostatic zero-line in the southern Baltic remained stable during the last 8000 14C yrs BP (8900 cal yrs BP).

An average Baltic Sea level rise of 1.4 ± 0.4 mm/y for the 20th century was estimated, which is found to be at about one fifth compared to the mid-Holocene sea level rise. However, considering the recent estimates of eustatic sea level rise for the 21st century, the slowly uplifting coastal areas in southern Sweden, SE Finland, Estonia, Latvia and NW Russia, which have experienced a long term relative sea level fall, will probably also be affected by future sea level rise reminiscent of the mid-Holocene one (Rosentau et al., 2012).

COASTAL MORPHOGENESIS OF THE POMERANIAN BAY, SOUTHERN BALTIC SEA – PAST AND FUTURE PROJECTION

Junjie Deng¹, Jan Harff¹, Wenyan Zhang², Ralf Schneider², Joanna Dudzinska-Nowak¹, Andrzej Giza¹, Paweł Terefenko¹, Kazimierz Furmańczyk¹

¹ Institute of Marine and Coastal Sciences, University of Szczecin, Poland

² Institute of Physics, University of Greifswald, Germany

Sea coasts are highly sensitive to global environmental changes such as accelerated sea level rise and intensification of extreme storm events. The protection of coastlines as a natural resource within the frame of a sustainable coastal zone management requires quantitative methods to estimate the coastal morphodynamics including the change of coastlines and the sediment budget. In order to develop future projection scenarios based on the results of climate change projections, numerical models have to be developed and validated on a base of historical data.

A numerical approach, namely the Dynamic Equilibrium Shore Model (DESM), is developed based on the information about historical coastline changes, a high-resolution modern Digital Elevation Model (DEM), and records of eustatic sea level change and isostatic crustal movement. The basic concept of the model is a dynamic equilibrium of the coastal cross-shore profiles adapting to sediment mass balancing of a semi-enclosed coastal area, in which the unknown parameters of the cross-shore profile shapes are calculated by numerical iterations.

The model is validated by measured historical bathymetrical data at 1980AD, and the comparison of geomorphological changes with a highly complex long term morphodynamic model BS-LTMM, which starts with the ~1900AD DEM approximated by DESM. It is found that the sediment mass budget estimated by DESM can be simplified to a function of coastline change, sea level change, and the closure distance between coastline and closure depth. The governing equations for bed level change are introduced to connect wind-wave induced sediment flux with the sediment budget calculated by DESM, which provides a possibility to project the coastline change based on future sea level rise scenarios.

The model proposed here can serve as a useful tool for coastal morphological studies and for the future projection of coastal morphogenesis.

PARALLEL WORKSHOP SESSION
COASTLINE CHANGES OF THE SOUTHERN BALTIC SEA
– PAST AND FUTURE PROJECTION (COPAF)

SESSION TWO

**RETRIEVING THE SIGNAL OF CLIMATE CHANGE
FROM NUMERICALLY SIMULATED SEDIMENT TRANSPORT
ALONG THE EASTERN BALTIC SEA COAST**

Tarmo Soomere, Maija Viška

Institute of Cybernetics, Tallinn University of Technology, Estonia

We highlight the potential “ability” of numerically simulated potential longshore sediment transport along the eastern Baltic Sea coast (from the Sambian Peninsula up to Pärnu Bay) to reflect substantial variations in the wind and wave fields in the Baltic Sea basin. The study uses time series of wave properties reconstructed for the Baltic Sea for 1970–2007 using adjusted geostrophic winds and the WAM model with a spatial resolution of 3 nautical miles.

A highly persistent divergence area of sediment flux at Akmenrags Cape (Latvia) divides the long coastal stretch of the Baltic proper from the Sambian Peninsula up to Kolka Cape into two almost completely separated compartments. A similar convergence area moves cyclically over the entire Curonian Spit and keeps this landform in almost perfect equilibrium.

Consistently with the gradual increase in the wind speed over the Baltic Sea basin, bulk sediment transport shows extensive decadal-scale variability but clearly increases over the entire simulation period. A rapid increase in the net sediment transport along the entire eastern Baltic Sea coast in the 1970s–1980s has been replaced by an equally strong decrease since about 1990.

This change in the course of coastal processes is accompanied by a substantially different nature of variations of the annual transport in the Gulf of Riga since about 1990 compared to that at the coasts of the Baltic proper. The reason for such abrupt changes is a major shift (by about 40 degrees) in the direction of the geostrophic air flow in the southern part of the Baltic Sea since 1988 that was first identified from the analysis of changes to wave properties in the southern Baltic Sea (Soomere and Räämet, 2013).

RECENT WAVE INDUCED SEDIMENT TRANSPORT CAPACITIES AND EFFECTIVE SEDIMENT TRANSPORT AT THE GERMAN PART OF THE BALTIC SEA

Peter Fröhle

Institut für Wasserbau, Technische Universität Hamburg-Harburg, Germany

The open coasts at the German Baltic Sea are approximately 850 km long. Most of the open Baltic Sea coasts are directly exposed to the waves and currents of the Baltic Sea and to the winds which are blowing stronger near the open coasts compared to the hinterland. Approximately 70% of the open Baltic Sea coasts are facing more or less severe erosion at least temporarily, and are therefore not stable over periods of years and decades.

For practical engineering tasks the wave driven sediment transport is divided into cross-shore transport and long-shore transport, where cross-shore transport means mostly event-driven movement of sediments normal to the shoreline. The sediment remains more or less only in the cross shore profile. Long-term changes may result from a local gradient of the long-shore transport where the sediment moves more or less parallel to the coastline.

Cross-shore and long-shore sediment transport are analyzed for periods in the order of decades based on numerical simulation of both effects and have been compared to the results of field surveys. Input parameters are derived from field measurements in combination with statistical and numerical modelling for the treatment of data gaps.

Results are presented for both effects. Due to the prevailing westerly winds in the western part of the Baltic, the main long-shore transport direction is facing east. The amount of long-shore sediment transport is structured along the western part of the Baltic. The greatest long-shore sediment transport is observed at the area of the Rostocker Heide up to the Darsser Ort, an area west of Rostock with sediment transport capacities of about 275,000 m³/a. Lower long-shore sediment transport rates of only a few thousand cubic meters per year are observed in other parts, e.g. south of Fehmarn or in parts of the Lübeck bay.

The obvious part of the cross-shore sediment transport is mainly event-driven and takes place during high-water events. Here, erosion of the normally dry part of the cross-section (beaches and dunes) of up to 30 m to 40 m within a single extreme event is observed. In addition, the seasonal changes of the cross-section are obvious where so called summer-profiles and winter-profiles are observed and described.

Parts of the work have been performed during my time as head of the Coastal Engineering group at the University of Rostock. I thank all the colleagues there and especially Steffi Dimke and Christian Schlamkow for their support. I also thank my colleagues from the Institute of River and Coastal Engineering, namely Angelika Gruhn and Dörte Salecker for their help.

COASTAL MONITORING, MODELLING AND PREDICTING. SELECTED EXAMPLES

Kazimierz Furmańczyk, Paweł Andrzejewski, Natalia Bugajny, Łukasz Cieszyński

University of Szczecin

Understanding processes taking place in the coastal zone is a key for their prediction. This is especially applicable when we are looking for the results stemming from climate changes. Prediction of phenomena and processes occurring in the coastal zone is possible, on the basis of adequate numerical models properly approximating the reality. The quality of these models depends on a well-organized system of monitoring. Some examples of the monitoring, modelling and prediction of the selected coastal states and processes provided by the Remote Sensing and Marine Cartography Unit are presented in the paper.

Remote Sensing monitoring uses two kinds of tools: (1) a video camera installed on a tower, which takes pictures every second; (2) air photographs, with pictures taken about twice a year by a specialist company.

Particular attention is paid to monitoring of several variables: underwater long-shore bar dynamics, rip current activity, shore line changes, bottom morphology and changes of bottom morphology. Some of these are currently modelled using the XBeach model. On the base of this and other models, an early warning system connected with sea-land interaction was applied. In this paper, the problem of monitoring, modelling and prediction of rip current activity, beach floods and bottom morphology will be described in detail.

TRENDS IN COAST DEVELOPMENT OF THE SWINA GATE AREA

Joanna Dudzinska-Nowak

Institute of Marine and Coastal Sciences, Faculty of Geosciences, University of Szczecin, Poland

In recent years, on many coastal zones of the world, intensive erosion processes have been observed, but there are also some places where strong accumulation processes have occurred. One of them is the Swina Gate area, a very specific location created by a convergence zone, located on the Pomeranian Bay coast of the southern Baltic Sea.

The main goal of the research presented here is to define a long-term coastal dynamic of this area on the basis of remote sensing methods.

The coastline evolution was estimated based on 4 series of aerial photographs taken in 1938, 1951, 1973, 1996, and an orthophoto map from 2012. The 1996 series was used to develop an orthophoto map, which was subsequently used to calibrate the remaining series (1938, 1951, and 1973). The dune base line was identified on every picture in each year. The changes in the location were calculated in different time spans (1938–51, 1951–73, 1973–96, 1996–2012 and 1938–2012). Results of the calculations were used to analyse trends in the coast development and the rates of change, and classification of coastal dynamics was effected as well.

Based on coastline change diagrams for 1938–1951, 1951–1973, 1973–96 and 1996–2012, the magnitude of coast accretion and erosion in the area was analysed. As indicated by the results obtained, the Swina Gate area coast is dominated by accretion processes. In all the periods analysed, a substantial diversity in the magnitude of changes was observed, even in neighbouring, morphologically homogenous areas. The temporal analysis indicates that the accretion area has been reduced, the accretion sections of the coast have become shorter, and at the same time an increase in the length of the coast affected by erosion has been observed.

NEW DEMANDS ON OLD MAPS – A SYNOPSIS ABOUT SPECIFIC FEATURES OF HISTORICAL MAPS USED IN THE GIS ANALYSIS

Jörg Hartleib

Institute of Geography and Geology, University of Greifswald

With increasing digitisation of historical maps, new opportunities arise for analysis of historical geographical space. Comparing the structural elements found in maps at different time slices is the fundamental basis for analyses carried out by various sciences employing time at a scale of decades to centuries as a parameter. This leads to the question: How precise is the information found on maps?

This presentation discusses cartographic aspects of historical and recent maps frequently used in the West Pomerania region, such as the Swedish Land Survey (Schwedische Matrikelkarten, 1:8,200), Messtischblatt (1:25,000), etc. Resulting consequences in the present interpretation and potential limitations are touched on.

RECONSTRUCTIONS OF COASTLINE CHANGES BY THE COMPARISONS OF HISTORICAL MAPS AT THE POMERANIAN BAY, SOUTHERN BALTIC SEA

**Junjie Deng¹, Jan Harff¹, Andrzej Giza¹, Jörg Hartleib², Joanna Dudzinska-Nowak¹,
Bernd Bobertz², Kazimierz Furmańczyk¹, Reinhard Zölitz²**

¹ Institute of Marine and Coastal Sciences, University of Szczecin, Poland

² Institute of Geography and Geology, University of Greifswald, Germany

Coastline changes are becoming an increasingly important topic for populations living in coastal areas, in front of a continuously rising sea level and an increase in extreme storm events. This is the case at the southern Baltic Sea coast, where eustatic change and glacio-isostatic land subsidence cause a relative sea level rise of up to 2 mm/y, and where strong storms events lead to continuous coastal retreat on most parts of the coast. Coastline changes on decadal to centennial time scales are the long-term accumulative effect of climate forces, and anthropogenic influences have to be taken into consideration as well.

