SEA-LEVEL CHANGE AND SUBMERGED LANDSCAPES OF THE CONTINENTAL SHELF

For most of human history on this planet, sea levels have been 50m or more below the present as Professor Geoffrey N Bailey, of the University of York, explains

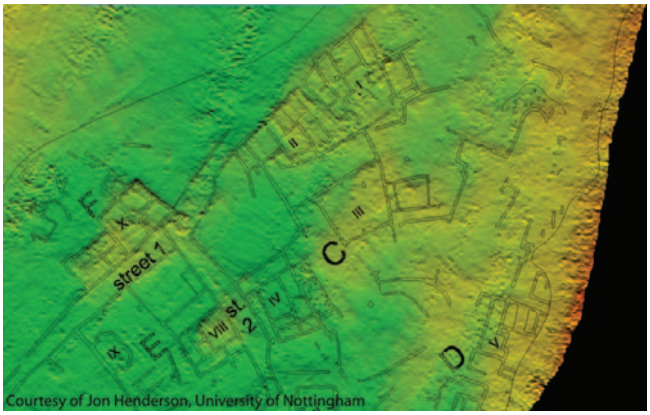
AT the glacial maximum, 20,000 years ago, sea level was 130m below present, adding more than 40% of land to the European continent alone. It then rose steadily to reach the modern level 6,000 years ago. Sea levels have oscillated between these extremes throughout human existence over the past one million years, reflecting repeated expansion and contraction of the continental ice sheets during the ice ages.

For 90% of that time, sea-levels remained mostly low. Periods of high sea level, like the present, rarely lasted more than 10,000 years, and even within these periods, sea level fluctuated by as much as 5m. The rise of 3m predicted over the next few centuries that many fear will threaten our modern civilisation looks puny by comparison.

Continuously changing sea levels, whether caused by the growth and melting of the ice-sheets, or by more subtle and localised movements of the Earth's crust, have been the dramatic accompaniment to human evolution and social development throughout our history as a species, even in recent millennia, and are not simply a new threat in the modern world.

Until recently, the motivation, resources and technology to explore this hidden world of the continental shelf were lacking. Archaeologists ignored this submerged landscape, believing that it was too difficult to explore, that few traces of ancient settlements, shorelines or other features of the original landscape would have survived repeated inundation, and that it would make little difference to our understanding.

Geoscientists have also tended to prefer working at much deeper levels on the sea bed, where deep-sea sediments provide



Street plan of the submerged Bronze Age town of Pavlopetri in the Aegean

Europe at the glacial maximum, 20,000 years ago, showing extra land (in red)

continuous sedimentary records of climate and sea level change, and geological structures are more easily observed.

In fact, more than 3,000 underwater finds of Stone Age artifacts or traces of settlement are now known, many found by chance, ranging in depth from greater than 50m to shallow inshore waters, and in age from flint hand axes aged 250,000 years or more, to Neolithic villages and Bronze Age towns, sometimes with spectacular preservation of organic materials because of burial in anaerobic sediments, such as wooden implements, basketry, canoes, houses, and biomolecular residues of food remains.

Moreover, since coastal lowlands often afford the most attractive food resources, abundant water supplies, easy routes of movement and transportation, and the biggest concentrations of population, whatever the level of technology and civilisation, it must follow that some of the most important evidence of our earliest history and social development now lies submerged on the seabed.

All the great formative stages of human development, including the expansion of our own species, Homo sapiens, out of Africa, the extinction of our more archaic cousins like the Neanderthals, the expansion of diet to include fishing and other marine resources, the development of seafaring, the earliest origins and dispersal of agriculture, and the foundation of the earliest European polities such as the Minoan civilisation of the Aegean, mostly took place during periods of time, or in geographical regions, when local sea level was lower than the present. It must

RV Aigaio, specially equipped for underwater landscape survey

follow that most of the archaeological evidence of our deep history now lies on the seabed.

Geoscientists, for their part, are discovering that collaboration with archaeologists can lead to the discovery and precision-dating of submerged landscape features such as ancient shorelines, which will help to improve models of sea-level and climate change.

Now, new research collaborations are under way, supported by the COST (Co-operation in Science and Technology) funding scheme of the European Union, and the ERC (European Research Council) scheme of Advanced Grants for frontier research, taking advantage of new technologies of exploration, remote sensing and satellite imagery.

This research brings together archaeologists, many skilled in diving work on submerged sites, geoscientists with access to ships and underwater surveying equipment, governmental organisations charged with managing the underwater cultural heritage, and industrial companies working on the seabed, who are often willing to engage in co-operative scientific ventures for mutual benefit.

Archaeological trimix diver recording a submerged ancient shoreline in the southern Red Sea

SPLASHCOS – Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf – is a unique COST-funded research network of over 150 archaeologists, geoscientists and heritage managers from 23 European coastal states – who are developing an international framework of knowledge, collaboration and technical resources on which to build applications for large-scale funding to explore the European shelf.

DISPERSE – Dynamic Landscapes and Human Dispersals – is an ERC-funded project in which European and Saudi Arabian archaeologists, geoscientists and organisations will explore the tectonic history and submerged shelves of the southern Red Sea to throw light on how our African ancestors first expanded into Asia and Europe across the Red Sea over 60,000 years ago.

The results of these initiatives look likely to re-write the early history of human evolution, dispersal and social development, provide new and more precise data on long-term sea-level change and its causes, offer insights into how past human societies coped with sea-level change, of clear relevance to the modern predicament, and establish new protocols for the exploration and management of this underwater cultural heritage in accordance with national and international legislation.

It seems increasingly clear that regions of geological instability, caused by sea level change and tectonic movements of the Earth's crust, were also ecologically rich and diverse regions that have attracted our ancestors throughout human history, despite the repeated threats to human life, livelihood and social stability stemming from floods, tsunamis, earthquakes and volcanoes. Such instability may even have been the stimulus to our earliest evolution in the African Rift.

New, multidisciplinary research involving archaeologists and geoscientists is now helping to improve our understanding of the geophysical processes that mould the Earth's surface, to illuminate a huge and previously hidden part of our common history as a species, to stimulate new technologies of investigation in response to the demands of archaeological prospection, with potential spin-off benefits for commercial exploration, and to provide new insights into the threats that we should prepare for in the future.

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