We discuss a set of historical maps covering almost 300 years, in particular the Messtischblatt maps (starting with 1829 AD), which provide the conditions for geo-referencing, facilitating quantitative comparisons with modern Digital Elevation Models.

The accuracy of these maps is estimated by the Root Mean Square Error of spatial differences of fixed points between the modern aerial photographs (or open street map) and historical maps. A first-order polynomial transformation is chosen to geo-reference the maps. The comparison between historical maps and the modern coastline in the Digital Elevation Model indicates that the coast can be subdivided into four zones (types) in terms of the trend of coastline changes: (1) continuously retreating or advancing coastline in a linear trend; (2) relatively stable coastline (coastline changes are within the accuracy of the error bars); (3) anthropogenic-influenced coastline changes like decelerated retreat or accelerated advance; (4) randomly fluctuating coastline changes.

POSTER SESSION

PALAEO-LANDSCAPE RECONSTRUCTION OF A POSSIBLE PRE-NEOLITHIC SITE IN PANTELLERIA ISLAND, CENTRAL MEDITERRANEAN SEA

**Leonardo Abelli¹, Maria Vittoria Agosto², Fabrizio Antonioli³, Alessandro Bosman⁴,
Daniele Casalbore⁴, Francesco Latino Chiocci⁵, Claudia Romagnoli⁶,
Sebastiano Tusa⁷**

¹ Pantelleria Ricerche, Italy

² Università degli Studi di Sassari, Italy

³ ENEA-Casaccia, Italy

⁴ CNR-IGAG, Roma, Italy

⁵ Sapienza Università di Roma, Italy

⁶ Università di Bologna, Italy

⁷ Soprintendenza del mare, regione siciliana, Italy

Pantelleria Island is located at the centre of the Central Mediterranean Sea, in a key position between southern Europe and northern Africa. A possible prehistoric site was discovered at about –20 m in the north-eastern part of the island and the site was recently investigated in detail to define the palaeo-environment in which it might have developed.

Actually the present-day coastal setting is rather inhospitable with high cliffs and difficult access; on the contrary, the palaeolandscape, which was reconstructed in great detail by means of ultra-high precision multibeam survey, could have been substantially different and more suitable for human settlement, possibly related to the quarrying of obsidian on the island. The lithic industry at Cala Tramontana represents one of the major discoveries for the study of the prehistory of Pantelleria Island.

The archaeological submarine context is made up of a uniform and wide distribution of finds that can be dated to the Neolithic or even earlier, the age being consistent with the depth of –18 to –20 m at which the remains were found, as the predicted sea level curves range between –10 m (Nearly Neolithic) and –50 m (Mesolithic). The rough and expedient method of débitage may be due to an adaptation to local conditions requiring rapid production of fragments with at least one functional margin. With the exception of four obsidian samples, perhaps of local origin, and a fragment of gray flint, all the finds are made on a unique type of raw material, which was identified by means of optical microscope polarizer analysis. It is a red flint, probably of hydrothermal origin and linked to volcanic activity, which might have originated in a low-temperature hydrothermal setting.

HUMAN RESPONSES TO SEA-LEVEL CHANGES IN SOUTHERN SCANDINAVIA FROM 8000–4000 CAL BC

Peter Moe Astrup

Department of Culture and Society – Section for Prehistoric Archaeology, Moesgård Allé 20, 8270 Højbjerg, Denmark

This presentation investigates how sea-level changes might have influenced human populations in southern Scandinavia between 8000 and 4000 cal BC at different temporal and spatial scales.

Moreover, it examines to what extent people inhabited and utilized marine resources in the early Mesolithic, through targeted diving surveys along former coastlines, and also examines developments in the marine technology/economy.

In order to work with these research questions, the development of 8 new GIS models showing the Mesolithic coastline and its gradual movement plays an essential role in the execution of the project.

**PALAEOGEOGRAPHIC RECONSTRUCTION
AND SUBMERGED PREHISTORY PROSPECTION
FROM THE OUTER HEBRIDES, SCOTLAND: A HOLISTIC APPROACH**

Andrew Bicket¹, Genevieve Shaw¹, Jonathan Benjamin^{1,2}

¹ Wessex Archaeology, Coastal & Marine

² University of Edinburgh

The recent Outer Hebrides Coastal Community Marine Archaeology Pilot Project (OHCCMAPP) combined the study of three themes: **Marine Resource Exploitation, Maritime History & Transport** and **Submerged Prehistory Potential** in preparation for major research projects. A strong focus on working with local people with deep and detailed knowledge of the marine environment has produced a rich cultural heritage background to this thematic work which has enabled greater results than would have been otherwise possible.

This approach has culminated in the development of biotope-based palaeogeography models that bring together the marine resources, maritime transport and palaeogeography themes in the Sound of Harris. By integrating local Holocene relative sea-level (RSL) models (Jordan *et al.* 2010), existing regional RSL models and limiting points (Shennan *et al.* 2006; Ritchie 1985), publically-available LiDAR and multibeam bathymetry coverage and field data, a number of prospection models have been developed for submerged prehistory particularly for the Mesolithic and Neolithic periods.

Key findings include the implications for the entire submergence of the Neolithic coastline which include a bias against the preservation of evidence for marine resource exploitation in the Neolithic. With regards to the Mesolithic, the enduring feature of the palaeogeography is a wide open seaway linking the Minch (the seaway between western Scotland and the Outer Hebrides) and western seaways of the British Isles to the Atlantic across the Sound of Harris. This provides critical context to maritime transport during the Mesolithic and the *in situ* remains of lithics and organic remains at Northton, Harris (c. 6-7000 BC) which lies on the Atlantic side of this palaeo-seaway.

Furthermore, the importance of faults as bathymetric deeps affording access to the interior by small vessels (such as logboats or currachs) is significant in the south of the study area. A number of high-potential locations have been identified for future survey.

SHIFTING COASTS AND HUMAN OCCUPATION OF THE ICE MARGINAL LANDSCAPES IN THE NORTHERN EUROPE

Enno Bregman^{1,2}, Olga Druzhinina²

¹ Province of Drenthe

² I. Kant Baltic Federal University

In Northern Europe, in the Ice Marginal Landscapes (IML) from the Netherlands to Estonia, human settlements in the late Pleistocene and the Holocene were strongly influenced by post-glacial processes like glacio-isostasy. At the regional scale geological processes like updoming and tectonic block displacements not only influenced sedimentation of river systems in deltas, e.g. the Rine and Meuse [2], but also more general coastal development in Wadden areas and lagoons.

In recent decades, human settlements in the IML have been studied in detail in different countries, but without overview and correlation with Pleistocene-Holocene post-glacial processes, which influenced landscape formation. In only a few studies, processes like forebulging and local impact of forebulging and deformation of geological structures (e.g. loading, unloading, with differentiated tectonic block displacements and halokinese if salt domes are near the surface) are involved in Quaternary geological studies and correlated to impact on human settlement and past and actual landscape formation [1].

Modern insight into the influence of shifting coasts on the way of settling and living in the Pleistocene–Holocene and the description of ancient human adaptation to shifting coasts is needed.

In contrast to previous studies, we will study the impact of post-glacial shoreline changes and history of human settlement on the coast in the IML of Northern Europe with a focus on the past history of human-environment relations in river deltas, “Wadden” areas and lagoons, and on the implications for the future because of the impact of climate change.

RADAR EXPLORATION OF UNDERWATER SITES, CASE STUDY: PACUIUL LUI SOARE CITADEL, ROMANIA

Dragos Ene, Lucian Ratoiu, Roxana Radvan

National Institute of R&D for Optoelectronics, Romania

Radar exploration of inland archaeological sites has been proved to provide answers regarding unmapped buried sites, investigations that have led to the discovery of new settlements or how a known site extends over an unexplored region. This application uses electromagnetic waves as a means of exploration and studies their propagation in a medium such as soil. More precisely an inhomogeneity – difference of the electric constants – that the waves meet in their propagation causes a perturbation during their travel and a reflection of the wavefront, which is detected by a receiving antenna.

One of the most interesting areas for archaeology is near-water regions. The probability of finding sites should be very high, since the water offers sufficient resources and advantages for the people of the past to consider such areas for their settlements. Over the years these sites were affected by the sea level fluctuation, changes in the rivers courses, lakes draining or flooding, and some of them now extend both on land and underwater.

Applications to underwater mapping are limited due to the high absorption in water of the electromagnetic waves. Most examples are in shallow and clear water, especially maritime waters, and are limited to several metres depth.

Such an application is presented in this paper, where a Byzantine citadel is explored, which is now in part under water, flooded by the waters of the Danube, with visibility of less than half a metre. Walls may still be found on an island, and were considered as references for the rest of the citadel. Experiments were conducted on these walls, using radar in the UHF/VHF regime, for apparatus calibration and to determine the best acquisition parameters. On water, measurements were made, and signals from walls down to depths of 8 metres could be recorded, allowing underwater walls to be detected and mapped

PALAEODEMOGRAPHY AND HEALTH STATUS OF NEOLITHIC POPULATIONS: FINDS FROM ATLIT-YAM, A SUBMERGED SITE OFF THE ISRAELI COAST

Vered Eshed¹, Ehud Galili²

¹ Israel Antiquities Authority, P.O.B 586, Jerusalem, 91004, Israel; email: veshed@gmail.com

² Israel Antiquities Authority, and Zinman Institute of Archaeology, University of Haifa, P.O.B 180, Atlit 30350, Israel

Key Words: Paleodemography, Health status, Neolithic, Skeletal populations, Atlit-Yam, submerged sites, Israel

This study presents and discusses the paleodemographic characteristics and health status of the human remains excavated in Atlit-Yam (AY). The site is a Pre-Pottery Neolithic (PPN) C village submerged off the Carmel coast, Israel. The AY coastal population was compared to skeletal remains excavated in the Mediterranean zone of the southern Levant.

Mortality curves were reconstructed for the Levantine Neolithic sample and for the populations in sites containing large skeletal samples, i.e. Atlit-Yam (AY) (65 individuals) and Ain Ghazal (AG) (80 individuals). The mortality pattern of the AY population differed from that of the general Neolithic population and the AG site. It represented high mortality rates in the old age cohort (over 50 years) and higher life expectancy at birth.

The differences found are attributed to dietary and environmental dissimilarities between the two populations. The combined agro-pastoral-marine subsistence and sedentary way of life in AY may have provided more secure and stable food supplies and better balanced nutrition than in AG. The regular and frequent consumption of marine resources would have provided a rich supply of protein, fat and micronutrients. Cereals, vegetables, fruits, meat, and later other animal products as well as seafood, especially fish, are the core elements of the present-day Mediterranean diet, which is known to be nutritious and healthy. Particular pathology found in AY is also presented and discussed relative to the paleodemographic results

**MARINE GEO-ARCHAEOLOGICAL SURVEY
IN SOUTHERN ARGOSARONIC GULF (GREECE) FOCUSED
ON THE LATE BRONZE AGE SHIPWRECK AT MODI ISLET**

**Maria Geraga¹, George Papatheodorou¹, Christos S. Agouridis², Margarita Iatrou¹,
Michail Prevenios¹, Dimitris Christodoulou¹, Despina Zoura¹, Stavroula Kordella¹,
Elias Fakiris¹**

¹ Laboratory of Marine Geology and Physical Oceanography, Department of Geology, University of Patras, Greece

² Hellenic Institute of Marine Archeology (HIMA)

The present study presents the preliminary results of an interdisciplinary marine geophysical survey conducted at the islet of Modi and the area southwest of Poros Island and north of the Argolid Peninsula in Northeastern Peloponnese, Greece. The geoarchaeological marine remote sensing survey at Modi is an ongoing research project conducted by the Laboratory of Marine Geology and Physical Oceanography, University of Patras (supported by “*K. Karatheodoris*” programme, Research Committee of the University of *Patras*) in collaboration with the Hellenic Institute of Marine Archeology (HIMA).

The islet of Modi is situated east-southeast of the island of Poros on a sea route important for navigation in the Argosaronic Gulf. The marine geoarchaeological survey project was initiated and planned after the discovery and excavation of an impressive Late Bronze Age (Mycenaean) settlement on the island of Modi. During a preliminary underwater archaeological survey conducted by the HIMA, a Late Bronze Age shipwreck (13th–12th century BC) was brought to light, located off the north rocky slopes of Modi at a depth of 25–38 meters.

The potential of the Modi shipwreck to add to the understanding of a critical period of Aegean prehistory led to the implementation of a full scale underwater excavation together with a marine geophysical survey during the autumn of the years 2009 and 2010. The Modi geo-archaeological project has a fourfold purpose: (i) to define the evolution of the coastline configuration around Modi and Poros islands over the last 18000 years BP based on mapping of palaeoshorelines features; (ii) to depict the subbottom stratigraphy of the recent sediment sequence; (iii) to obtain detailed bathymetry of the area where the late Mycenaean shipwreck lies; and (iv) to detect surface and subsurface targets of potential archaeological interest. The marine remote sensing survey was carried out using an echo sounder, a sub-bottom profiler and a side scan sonar.

**SASMAP: TOOLS FOR ASSESSING THE BURIAL ENVIRONMENT
AND PRESERVATION AND DETERIORATION OF ORGANIC MATERIALS
ON UNDERWATER ARCHAEOLOGICAL SITES**

**David John Gregory¹, Mikkel Holmen Andersen², Robert Pedersen³,
Charlotte Björdal⁴**

¹ National Museum of Denmark

² Unisense

³ AKUT

⁴ University of Gothenburg, Sweden

The EU FP7 funded project SASMAP's seeks to develop tools and techniques to Survey Assess, Stabilise, Monitor and Preserve underwater archaeological sites. It takes an holistic- and process-based approach to investigate underwater environments and the archaeological sites contained therein and involves developing and utilising tools and technologies to allow "down-scaling" from the large scale regional level, moving on to the local site level and finally to the individual components of a site; [followed by] "up scaling".

The project started in September 2012 and preliminary results from the up scaling elements of the project will be presented in this paper. This will include an overview of the deterioration of wood and the development to date of equipment to assess the preservation potential of sites.

This includes coring systems to sample sediments, and micro sensor and datalogging equipment to measure key environmental parameters in both open water and sediments relevant to assessing the preservation of organic materials, in particular wood, on underwater archaeological sites.

MID- AND LATE-HOLOCENE SHORELINE CHANGES IN NORTHERN ESTONIA

Ieva Grudzinska, Jüri Vassiljev, Atko Heinsalu, Leili Saarse, Siim Veski

Institute of Geology, Tallinn University of Technology, Estonia

Problems of the Baltic Sea paleoshoreline, relative water/sea-level and salinity changes have been studied for over a century. These environmental changes in the circum-Baltic Sea areas were regulated in particular by interactions between deglaciation dynamics, glacio-isostatic land uplift and eustatic sea-level changes, which affected the location of the thresholds and the outlet and inflow passages and the magnitude, duration and direction of the water exchange between the Atlantic Ocean and the Baltic Sea basin.

In Estonia, research on Baltic Sea history has concentrated on the Baltic Ice Lake, Yoldia Sea and Ancylus Lake developments, whereas several problems concerning the younger stages, i.e. the Litorina Sea and Limnea Sea, are less studied. Many controversial aspects exist and current data are not always in harmony with the results from neighbouring countries. Paleoshoreline reconstructions are based on GIS analysis and high-resolution airborne laser scanning (LIDAR) elevation data.

Reconstructed water-level surfaces are subtracted from the modern digital terrain model, which allows modelling of ancient coastlines as well as sea bathymetry and mainland relief. A point kriging interpolation makes it possible to interpolate accurate water level surfaces from irregularly spaced shoreline data and to eliminate the outliers. Chronology for past shore levels is obtained from sediment records of small lake and bog basins, whereas the emergence of the basin from the sea is identified by geochemical and diatom evidence and isolation level are dated by AMS ^{14}C dating of terrestrial macrofossil remains. GIS based temporal 3D paleogeographical maps visualise coastline development during past millennia and give new paleoenvironmental information on the history of the Baltic Sea.

The paleo sea-level records are a potential resource to better constrain estimates of coastline changes in future. Sea-level changes are closely related to the prehistoric habitation pattern and new paleogeographical maps are important in archaeological studies and provide an innovative perspective on prehistoric cultural heritage.

**DONAX SERRA COLLECTING STRATEGIES DURING THE PLEISTOCENE
IN SOUTH AFRICA: INTEGRATION OF ARCHAEOLOGICAL
AND SEA-LEVEL DATA**

Antonieta Jerardino

ICREA (Institució Catalana de Recerca i Estudis Avançats), CaSEs, Departament d'Arqueologia i Antropologia, Institució Milà i Fontanals (IMF-CSIC), C/Egipcíacues 15, Barcelona 08001, Spain

South Africa's Middle Stone Age coastal sites have played a prominent role in documenting early evidence of systematic shellfish collection and adaptation to aquatic environments. Pinnacle Point 13B cave holds the earliest yet known evidence for human use of marine resources (~162 ka).

PALEOGEOGRAPHICAL EVOLUTION OF THE CORFU STRAITS DURING THE LATE QUATERNARY

**Vasilios Kapsimalis¹, Antoine Chabrol², Grigoris Rousakis¹, Panos Georgiou¹,
Eric Fouache³**

¹ Institute of Oceanography, Hellenic Centre for Marine Research, Greece

² Ecole Française d'Athènes, Greece

³ Université Paris Sorbonne, France

Archaeological findings in northern Corfu (NW Greece), dating from the Palaeolithic, imply that prehistoric humans had moved from Epirus to Corfu Island through the Corfu Straits during stages of low sea level, when a «land bridge» had connected these two land masses. Probably, this process occurred several times during the glacial phases of the Pleistocene, considering that sea level at that time had descended at least 100 m below its present position.

The region of the Corfu Straits is an elongated sea area located in the northeastern part of Greece. It is delimited by the coastlines of NW Epirus and S Albania to the east and THE Corfu coastline to the west, whilst its northern and southern entrance is connected to the Ionian Sea. The bottom relief is smooth without any pronounced irregularities, while water depth ranges from 50–70 m along the central axis of the Straits.

During two surveys, high resolution seismic profiles were acquired in the Corfu Straits revealing significant stratigraphic features, such as erosive surfaces, buried progradational wedges and infilled palaeo-channels or valleys. Based on these data, the Late Quaternary paleogeographic evolution of the area is presented indicating successive stages of emerged and submerged landscape. These geomorphological changes provide valuable information for the potential migration routes used by prehistoric humans and highlight the archaeological value of the Corfu Straits.

**ARCHAEOLOGY OF SZCZECIN LAGOON AND POMERANIAN BAY
– PRELIMINARY RESULTS AND FIRST CONCLUSIONS**

Przemysław Krajewski, Marta Chmiel, Michał Adamczyk

University of Szczecin, Poland

This poster presents preliminary archaeological results of the research project **Archaeological and Paleoenvironmental Studies of Submerged Landscapes in the Szczecin Lagoon and the Pomeranian Bay** realized by the University of Szczecin.

The project started in 2011. Two years of research has not only helped to broaden the knowledge of archaeology around the Szczecin Lagoon, but contributed to the creation of new questions on the prehistory of the area.

**WHAT ARE WE MISSING? SMALL-SCALE PROCESSES
AND THEIR IMPACT ON THE PRESERVATION OF ARCHAEOLOGICAL SITES
ON THE COAST**

Przemysław Krajewski, Marta Chmiel, Michał Adamczyk

University of Szczecin, Poland

This poster will present a new aspect of the study of coastal archaeology and the consequences for prehistoric settlement of coastal processes. Archaeologists have frequently pointed out these processes in their research on both cultures and settlements. However, modern studies are often based on the present environmental situation. Archaeological and environmental studies around the Szczecin Lagoon show that a simplified interpretation without detailed knowledge of the changes in the environment, which are non-uniform even in such a small area, can lead to a false reconstruction of the past.

It is not only large-scale phenomena, such as the Littorina Transgression, which impact on the preservation and interpretation of prehistoric settlement. Also, short-term and local events like temporary water level rise or erosion processes can result in destruction of archaeological sites. Therefore it is important to include the impact of such processes on prehistoric settlement and the state of preservation of archaeological sites.

**SICILIAN SUBMERGED LANDSCAPE.
RESHAPING THE PAST THROUGH THE STUDY OF PALAEOLANDSCAPES
AND UNDERWATER ARCHAEOLOGICAL SITES**

Alba Mazza

The University of Sydney, Australia

The Sicilian sea is well known to be one of the richest seas in the world in terms of submerged cultural heritage. Shipwrecks of all periods of time testify to the intense crossroads for traffic from all over the Mediterranean. These are not the only evidence of underwater archaeological heritage that have relevance for the panorama of Mediterranean history. Recently the scientific community has focused attention on other aspects of the submerged heritage like ancient shorelines, submerged landscapes, evidence of underwater settlements, etc.

Thanks to this renewed interest, words like frequentation and occupation are now broadly used for underwater settlements also. Subsequently, the interest in palaeolandscapes turned on the debate about the importance of a multidisciplinary approach to the study of past societies and their relation to the sea, giving stimulus to develop scientific collaboration and data integration. In addition, this approach stimulated a new interest in the application of submerged data to the debate on global climate change.

Taking into consideration this new approach the aim of this presentation is to analyze the nature, origin, evolution and present situation of coastal and submerged archaeological sites in Sicily (Lipari, Egadi Islands, Siracusa, Trapani) with a focus on the relation between sea and land settlements.

Finally I will try to develop a methodology to connect this data to sea level changes and geomorphological changes in order to the reconstruct the submerged landscape and its archaeological significance.

ARCH-MANCHE

Garry Momber¹, Lauren Victoria Tidbury¹, Julie Satchell¹, Jasmine Noble-Shelly¹, Marie-Yvane Daire², Tine Missiaen³, Peter C. Vos⁴, Robin McInnes⁵

¹ Maritime Archaeology Trust, National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, United Kingdom

² Centre National de la Recherche Scientifique, France

³ Ghent University, Renard Centre of Marine Geology, Krijgslaan 281 – S8, B-9000 Ghent, Belgium

⁴ Deltares, PO Box 85467, 3508 AL Utrecht, the Netherlands

⁵ C&G Services, UK)

Arch-Manche is a European funded project that aims to use archaeology, art and coastal heritage features to investigate long-term patterns of coastal climate change in order to better understand the processes.

Arch-Manche will both benefit and contribute to developing practices in the study of submerged and intertidal archaeological features. It also aims to further establish cross-border collaboration between the partners, sharing knowledge and data about our common maritime heritage.

The partners are the Hampshire and Wight Trust for Maritime Archaeology (HWTMA, UK), the Centre National de la Recherche Scientifique (CNRS, France), the University of Ghent (Belgium), and Deltares (the Netherlands).

BOULDNOR CLIFF: COASTAL CHANGE AND MESOLITHIC OCCUPATION

Garry Momber, Lauren Victoria Tidbury, Julie Satchell, Jasmine Noble-Shelly

Maritime Archaeology Trust, National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, United Kingdom

The Western Solent was first inundated by rising waters during the Flandrian Transgression about 8200 years ago. Prior to this a Mesolithic community dwelt by the fresh water streams and lakes of a low lying basin. Following the flooding, the old land surface was covered by estuarine silts. The sediments accumulated until c. 3500 BP at which point a new channel was formed and the protective deposit began to be removed by erosion.

Submerged forests on both sides of the waterway have now become exposed. Study of the area is helping to interpret the consequences of long term coastal change. This is particularly relevant to the European context as Britain would have still been linked to mainland Europe at the time of occupation.

Comparable infill deposits protect similar landscapes within the many inundated palaeo-channels that remain on the north-west European continental shelf. The work in the Solent is helping us to quantify the nature of occupation prior to the inundation, the impact of the flooding, the subsequent build-up of sediment and the current erosion.

PALAEOGEOGRAPHICAL RECONSTRUCTIONS OF RUHNU ISLAND IN THE GULF OF RIGA EASTERN BALTIC SEA

Merle Muru¹, Alar Rosentau², Hanna Raig²

¹ Department of Geography, University of Tartu,

² Department of Geology, University of Tartu

The geomorphology of Ruhnu Island in the Gulf of Riga, in the eastern Baltic Sea was studied to understand the development of the landscape and to describe the natural environment of Stone Age human settlements in conditions of regressive sea level.

The palaeogeography of the island was reconstructed based on a Digital Terrain Model, Holocene sediment samples, water level change and postglacial rebound data. The island emerged from the sea c. 12,000 cal BP and has an area of c. 12 km² today. The central flat part of the island is surrounded by coastal foredune ridges reaching 5–15 m a.s.l. The earliest human habitation on the island is dated c. 7300 cal. BP.

Relief analysis based on high resolution airborne Lidar data and ground penetrating radar studies was carried out and the geological profile of the Holocene deposits of the island was studied. The combination of different methods enables clarification of the development of Ruhnu Island. At the time of the maximum level of the Litorina Sea, Ruhnu was a small semicircular islet, and its area has been enlarging ever since. Well-developed foredune ridge sequences found almost symmetrically in all directions around the central plain of the island mark beach progradation. Palaeogeographical modelling shows that the youngest significant foredune ridges were formed at about 4000 cal BP and that Stone Age settlement sites on the island were located close to their contemporaneous shorelines, which are located far inland today.

INTRODUCING THE CHEROKEE – A 1000 M DEPTH RATED, OBSERVATION CLASS ROV WITH PAYLOAD OPTION

Nicolas Nowald

MARUM, Centre for Marine Environmental Sciences, University of Bremen, Germany

The research activities at MARUM, the Centre of Marine Environmental Sciences located in Bremen/Germany, focus on paleoclimatology, sediment dynamics and geosphere-biosphere interactions. Apart from the fundamental research carried out in the marine realm, MARUM develops and provides infrastructure for the marine science community in general and intends to expand its activities into the research area of marine archaeology.

MARUM operates a fleet of underwater vehicles that are used to address a variety of scientific questions and may also be of interest for marine archaeologists. One tool to work in water depths beyond the reach of divers is the 1000 m depth rated, Class II Observation ROV with payload option, "*Cherokee*". Here, we present the vehicle with its capabilities but also its limitations.

PALAEOGEOGRAPHY OF THE CYCLADES ARCHIPELAGO DURING LGM (AEGEAN SEA, GREECE)

Pinelopi Papika¹, Athanasios Skentos¹, Kosmas Pavlopoulos¹, Vasilios Kapsimalis²

¹ Harokopio University

² Hellenic Centre for Marine Research

The Cyclades plateau is located in the central Aegean Sea and represents a shallow platform with an average depth of about 200 m. The sea floor is characterized by a complex morphology as a result of the recent geodynamic activity of the Aegean Sea and the climatic changes of the Quaternary. The purpose of this study is the palaeogeographic reconstruction of the Cyclades archipelago during the Last Glacial Maximum period.

High resolution seismic profiles and existing bathymetric data were used for mapping the seabed relief by using semi-automated cartographic tools. Further analysis and interpretation of the seismic profiles combined with stratigraphical and geoarchaeological data led to the identification of the sedimentary and geomorphological processes occurring in the study area.

All data were imported into a Geographical Information System (GIS) and were properly managed with the main objective of creating a palaeogeographical map of the Cyclades archipelago.

PLEISTOCENE SEA-CROSSINGS AND SUBMERGED TERRESTRIAL ROUTES IN THE NE MEDITERRANEAN

Christina Papoulia

Department of History & Archaeology, University of Crete, Greece

The Eastern Mediterranean's changing coastline has been both an obstacle and a crossing point for some of the earliest acts of human colonization. Early hominin adaptations and dispersals were significantly influenced by the seascapes and submerged Pleistocene landscapes. The choice of particular terrestrial and maritime migration routes, the subsistence strategies, the exploitation of marine resources, the settlement patterns and the origins of sea-faring would all have been shaped by the morphology of the palaeolandscapes.

Recent interdisciplinary data and on-going research in the Northeastern Mediterranean propose that unfamiliar, insular territories were for the first time colonized during the Pleistocene. Due to sea-level fluctuations, several of the present-day islands of the Aegean and Ionian Sea were connected to mainland Greece or Turkey during most of the Pleistocene, while others seem to have been isolated since the Miocene.

This poster presents the archaeological evidence for early Palaeolithic settlements on the present-day islands of the Aegean and Ionian regions in order to talk about early land- and sea-crossings. It proposes the possible crossing routes and, finally, stresses the significance of the submerged landscapes and the need for targeted underwater Palaeolithic investigations in this part of the continental shelf.

SEA LEVEL RISE AND HUMAN ADAPTATION TO ENVIRONMENTAL CHANGES DURING LATE PREHISTORY ALONG THE WESTERN BLACK SEA COAST

Preslav Iliev Peev, Raina Hristova

Institute of Oceanology, Bulgarian Academy of Sciences, Bulgaria

Climate changes, sea-level changes and the palaeoecological conditions of the Black Sea coastal area during the Holocene have been reconstructed and discussed from the point of view of submerged prehistoric settlements, dating from the Eneolithic period and the Early Bronze Age. The established settlements have been analyzed in their geomorphological context with the methodology of underwater archaeology.

A number of submerged prehistoric settlements are known along the western coast of the Black Sea. Geomorphological analysis and underwater archaeological investigation indicates their existence from the Eneolithic period and Early Bronze Age (between 6500-4000 BP). This has also been proven by the curve of the changes of the sea level during the Holocene in the Western part of the Black Sea.

In the peculiar context along the western Black Sea coast numerous recent works have shown that at the beginning of the Holocene, the Black Sea was a water expanse disconnected from the Mediterranean. The re-connection occurred sometime around 6700–6500 BC. This phenomenon resulted in a rapid rise of the sea level and consequently in «dramatic» changes in the coastline geometry and fluvial dynamics. These modifications probably affected the capacities of these coastlines and deltaic areas to produce and maintain biodiversity. The general worldwide sea-level rise was and still is a major source of social, geographical and environmental transformations.

MESOLITHIC FISHERY ON POLISH COAST OF THE BALTIC SEA

Mateusz Popek

Department of Underwater Archaeology, Nicolaus Copernicus University, Torun, Poland

The main way of life in Mesolithic cultures was hunting, fishing and gathering. In different environments people used different variation of these three ways of getting food. On the seashore most studies suggest that fishing and sea mammal hunting was the main activity. Therefore, the aim of this presentation is to describe various artefacts identified as ancient fishing equipment and methods of sea mammals hunting and fishery.

There are three methods to reconstruct sea mammal hunting and Stone Age fishery. First are artefacts identified as sea mammal hunting equipment, and fishery equipment. A second method is archaeozoological analysis of bones. A third method of reconstruction is ethnological analogies.

On Polish archaeological sites there are relatively few artefacts identified as hunting and fishing equipment like: hooks, harpoons or net floats. We obtain more information from bones of fish and sea mammals. In Poland there is over a dozen archaeological sites with bone remains. This gives information about species, and hunting periods. Ethnological analogies could show the methods of fishery and sea mammal hunting: how people use nets, rods or fish traps. We can try to reconstruct hunting organization and the social meaning of this way of getting food.

The state of research on Mesolithic fishery and sea mammal hunting on the Polish coast is disappointing. Therefore, we should focus on this aspect of Mesolithic communities' life to get a fuller picture of these Stone Age cultures.

STONE AGE SETTLEMENT AND POSTGLACIAL DEVELOPMENT OF THE BALTIC SEA IN THE TÕRVAJÕE BASIN AREA IN NARVA-LUGA KLINT BAY, NE ESTONIA

Hanna Raig, Alar Rosentau

University of Tartu, Estonia

The Tõrvajõe basin is located in NE Estonia, in the Estonian part of the Narva-Luga Klint Bay. Development of the basin has been affected by the combination of postglacial land uplift and changes in the Baltic Sea water-level and that has led to submergence or emergence of the area several times.

Development of the Tõrvajõe basin area during the period of Stone Age settlement (c 8.5–6.0 cal. ka BP) is studied with multiple geological and archaeological proxies. Sediments are described by lithostratigraphical methods, loss-on-ignition and mineral magnetic parameters. AMS radiocarbon dates are used for the age-depth model. Environment is described by pollen analyses and water environment by siliceous microfossil analyses. Palaeogeographical reconstructions are created to illustrate changes of the coastline and landscape over time.

The aim of this interdisciplinary study is to investigate and associate palaeoenvironmental conditions and water-level changes with Stone Age settlement patterns in the Tõrvajõe area.

Results show four developmental stages in the post-glacial history of the basin: Ancylus Lake lagoon, mire, lagoon during the Litorina Sea and mire. During the Ancylus Lake transgression (amplitude c 9 m) at about 10.8–10.2 cal. ka BP a spit started to form north of the basin and a lagoon evolved behind it. Following the Ancylus Lake regression river activity and formation of a palaeosol and fen peat took place in the Tõrvajõe basin.

The oldest traces of human activity in the area are dated to 8.5–7.9 cal. ka BP and are associated with the pre-Litorina Sea transgression period of low water-level. Some finds of this age are in water-laid sediments and could be connected with reorganization of the Narva River streams.

The terrain was inundated by the fast Litorina Sea transgression (amplitude c 8 m) and a lagoon formed in the Tõrvajõe basin. The sheltered shores of this lagoon were favourable living environments for Neolithic people between 7.1–6.0 cal. ka BP as appears from the 15 Neolithic settlement sites around the basin. Due to slowing of water-level rise of the Litorina Sea and on-going land uplift, the water body dried up. People abandoned the Tõrvajõe area and concentrated mostly along the ancient rivers in Narva-Luga Klint Bay.

**RECENT SEDIMENT SOURCES, PATHWAYS, DISPERSAL PATTERNS
AND RELICT FEATURES IN THE JIZAN-FARASAN ISLAND AREA,
RED SEA, SAUDI ARABIA**

**Najeeb Rasul¹, Geoff Bailey², Dimitris Sakellariou³, Salem Al Nomani¹,
Garry Momber⁴, Abdullah Alsharekh⁵, Abdalnasser Qutub¹**

¹ Saudi Geological Survey, P.O. Box 54141, Jeddah, 21514, Kingdom of Saudi Arabia

² Department of Archaeology, University of York, York, YO1 7EP, UK

³ Hellenic Centre for Marine Research, 19013 Anavyssos, Greece

⁴ Maritime Archaeology Trust, National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, United Kingdom

⁵ Department of Archaeology, King Saud University, P.O. Box 2627, Riyadh, 7524-12372R, Kingdom of Saudi Arabia

The analysis of present-day submarine sediment distributions and sediment sources plays a vital role in understanding the evolution of the Arabian coastal zone. It also plays a vital role in contributing to an understanding of the submerged continental shelf and the way this has evolved under varying impacts of sea-level change.

This poster will present the preliminary results of research currently under way in the vicinity of the Farasan Islands and Gizan in the Saudi Arabian sector of the Red Sea, and run by the Saudi Geological Survey, and a joint Saudi-UK geoarchaeological project forming part of the ERC-funded DISPERSE project (Dynamic Landscapes, Coastal Environments and Human Dispersals)

THREATENED PALEO-LANDSCAPE NORTH SEA

Ursula Warnke

Deutsches Schiffahrtsmuseum, Germany

The German North Sea is part of a marginal sea under high utilization pressure. There are only a few areas that have not been exploited by fishery, maritime traffic, wind energy, pipelines etc. These interferences are threatening to destroy our cultural wealth preserved on the seabed of the North Sea.

German state heritage legislations are only valid within the 12-mile-zone. Beyond that zone in the German Exclusive Economic Zone (EEZ) no heritage authority has responsibility. Accordingly underwater cultural heritage outside the twelve-mile zone cannot be placed under monument protection. Further, to this day the German government has not signed the UNESCO Convention on the Protection of the Underwater Cultural Heritage.

To produce a basis for future protection and archaeological research, the Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung/BMBF) is financing a three year (2011–2014) pilot project at the National Maritime Museum of Germany (Deutsches Schiffahrtsmuseum/DSM). This project is carried out in close cooperation with the Federal Department for Shipping and Hydrography (Bundesamt für Seeschifffahrt und Hydrographie/BSH). The evaluation of their data base is one important part of this pilot project. The aim is to collect relevant including substantial data on paleo-landscapes in a research data base and to develop appropriate methods for the evaluation of the underwater cultural heritage in the German EEZ. Data from core drillings and geophysical surveys is collected from cooperating institutions and private companies active in the North Sea. In addition a number of underwater sites will be investigated with the museums geophysical survey equipment and diving investigations and additional data will be collected.

MORPHOGENETIC MODELLING OF LARGE-SCALE HOLOCENE SEDIMENTARY SYSTEMS USING A HYBRID MULTI-SCALE MORPHODYNAMIC MODEL

Wenyan Zhang

MARUM – Centre for Marine Environmental Sciences, University of Bremen, Germany

Large-scale modern sedimentary systems (either subaerial or subaqueous) are developed as a result of the interplay of multi-scale land-sea processes. A modelling methodology based on a multi-scale hybrid morphodynamic model and representative climate driving conditions is presented to study the long-term morphological evolution of these systems on a centennial-to-millennial scale.

The first case study is applied to a Holocene barrier island (Darss-Zingst Peninsula) at the southern Baltic Sea. A palaeo-Digital Elevation Model (DEM) serving as the initial condition is reconstructed by a compilation of recent digital elevation data sets, an eustatic sea-level curve, an isostatic map and dated sediment cores.

Representative wind series are initially generated based on a statistical analysis of a palaeo-wind data set from a simulation with the coupled atmosphere-ocean general circulation model ECHO-G over the last 7000 cal yrs. These wind data were further fine-tuned using proxies from lithostratigraphic studies of sediment cores from the central Baltic Sea, and used as climate driving conditions for the model.

Based on the reconstructed palaeo-DEM and the representative climate driving conditions, the methodology is applied to reconstruct the morphogenesis of the Darss-Zingst Peninsula since 6000 cal. yr BP. Simulation results aid a further understanding of the roles that wind driven circulation, relative sea level change, wave dynamics, aeolian transport as well as storms played on the long-term development of the barrier island. A similar modelling methodology will be applied to investigate the morphogenesis of modern mid-shelf mud depocenters distributed world-wide.

PARTICIPANTS

Adamczyk, Michał
University of Szczecin, Faculty of Humanities, Institute of History and International
Relations, Krakowska 71-79, 71-017 Szczecin, Poland
michal.adamczyk.us@gmail.com

Arias, Pablo
Universidad de Cantabria, Av. de los Castros s/n Santander, 39005, Spain
pablo.arias@unican.es

Astrup, Peter Moe
Aarhus University, Department of Culture and Society, Ny Moesgaard Alle 20,
8270 Hfrbjerg, Denmark
farkpma@hum.au.dk

Baika, Kalliopi
Department of Underwater Antiquities, Hellenic Ministry of Culture, Dion. Aeropagitou
and Erechteiou 59, Athens, 117 42, Greece
kbaika@gmail.com

Bailey, Geoff
University of York, Department of Archaeology University of York,
YO1 7EP, United Kingdom
geoff.bailey@york.ac.uk

Bartzke, Gerhard
MARUM – University of Bremen, Leobener Straße, 28359, Germany
gbartzke@marum.de

Benjamin, Jonathan
University of Edinburgh & Wessex Archaeology, 21/8 Henderson Row Edinburgh, EH3
5DH, United Kingdom
jonathan.benjamin@ed.ac.uk

Berlinghieri, Elena Flavia Castagnino
Soprintendenza ai Beni Culturali e Ambientali di Siracusa,
Via Mar di Marmora 2, 96100, Italy
elfcb@tiscali.it

Bitinas, Albertas
Coastal Research and Planning Institute, Klaipėda University,
Herkaus Manto st. 84, Klaipėda, LT-92294, Lithuania
albertas.bitinas@corpi.ku.lt

Borówka, Ryszard Krzysztof

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
ryszard@univ.szczecin.pl

Bregman, Enno

Utrecht University Province of Drenthe, Aquarius, 58, Assen, 9405 RC, Netherlands
enno.bregman@gmail.com

Brenk, Seger van den

Periplus Archeomare, Asterweg 17A4, 1031HL, Netherlands
s.v.d.brenk@periplus.nl

Brzozowska, Karolina

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
karkbb@poczta.onet.pl

Bugajny, Natalia

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
natalia.bugajny@univ.szczecin.pl

Çađatay, Namýk

Istanbul Technical University, Maden Fakóltesi Ayazađa Kampusu, 34469, Turkey
cagatay@itu.edu.tr

Caraivan, Glicherie Vasile

GeoEcoMar, 22-25, Dimitrie Onciul Str, Bucharest, 024053, Romania
glicheriecaraivan@yahoo.com

Cawthra, Hayley C.

Joint Council for Geoscience Marine Geoscience Unit - University of Cape Town,
3 Oos Street Bellville Cape Town, 7535, South Africa
hcawthra@geoscience.org.za

Chmiel, Marta

University of Szczecin, Faculty of Humanities, Institute of History and International
Relations, Krakowska 71-79, 71-017 Szczecin, Poland
chmiel.marta86@gmail.com

Chu, Nan-Chin

European Marine Board, Wandelaarkaai 7 Oostende, 8400, Belgium
nchu@esf.org

Colpman, Davina

University of Aberdeen, 18 Hampton Court Road Harborne Birmingham West Midlands,
B17 9AE, United Kingdom
dav.colpman@gmail.com

Damlien, Hege

Museum of Archaeology, University of Stavanger, Stensgata 41B, 0451 Oslo, Norway
hege@damlien@khm.uio.no

Damuđytė, Aldona

Lithuanian Geological Survey, Konarskio Str. 35, LT-03123, Lithuania
aldona.damusyte@lgt.lt

Daniszewska-Kowalczyk, Genowefa

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
flora@univ.szczecin.pl

Dawood, Jasim Alrubaye

University of Basrah, Geography Department College of Arts Bab Al Zubair Post Basrah,
61001, Iraq
dawod50@hotmail.com

Dellaporta, Katerina

Ministry For Culture Greece, 2-Eba, Klepsydras 2 Athens, 105 55, Greece
katerinadellaporta@yahoo.com

Dencker, Jørgen Spaanheden

The Viking Ship Museum, Roskilde, Vindeboder 12, 4000 Roskilde, 4000, Denmark
jd@vikingskibsmuseet.dk

Deng, Junjie

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
deng.junjie@gmail.com

Drozd, Magdalena

University of Szczecin, Faculty of Humanities, Institute of History and International
Relations, Krakowska 71-79, 71-017 Szczecin, Poland
anchesanamom@gmail.com

Druzhinina, Olga

I. Kant Baltic Federal University, A. Nevskogo str., 14 B, 404, 236038, Russian Federation
druzh78@mail.ru

Dudzińska-Nowak, Joanna

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
jotde@univ.szczecin.pl

Ene, Dragos

National Institute of R&D for Optoelectronics, Atomistilor 409 Str., Magurele, Ilfov,
077125, Romania
dragos@inoe.ro

Eshed, Vered

Israel Antiquities Authority, P.O.B 586, Jerusalem, 91004, Israel, P.O.B 586, Jerusalem, Israel

vished@gmail.com

Fischer, Anders

Danish Agency for Culture, H.C. Andersens Boulevard 2 Copenhagen V, 1553, Denmark
afi@kulturstyrelsen.dk

Fitch, Simon

94 Coniston Road Leamington spa Warwickshire, CV32 6PF, United Kingdom
si_fitch@yahoo.co.uk

Flemming, Nicholas Coit

National Oceanography Centre, European Way, Southampton, Hants,
GU24 0EN, United Kingdom
n.flemming@sheetsheath.co.uk

Fröhle, Peter

Institute of River and Coastal Engineering Hamburg University of Technology,
Denickestr. 22 Hamburg, D21073, Germany
froehle@tuhh.de

Furmańczyk, Kazimierz

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
kaz@univ.szczecin.pl

Gaffney, Vincent

University of Birmingham, Digital Hub ERI Building University of Birmingham Edgbaston
Birmingham, B15 2TT, United Kingdom
v.l.gaffney@bham.ac.uk

Galanidou, Nena

University of Crete, Dept. of History & Archaeology Univ. of Crete Gallou Rethymno,
74100, Greece
galanidou@uoc.gr

Geraga, Maria

University of Patras, Greece, Rio, Patras, 26504, Greece
mgeraga@upatras.gr

Glorstad, Hakon

Museum of Cultural History, University of Oslo, Box 6762 St. Olavsplass, 0130, Norway
hakon.glorstad@khm.uio.no

Goldhammer, Julia

Niedersächsisches Institut für historische Küstenforschung, Viktoriastr. 26/28
Wilhelmshaven, D26382, Germany
julia.goldhammer@nihk.de

Górecka, Ewa

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland. gorecka@o2.pl

Gregory, David John

National Museum of Denmark Dept of Conservation, I.C. Modewegs Vej Brede Kongens
Lyngby, DK 2800, Denmark
david.john.gregory@natmus.dk

Groh, Andreas

TU Dresden Institut für Planetare Geodäsie 01062 Dresden, D01062, Germany
andreas.groh@tu-dresden.de

Gron Ole, Culture & Preservation, Kystvænget 8 Rudkøbing, 5900, Denmark
olegron.lmr@gmail.com

Grudzinska, Ieva

Institute of Geology Tallinn University of Technology, Ehitajate tee 5, Tallinn,
19086, Estonia
ieva.grudzinska@gmail.com

Gundersen, Jostein

Norwegian Directorate for Cultural Heritage (Riksantikvaren, P.O Box 8196 Dep,
0034, Norway
jogunder@gmail.com

Hamanowski, Paweł

University of Szczecin, Faculty of Humanities, Institute of History and International
Relations, Krakowska 71-79, 71-017 Szczecin, Poland
hamanarcho@gmail.com

Hammarlund, Dan

Department of Geology, Lund University, Sölvegatan 12, Lund, SE-223 62, Sweden
dan.hammarlund@geol.lu.se

Hansson, Anton

Department of Geology, Lund University, Utbrytningsgränden 15C Lund, 22647, Sweden
anton.hansson@geol.lu.se

Harff, Jan

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
jan.harff@io-warnemuende.de

Hartleib, Jörg

Institute of Geography and Geology Ernst-Moritz-Arndt-University Greifswald,
Friedrich-Ludwig-Jahn-Strasse 16 17489 Greifswald, D-17487, Germany
hartleib@uni-greifswald.de

Hepp, Daniel A.

MARUM – Center for Marine Environmental Sciences, University of Bremen,
Leobener Strasse, Bremen, 28359, Germany
dhepp@marum.de

Iatrou Margarita

University of Patras, Rio, Patras, 26504, Greece
iatroum@upatras.gr

Jensen, Jørn Bo

Geological Survey of Denmark and Greenland, Østervoldgade 10, 1350, Denmark
jbj@geus.dk

Jensen, Theis Trolle

University of York, 48 Tannery Mews, Lawrence Street, YO10 3WG, United Kingdom
theistrollejensen@stud.ku.dk

Jerardino, Antonieta

ICREA/ Spanish National Research Council, C/ de les Egipcíacues, 15. Barcelona,
08001, Spain
amsjerardino@gmail.com

Johansen, Morten

Vikingskibsmuseet/The Viking Ship Museum, Roskilde, Vikingskibsmuseet Vindeboder
12 DK-4000 Roskilde, 4000, Denmark
mj@vikingskibsmuseet.dk

Jöns, Hauke

Niedersächsisches Institut für historische Küstenforschung, Viktoriastr. 26/28,
26382 Wilhelmshaven, Germany
joens@nihk.de

Kierzek, Agnieszka

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
kierzek@univ.szczecin.pl

Kleingärtner, Sunhild

German Maritime Museum, Hans-Scharoun-Platz 1 Bremerhaven, 27568, Germany
kleingaertner@nihk.de

Krajewski, Przemysław

University of Szczecin, Faculty of Humanities, Institute of History and International
Relations, Krakowska 71-79, 71-017 Szczecin, Poland
p.kraj@univ.szczecin.pl

Laimdota, Kalnina

University of Latvia, Faculty of Geography and Earth Sciences, 19, Rainis Blvd.,
LV-1586, Latvia
Laimdota.Kalnina@lu.lv

Lambeck, Kurt
The Australian National University, Canberra, 0200, Australia
Kurt.Lambeck@anu.edu.au

Larsson, Lars Olof Georg
Institute of Archaeology and Ancient History, Lund University Box 117 Lund,
SE-221 00, Sweden
Lars.Larsson@ark.lu.se

Lericolais, Gilles
MARUM - University of Bremen, Leobener Straße, 28359, Germany
gilles.lericolais@ifremer.fr

Lübke, Harald
Centre for Baltic and Scandinavian Archaeology - Schleswig-Holstein State Museums
Foundation Schloss Gottorf, Schlossinsel 1 Schleswig, 24837, Germany
harald.luebke@schloss-gottorf.de

Maarleveld, Thijs
Jakob Maritime Archaeology Programme University of Southern Denmark, NielsBohrsvej 9,
DK-6700, Denmark
t.maarleveld@sdu.dk

Mazza, Alba
The University of Sydney, unit 8, 1 Goodsell St Peters, NSW, 2044, Australia
alba.mazza@gmail.com

Missiaen, Tine
Renard Centre of Marine Geology, Ghent University, Krigsilaan 281 S8, B9000 Ghent,
B9000, Belgium
tine.missiaen@ugent.be

Momber, Garry
Maritime Archaeology Trust, W1/95 National Oceanography Centre,
SO14 3ZH, United Kingdom
garry.momber@hwtma.org.uk

Moore, Fionnbarr M.
Underwater Archaeology Unit, National Monuments Service, Dept. of Arts Heritage
and the Gaeltacht, Custom House, Dublin, Ireland
fionnbarr.moore@ahg.gov.ie

Muru, Merle
University of Tartu, Institute of Ecology and Earth Sciences, Department of Geography,
Vanemuise 46, 51014, Estonia
merle.muru@ut.ee

Musielak, Stanisław

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
muss@univ.szczecin.pl

Nilsson, Björn

Maritime Archaeological Research Institute Södertörn University, Alfred Nobels Allé 15
Flemingsberg Sweden, SE-14189, Sweden
bjorn.nilsson@sh.se

Nowald, Nicolas

MARUM - University Bremen, Leobener Strasse Gebaude MARUM 28359 Bremen,
Germany
nnowald@marum.de

Oniz, Hakan

Selcuk University, Department of underwater Archaeology, Kampus, Konya, 42100, Turkey
hakan.oniz@gmail.com

Osadczyk, Andrzej

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
andros@univ.szczecin.pl

Otte, Andrea

Cultural Heritage Agency, Smallepad 5, Amersfoort, 3811 MG, Netherlands
amotte@zonnet.nl

Papika, Pinelopi

Harokopio University Athens, 156Arapaki Str Athens, 17675, Greece
ppapika@hotmail.com

Papoulia, Christina

University of Crete, Department of History & Archaeology, Salaminos 52-54, Athens,
10435, Greece
christina_papoulia@hotmail.com

Peev, Preslav Iliev

Institute of Oceanology, P.O. Box 152, 9000, Bulgaria
peev@io-bas.bg

Piotrowski, Andrzej Konrad

Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy Oddział Pomorski
w Szczecinie, ul. Wieniawskiego 20, Szczecin, 71-130, Poland
andrzej.piotrowski@pgi.gov.pl, apiot@pgi.gov.pl

Popek, Mateusz

Nicolaus Copernicus University in Torun, Department of Underwater Archaeology,
Instytut Archeologii, Szosa Bydgoska 44-48, 87-100 Toruń, Poland
mateusz.popek@o2.pl

Pydyn, Andrzej

Department of Underwater Archaeology, Institute of Archaeology, Nicolaus Copernicus University, Szosa Bydgoska 44-48, 87-100 Toruń, Poland
pydyn@umk.pl

Radić Rossi, Irena

University of Zadar, Department of Archaeology, Obalakrajla Petra Krešimira IV. 2, Zadar, 23000, Croatia
irradic@unizd.hr

Raig, Hanna

University of Tartu, Institute of Ecology and Earth Sciences, Ravila 14a, 50411, Estonia
hanna.raig@ut.ee

Rębkowski, Marian

University of Szczecin, Faculty of Humanities, Institute of History and International Relations, Krakowska 71-79, 71-017 Szczecin, Poland
marian.rebkowski@neostrada.pl

Rosentau, Alar

University of Tartu, Department of Geology, Ravila 14a, Tartu, 50411, Estonia
alarr@ut.ee

Sakellariou, Dimitris

Institute of Oceanography, Hellenic Centre for Marine Research, 47km Athens-Sounio Ave, Anavyssos, 19013, Greece
sakell@hcmr.gr

Satchell, Julie

Maritime Archaeology Trust, HWTMA, Room W1/95, National Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, United Kingdom
julie.satchell@hwtma.org.uk

Sjöström, Arne

Maritime Archaeological Research Institute MARIS Södertörn University, Huddinge, SE-141 89, Sweden
arne.sjostrom@sh.se

Skentos, Athanasios

Harokopio University of Athens, 35 Karaiskakist Likovrisi Attica, 14123, Greece
thanskentos@gmail.com

Skonieczna, Zuzanna

University of Szczecin, Faculty of Humanities, Institute of History and International Relations, Krakowska 71-79, 71-017 Szczecin, Poland

Skriver, Claus

Moesgård Museum, Moesgårdalle 20, 8270 Højbjerg, Denmark
claus.skriver@moesmus.dk

Soomere, Tarmo

Institute of Cybernetics at Tallinn University of Technology, Akadeemia tee 21, Tallinn,
12618, Estonia
soomere@cs.ioc.ee

Spiteri, Cynthia Debono

Max Planck Institute for Evolutionary Anthropology, Department of Human Evolution,
Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, Leipzig., D04103,
Germany
cynthianne_spiteri@eva.mpg.de

Terefenko, Paweł

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
terefenko.pawel@gmail.com

Tidbury, Lauren Victoria

Maritime Archaeology Trust, Room W1/95, National Oceanography Centre, Empress Dock,
Southampton, SO14 3ZH, United Kingdom
lauren.tidbury@hwtma.org.uk

Tizzard, Louise

Wessex Archaeology, Portway House Old Sarum Park Salisbury, SP4 6EB, United
Kingdom
l.tizzard@wessexarch.co.uk

Tomczak, Michał

University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
tomcz.michal@gmail.com

Van Haelst, Sven

Flanders Heritage Agency, Acht Meilaan 21 3680 Maaseik, 3680, Belgium
sven.vanhaelst@rwo.vlaanderen.be

Vázquez, Imanol

Prehistoric and Archaeology Area. Antiquity Sciences Department. Zaragoza University,
Calle Moncayo, N.º 15, Urb. Setabia (Utebo), Zaragoza, 50180, Spain
i.vazquez.zabala@gmail.com

Veth, Peter Marius

University of Western Australia, 73A Solomon St Fremantle WA, 6160, Australia
peter.veth@uwa.edu.au

von Storch, Hans

Institute of Coastal Research Helmholtz Zentrum Geesthacht, Max Planck Strasse 1
Geesthacht, 21502, Germany
hvonstorch@web.de

Vos, Peter C.
Deltares, P.O. Box 80015, 3508 TA, Netherlands
peter.vos@deltares.nl

Warnke, Ursula
The National Maritime Museum of Germany, Hans-Scharoun-Platz 1,
D-27568 Bremerhaven, Germany
warnke@deutsches-schiffahrtsmuseum.de

Weerts, Henk
Cultural Heritage Agency, the Netherlands, PO Box 1600 Amersfoort, 3800 BP,
Netherlands
h.weerts@cultureelerfgoed.nl

Wefer, Gerold
MARUM - Center for Marine Environmental Sciences, University of Bremen Leobener Str.
Bremen, 28359, Germany
gwefer@marum.de

Werthe, Elise
UMR 6566 CReAAH, Rennes 1, Avenue du Général Leclerc Campus de Beaulieu Bâtiment
24-25 Université de Rennes 1 CS74205 35042 Rennes Cedex, 35042, France
elise.werthe@live.fr

Westley, Kieran
University of Ulster, Centre for Maritime Archaeology University of Ulster Coleraine, BT52
1SA, United Kingdom
kl.westley@ulster.ac.uk

Wickham-Jones, Caroline
University of Aberdeen, Scotland, Cassie, Sunnybank Road, Kirkwall, Orkney, Scotland,
KW15 1TP, United Kingdom
c.wickham-jones@abdn.ac.uk

Witkowski, Andrzej
University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
witkowski@univ.szczecin.pl

Wroniecki, Marcin
University of Szczecin, Institute of Marine and Coastal Sciences, Faculty of Geosciences,
Mickiewicza 18, 70-383 Szczecin, Poland
marcin.wroniecki@univ.szczecin.pl

Yanko, Valentina V.
Odessa I.I. Mechnikov National University, Department of Physical and Marine Geology, 2
Shampansky Per., Odessa, 65082, Ukraine
valyan@onu.edu.ua

Zdebski, Piotr

University of Szczecin, Faculty of Humanities, Institute of History and International Relations, Krakowska 71-79, 71-017 Szczecin, Poland

piotrek.zdebski@gmail.com

Zhang, Wenyan

MARUM - Center for Marine Environmental Sciences, University of Bremen, Leobener Straße 1, D28359, Germany

wzhang@marum.de

Žulkus, Vladas

Klaipeda University, H. Manto 84, Klaipeda, LT-92294, Lithuania

vladas.zulkus@ku.lt

INDEX OF AUTHORS

- Abelli Leonardo 29
Adamczyk Michał 111, 112
Agosto Maria Vittoria 29
Agouridis Christos S. 106
Al-Hamdani Zyad 63
Al Nomani Salem 40
Alsharekh Abdullah 40, 124
Andrzejewski Paweł 95
Antonioli Fabrizio 29
Astrup Peter Moe 101
- Baika Kalliopi 27, 28
Bailey Geoff 40, 124
Benjamin Jonathan 23, 102
Berlinghieri Elena Flavia Castagnino 52
Bicket Andrew 23, 102
Bitinas Albertas 85
Björck Svante 20, 36
Björdal Charlotte 107
Bobertz Bernd 98
Boetto Giulia 27
Borówka Ryszard Krzysztof 12, 86
Bosman Alessandro 29
Bregman Enno 103
Bugajny Natałia 95
- Caraivan Glicherie Vasile 16
Casalbore Daniele 29, 61
Cawthra Hayley C. 39
Chabrol Antoine 110
Chen Hongjun 12
Chmiel Marta 111, 112
Christodoulou Dimitris 27, 106
Cieszyński Łukasz 95
Compton John S. 39
Cukrov Neven 26
- Daire Marie-Yvane 72, 114
Damušytė Aldona 85
Dellaporta Katerina 76
Dencker Jørgen Spaanheden 47
Deng Junjie 83, 89, 98
Dietrich Reinhard 10
Dimitris Christodoulou 28
Dobosz Sławomir 15
Druzhinina Olga 103
Dudzinska-Nowak Joanna 89, 96, 98
- Ene Dragos 104
Erkens Gilles 65, 73
Eshed Vered 51, 105
- Fabrizio Antonioli 52
Fakiris Elias 27, 28, 106
Fischer Anders 45
Fisher Erich C. 39
Fitch Simon 60
Flemming Nicholas Coit 19, 33, 79
Fröhle Peter 94
Furmańczyk Kazimierz 83, 89, 95, 98
- Gaffney Vincent 60
Galanidou Nena 37, 76
Galili Ehud 51, 105
Gambin Timmy 64
Georgiou Panos 40, 110
Geraga Maria 27, 28, 106
Gerasimov Dmitry 25
Giza Andrzej 89, 98
Glorstad Håkon 42
Goldhammer Julia 49, 53
Gregory David John 107
Groh Andreas 10
Grøn Ole 57, 58
Grudzinska Ieva 108
- Hammarlund Dan 20, 36
Harff Jan 11, 12, 15, 19, 83, 88, 89, 98
Hartleib Jörg 97, 98
Hartz Sönke 49
Heinsalu Atko 108
Hepp Daniel A. 75
Hermand Jean-Pierre 58
Heteren Sytze van 65, 73
Holmen Andersen Mikkel 107
Holmlund Joakim 36, 67
Hoogendoorn Bob 74
Hristova Raina 120
Hünicke Birgit 11
- Iatrou Margarita 28, 106
- Jakobsson Martin 36
Jensen Jørn Bo 63
Jerardino Antonietta 109

- Jöns Hauke 54
 Jurkin Viačeslav 85
- Kallergis Manolis 40
 Kalogirou Stefanos 40
 Kapsimalis Vasilios 110, 118
 Karle Martina 53
 Kierzek Agnieszka 15
 Kleingärtner Sunhild 53
 Kordella Stavroula 27, 106
 Krajewski Przemysław 111, 112
 Krawczyk Diana 15
 Kriiska Aivar 25
- Lambeck Kurt 9, 19
 Larsson Lars Olof Georg 46
 Latino Chiocci Francesco 29, 61
 Lericolais Gilles 19
 Linderson Hans 20
 Lübke Harald 50
- Maes Frank 74
 Maeyer Philippe De 74
 Manousakis Lionidas 40
 Mantopoulos Prokopis 40
 Marean Curtis W. 39
 Mazza Alba 113
 McInnes Robin 114
 Meadows John 50
 Mees Jan 74
 Meredith-Williams Matthew 40
 Meyer Michael 11, 88
 Missiaen Tine 19, 57, 72, 74, 114
 Momber Garry 35, 40, 72, 114, 115, 124
 Morfis Ioannis 40
 Mörz Tobias 75
 Muru Merle 25, 116
- Nilsson Björn 20, 36, 67
 Noble-Shelly Jasmine 114, 115
 Nomani Salem Al 124
 Nowald Nicolas 117
- Oja Tõnis 88
 Osadczuk Andrzej 12, 86
 Osadczuk Krystyna 86
 Otte Andrea 65, 73
- Pampidis Ioannis 40
 Panagiotopoulos Ioannis 40
 Papatheodorou George 27, 28, 106
 Papika Pinelopi 118
- Papoulia Christina 119
 Pavlopoulos Kosmas 118
 Pedersen Robert 107
 Peeters Hans 35, 65, 73
 Peev Preslav Iliev 120
 Pieters Marnix 74
 Plets Ruth 24
 Popek Mateusz 30, 121
 Prevenios Michail 106
 Pydyn Andrzej 30, 122
- Quinn Rory 24
 Qutub Abdalnasser 124
- Radić Rossi Irena 26, 27
 Radvan Roxana 104
 Raig Hanna 25, 116, 123
 Ramsey Eleanor 60
 Rasul Najeeb 124
 Ratoiu Lucian 104
 Renieris Panagiotis 40
 Richter Andreas 10
 Romagnoli Claudia 29, 61
 Rönnby Johan 36, 67
 Rosen Baruch 51
 Rosentau Alar 19, 25, 88, 116, 123
 Rotnicki Karol 84
 Rousakis Grigoris 40, 110
 Rundgren Mats 20
- Saarse Leili 108
 Sakellariou Dimitris 19, 37, 40, 59, 124
 Satchell Julie 71, 72, 114, 115
 Schmölcke Ulrich 50
 Schneider Ralf 11, 89
 Scicchitano Gianfranco 52
 Shaw Genevieve 102
 Sjöström Arne 20, 36
 Skentos Athanasios 118
 Skriver Claus 48
 Soomere Tarmo 93
 Soura Konstantina 27
 Stasinou Vasileios 40
 Stavrakakis Spyros 40
 Stefanescu Diana 16
 von Storch Hans 62
 Subetto Dmitry 25
- Terefenko Pawel 14, 89
 Tidbury Lauren Victoria 72, 114, 115
 Tizzard Louise 23
 Tomczak Michal 12

Törnqvist Oscar 36
Truszkowska Aleksandra 12
Tusa Sebastiano 29

Vaičiulytė Simona 85
Van Haelst Sven 74
Vassiljev Jüri 108
Veski Siim 108
Veth Peter Marius 38
Vincent Bernard 21
Viška Maija 93
Voinea Valentina 16
Vönhögen-Peeters Laura 65, 73
Vos Peter C. 66, 72, 114
Vreenegoor Ellen 65, 73

Warnke Ursula 75, 125
Weerts Henk 65, 73
Wefer Gerold 13
Werthe Elise 21
Westley Kieran 24
Witkowski Andrzej 12, 15, 86
Wziątek Dagmara 14

Yanko Valentina 22
Yan Qiu 12

Zhang Wenyan 11, 89, 126
Zölitz Reinhard 98
Zorita Eduardo 11, 62
Zoura Despina 106
Zubčić Krno 27

PROGRAM

UNDER THE SEA: **ARCHAEOLOGY AND PALAEOLANDSCAPES**

SPLASHCOS Final Conference: **Szczecin**

Venue: **University of Szczecin, Faculty of Humanities, ul. Krakowska 71-79 (unless indicated otherwise)**

Provisional Timetable

SPECIAL EVENTS

Time	Event	Details, Location
Various	City Tours	Meeting Place: Hotel Ibis, ul. Dworcowa 16, 70-206 Szczecin

SUNDAY, SEPTEMBER 22nd

15:00–18:00	Registration	
19:00–...	Ice breaker reception	

MONDAY, SEPTEMBER 23rd

Various times	The Mysteries of Atlit Yam: Alpha-Zoulou Film	Drop-in showings
12:30–14:00	Experimental Archaeology: Human Origins	Drop-in session
12:30–14:00	Public Open Ship Event: R/V BRABANDER	Waly Chrobrego (Quayside)
20:30–21:30	Public Lecture: Atlantis: Is There a Physical Basis for the Myth?	Faculty of Mathematics, ul. Wielkopolska 15 Kurt Lambeck

TUESDAY, SEPTEMBER 24th

Various times	The Mysteries of Atlit Yam: Alpha-Zoulou Film	Drop-in showings
12:30–14:00	Experimental Archaeology: Stone Age of the Southern Baltic I	Drop-in session
12:30–14:00	Public Open Ship Event: R/V BRABANDER	Waly Chrobrego (Quayside)
16:00–19:00	Public Open Ship Event: R/V ELISABETH MANN BORGESE	Waly Chrobrego (Quayside)
20:00	Conference Dinner	Zamkowa restaurant, ul. Rycerska 3, 70-537 Szczecin

WEDNESDAY, SEPTEMBER 25th

Various times	The Mysteries of Atlit Yam: Alpha-Zoulou Film	Drop-in showings
12:30–14:00	Experimental Archaeology: Stone Age of the Southern Baltic II	Drop-in session
12:30–14:00	Public Open Ship Event: R/V BRABANDER	Waly Chrobrego (Quayside)

THURSDAY, SEPTEMBER 26th

8:30–...	Field excursion: Szczecin→Wolin→Lubin→Gosan→Trzęsacz→ Malkocin→Szczecin	
17:30–21:00	Barbecue in Kulice	

MONDAY, SEPTEMBER 23rd – OPENING CEREMONY

8:45–9:30	E. Włodarczyk (REctor, Szczecin University) A. Witkowski (Chair of Organising Committee), G. Bailey (Chair of Scientific Committee)
-----------	--

PLENARY SESSION 1: SEA LEVEL, CLIMATE & PALAEOENVIRONMENT

Time	Short Title	Lead authors
9:30–10:00	Sea level change and palaeo shorelines in the Baltic and E Atlantic during glacial cycles	Keynote: Kurt Lambeck
10:00–10:15	GIA model predictions, relative sea level change & crustal deformation in the S Baltic	A. Groh et al.
10:15–10:30	Multi-scale morphodynamic models and long-term climate impacts on submarine and subaerial depocentres	W. Zhang et al.
10:30–10:45	Last Glacial-Holocene sea level fluctuations in the S China Sea	M. Tomczak et al.
11:00–11:30	Coffee break	
11:30–12:00	Understanding the drivers of environmental changes in W. African from sedimentary deep-sea records	Keynote: Gerold Wefer
12:00–12:15	High precision Lidar in 3D modeling of wave cut notch formation	P. Terefenko, D. Wziątek
12:15–12:30	Diatom based inundation history of Late Mesolithic Wismar Bay	A. Witkowski et al.
12:30–12:45	Dobrogea sea level change, water supply and human impact	G. Caravan et al.
13:00–14:30	Lunch	

PLENARY SESSION 2: SUBMERGED LANDSCAPES & ARCHAEOLOGY

14:30–15:00	Sea level and climate	Keynote: Jan Harff et al.
15:00–15:15	Early Holocene landscape, climate, Baltic sea history, submerged wood, high resolution bathymetry and sediments in south Sweden	D. Hammarlund et al.
15:15–15:30	Subfossil forests, palaeoenvironment and human change in NW France	E. Werthe, B. Vincent
15:30–15:45	Late Pleistocene environmental factors defining the Black Sea, and identification of potential areas for seabed prehistoric sites and landscapes on the Black Sea continental shelf	V. Yanko-Hombach
15:50–16:20	Coffee break	
16:20–16:35	Field investigation and prospection for submerged prehistoric archaeology in the North Sea	L. Tizzard et al.
16:35–16:50	Submerged archaeological landscapes off the North coast of Ireland	K. Westley et al.
16:50–17:05	Stone Age settlement and Holocene shore displacement in the Nava-Luga Klint Bay of the Eastern Gulf of Finland	A. Rosentau et al.
17:05–17:20	Archaeological potential of anchialine caves in Croatia	I. Radić Rossi, R. Bošković
17:20–17:35	Palaeogeographic evolution of Caska Bay, Pag Island, Croatia, the last 10,000 years using marine remote sensing	M. Geraga et al.
17:35–17:50	Submerged Attika: archaeology, marine geology and landscape reconstruction	K. Baika
17:50–18:05	Palaeolandscapes reconstructions of a possible pre-Neolithic site in Pantelleria Island, central Mediterranean	L. Abelli
18:05–18:20	Sacred landscape along the sea: interdisciplinary data from Bronze Age SE Sicily	G. Scicchitano et al.

PARALLEL WORKSHOP SESSION 1: SOUTH BALTIC COASTLINES – PAST AND FUTURE

16:20–16:40	Southern Baltic coasts – geological processes and changing climate	J. Harff et al.
16:40–17:00	Late Glacial and Holocene sea level change in SE Baltic: methodology	A. Bitinas et al.
17:00–17:20	Postglacial evolution of the Odra River Mouth, Poland-Germany	R. Borowka et al.
17:20–17:40	Postglacial rebound and sea level since the Litorina transgression	A. Rosentau et al.
17:40–18:00	Coastal morphogenesis of the Pomeranian Bay - past and future projection	J. Deng et al.

TUESDAY, SEPTEMBER 24th

PLENARY SESSION 3: SUBMERGED LANDSCAPES & HUMAN DISPERSAL

Time	Short Title	Lead authors
9:00–9:30	The role of submerged prehistoric landscapes in ground-truthing models of human dispersal	Keynote: Nic Flemming
9:30–9:45	Flooded landscapes, cultural divergence and the North Sea Basin	G. Momber, H. Peeters
9:45–10:00	Landscapes lost: new archaeological / geological explorations of Early Holocene flooded landscapes in the southern Baltic	B. Nilsson et al.
10:00–10:15	Pleistocene submerged landscapes and Palaeolithic archaeology in the tectonically active Aegean	D. Sakellariou, N. Galanidou
10:30–11:00	Coffee break	
11:00–11:30	To the Islands: the archaeology of archipelagos of NWAustralia and its implications for drowned cultural landscapes	Keynote: Peter Veth
11:30–11:45	Drowned Quaternary environments and the significance for the South African southern Cape archaeological record	H. Cawthra et al.
11:45–12:00	Africa-Arabia connections: earliest human dispersals and geoarchaeological exploration of the Red Sea continental shelf	G. Bailey et al.
12:00–12:15	Social and economic importance of submerged coasts of Europe	H. Glorstad
12:30–14:00	Lunch	

PLENARY SESSION 4: UNDERWATER ARCHAEOLOGICAL SITES

14:00–14:30	Evaluating the archaeological record from the continental shelf – a summary of facts and potentials	Keynote: Anders Fischer
14:30–14:45	Submerged settlement in the Öresund Strait, southern sweden	L. Larsson
14:45–15:00	Tudse Hage: update on a 7000-year-old submerged Stone Age settlement with unique preservation and potential for locating older phases in deeper water	J. Dencker
15:00–15:15	Hjarnø: an eroding Mesolithic site with organic materials	C. Skriver
15:15–15:30	Fished up from the Baltic: a new Ertebølle site near Stohl cliff line, Bay of Kiel	J. Goldhammer, S. Hartz
15:40–16:10	Coffee break	
16:10–16:25	Submerged Late Mesolithic sites on the Jäckelberg, Wismar Bay, Germany: an update	H. Lübke et al.
16:25–16:40	Submerged Neolithic settlements off the Carmel Coast and transition from Pre-Pottery to Pottery Neolithic on the Levant coast	E. Galili et al.
16:40–16:55	Submerged Prehistoric sites from Polish inland and coastal waters	A. Pydyn, M. Popek
16:55–17:10	The Lower Saxony Wadden Sea: a marine landscape with high research potential	J. Goldhammer et al.
17:10–17:25	Discovering the submerged archaeological sites of Europe: the SPLASHCOS viewer	H. Joens

WEDNESDAY, SEPTEMBER 25th

PLENARY SESSION 5: SURVEY STRATEGIES, TECHNIQUES & COLLABORATION WITH INDUSTRY

Time	Short Title *	Lead authors *
9:00–9:20	A review of acoustic survey strategies in maritime archaeology	Keynote: Ole Grøn, Tine Missiaen
9:20–9:35	Resolution of seismics for underwater archaeology and a possible new technique	O. Grøn, J.-P. Hermand
9:35–9:50	Integration of seafloor and sub-seafloor acoustic survey techniques in underwater geoarchaeological research	D. Sakellariou
9:50–10:05	Beyond Doggerland: opportunities and recent work in the North Sea	V. Gaffney et al.
10:05–10:20	Submerged depositional terraces and sea level reconstruction in volcanic islands: examples from Italy	F. Chiocci et al.
10:30–11:00	Coffee break	

Time	Short Title	Lead authors
11:00–11:30	The challenge of detecting and attributing sea level change – the case of the Baltic	Keynote: Hans von Storch, Eduardo Zorita
11:30–11:45	SASMAP: geological modelling, downscaling and locating possible submerged archaeological sites	J. Bo Jensen, Z. Al-Hamdani
11:45–12:00	Remote sensing and the management of underwater cultural heritage	T. Gambin
12:00–12:15	Maasvlakte 2 Harbour: industry, landscapes and archaeology	A. Otte et al.
12:15–12:30	Efficient stepped approach to underwater archaeology: Yangtze Harbour, Rotterdam	P. Vos
12:30–12:45	Exchanging knowledge between industry and academia in Scandinavia: the MMT and MARIS collaboration	J. Rönby et al.
13:00–14:30	Lunch	

PLENARY SESSION 6: MANAGEMENT & OUTREACH

14:30–15:00	Education, engagement, and submerged prehistoric landscapes	Keynote: Julie Satchell
15:00–15:15	Arch-Manche: archaeology, art, coastal change and management	L. Tidbury et al.
15:15–15:30	Drowned prehistoric landscapes and archaeology in the Dutch sector	H. Weerts et al.
15:30–16:00	Coffee break	
16:00–16:15	The SeArch Project: archaeological heritage in the North Sea: assessment, sustainable management and legal framework	T. Missiaen et al.
16:15–16:30	Threatened palaeolandscape in the German Bight, North Sea	D. Hepp et al.
16:30–16:45	Submerged prehistoric landscapes: an emerging European heritage resource in need of protection and management	K. Dellaporta, N. Galanidou

PARALLEL WORKSHOP SESSION 2: SOUTH BALTIC COASTLINES – PAST AND FUTURE

14:30–14:50	The signal of climate change from numerically simulated sediment transport along the eastern Baltic	T. Soomere, M. Viška
14:50–15:10	Recent wave induced sediment transport and effective sediment transport at the German part of the Baltic Sea	P. Fröhle
15:10–15:30	Coastal monitoring, modeling and prediction	K. Furmańczyk et al.
15:30–16:00	Coffee Break	
16:00–16:20	Trends in coast development of the Swina Gate area.	J. Dudzinska-Nowak
16:20–16:40	New demands on old maps - a synopsis about specific features of historical maps used in GIS	J. Hartleib
16:40–17:00	Reconstructions of coastline changes from historical maps in the Pomeranian Bay	J. Deng et al.

PLENARY SESSION 7: FINALE

17:00–18:00	POSTER SESSION: Drinks	
18:00–18:20	Figures in an underwater landscape: the institutional evolution and future of continental shelf prehistory	N. Flemming
18:20–19:00	Discussion and closing comments	

FRIDAY, September 27th (SPLASHCOS members only)

9:00 –10.30	SPLASHCOS WG meetings
10:30–11:00	Coffee Break
11:00–12:30	SPLASHCOS Evaluators Meeting
12:30–14:00	Lunch
	DEUKALION PG meeting
14:00–15:00	MC Meeting

