*Manuscript
Click here to view linked References

Title: Submerged Prehistory: past, present and future *or*
The next frontiers in research on submerged prehistoric sites and landscapes on the continental shelf

Authors: F. Sturt[1], N.C. Flemming[2], D. Carabias[3], H. Jöns[4], J. Adams[1]

1 Centre for Maritime Archaeology, University of Southampton, SO171BF www.soton.ac.uk/archaeology
2 National Oceanography Centre, Southampton www.noc.ac.uk
3 Lower Saxony Institute for Historical Coastal Research, Viktoriastreet 26/28, 26382 Wilhelmshaven, Germany http://nihk.de/index.php?id=404&L=1
4 ARQMAR, Centre for Maritime Archaeology Research of the South Eastern Pacific Muelle Barón s/n, Valparaiso, Chile

Abstract:

Submerged prehistory has emerged as a key topic within archaeology over the last decade. During this period the broader academic community has become aware of its potential for revolutionising our understanding of the past. With recent technological and scientific developments has come an opportunity to investigate larger areas and learn more than previously thought possible. When charting the future of the subject, however, it is also necessary to consider its historical trajectory. This sense of opportunity and optimism has been experienced before, but not sustained. As such, our greatest challenge lies not in adopting technological developments, but in maintaining momentum.

Key Words: Submerged Landscape, Submerged Prehistory, Sea-Level Change, Prehistory, Archaeology

Introduction

Over the last decade submerged prehistory has emerged as a key topic within archaeology and acted as a unifying point of focus across a range of disciplines. The submerged extent of the continental shelves represent an additional 5% of the land area currently exposed across the globe (Figure 1), and in regions such as Europe, South East Asia, and northern North America can add 40-100% of the present land area again (Bailey et al., 2017a, p. 1; Harff et al., 2016, p. 1). With sea-level fluctuating by up to 130m over glacial cycles (Grant et al., 2014, see figure 1), this space has been repeatedly exposed and inundated over the six million year temporal window that archaeology is largely concerned with. These changes in land/sea boundaries significantly altered the world that our ancestors lived in, not just in terms of distribution of landmass, but also the behaviour of major ocean currents and the distribution of resources. Although the process of repeated transgression and regression may sound destructive, the variable nature of coastal geomorphology and geology has ensured that in some regions key depositional sequences survive, with artefacts that can be retrieved from both in situ and derived contexts. The corollary of this is that submerged regions of the continental shelves contain an important, and in some areas unique, resource for improving our understanding of human history and environmental change.

The investigation of this resource is a complex and demanding operation, requiring input from oceanographers, geologists, geophysicists, archaeologists and marine engineers (to name but a few). As such, submerged prehistory stands as a truly transdisciplinary subject, one that moves increasingly smoothly between academia and industry. It is this transdisciplinary nature, matched to the varied distribution and extent of continental shelves globally, that has led to a complex and erratic development. This variable history of research and engagement has shaped regional expectations and skewed baseline levels of knowledge. While some regions grapple with complex tectonic histories that have radically altered local geography, others cope with large tidal regimes, greater water depths, erosion and sedimentation. For parts of the world offshore construction and exploration work has seen large scale survey and mapping of the seabed, while in others detailed research has yet to be carried out. Similarly, the questions that we wish this resource to answer vary radically with regard to temporal and spatial scale; from large scale patterns of colonization and movement, through to more local signatures of adaptation, community structure, and change.

Contributing to the growing realisation of the potential of submerged prehistory over the last decade have been dramatic changes in technological and scientific capability. The evolution of improved acoustic survey and mapping systems, mechanical intervention through remotely operated and autonomous vehicles, as well as leaps in computing power, provide a new range of opportunities for effective research. Vast quantities of data acquired for different objectives can now be integrated, incorporated into models, and analysed at a range of scales. Innovative sampling and dating methods are allowing us to ask new and different questions of sedimentary archives and artefactual material. As such, research into submerged prehistory does not stand as single monolithic entity, but as a shared area of interest amongst academics working on a number of related fronts.

In this paper we chart the development of research into submerged prehistory at a global scale, consider recent developments and reflect on what the future may bring. For reasons that will become clear below, an historical and geographically focused review is critical in order to recognise the strengths and weaknesses that have emerged. It is only once this has been appreciated that a sound platform for future developments can be constructed. In being so ambitious, through offering a global view, it is clear that there are details that will have been omitted. However, we hope to offer a snapshot of the current state of play, and equally importantly explain how we have got to our current position. Rather than see submerged prehistory as an adjunct to traditional modes of investigation we present it as central to future progress. We suggest ways in which we might prioritise and conduct research, emphasising the most significant goals that are usually beyond the reach of single institutions.

Four unifying themes emerge through this paper:

- Strength through diversity: The variable history of research and investigation into submerged prehistory around the world provides an important baseline level of understanding. Significantly, due to regional differences in the challenges faced, collectively we have developed a suite of expertise that now allows for a wide range of sites and environments to be investigated.
- The significance of context: Archaeological questions are not answered by material culture alone. Transdisciplinary research into sedimentary archives that bridge the contemporary land/sea boundary are transforming our understanding of the changing shape of the world, the coastal zone, and how humans have interacted with it.
- Clear opportunities: Some regions (e.g. the tropics, the coastlines of Indonesia, China and Japan) are under-researched and would benefit from targeted survey work, while in others (the North Sea, Australasia, North America) a shift in approach may be needed to move research forward; exploiting available data, consciously selecting new targets and adopting innovative techniques.
- The need for coordinated action: The challenges faced in working on this subject are still significant, and the community of scholars relatively small. As such to maintain momentum increased collaboration will be beneficial, and possibly new institutional frameworks.

Submerged Prehistory: a brief review

When writing (and reading) a paper like this there can be a temptation to think that an historical review is a comforting crutch on which the paper can lean, rather than an analytical device of explicit use. However, as argued below, in the case of research into submerged prehistory an understanding of developmental trajectories is crucial for any attempt to evaluate past successes, current issues and future possibilities. It would be relatively easy to construct a paper that focuses solely on the promise of the 'new', of how submerged prehistory represents an emergent area of research where innovative technologies can help reshape the discipline and how modern-day researchers are asking different and new questions of the record, driving research forward in exciting directions. However, this would be to ignore critical lessons we can learn from previous forays into the topic. The course of research into submerged prehistory has not run smoothly from recognition to advanced development. Instead, interest and expertise have waxed and waned resulting in intellectual 'tacking' back and forth, with the requisite initial loss of ground with each turn, and variations of advance and retreat in different regions. In writing this paper we hope to draw attention to this 'tacking' in an effort to consolidate and accelerate future development. Thus, while elements of the narrative constructed below may be familiar to some readers, we hope the broader trajectory painted will give pause for thought.

An awareness of the potential for submerged contexts to inform our understandings of the past has long been established. In Europe during the late 18th, 19th, and early 20th century researchers identified the presence of terrestrial deposits and anthropogenic material in the inter- and sub-tidal zones, as well as in submerged cave systems (Blanc, 1940; Borlase, 1758; Boule, 1906; Boyd Dawkins, 1870; Reid, 1913). Even at this early stage there was a keen awareness that resolving the nature of these deposits, and their significance for our understanding of humanity's past, would need academic cooperation. Reid (Reid, 1913, p. 10), in his seminal work on submerged forests, argued that it required antiquarians and geologists to work together to resolve the complex questions of changing paleogeography that he had identified. He perceived this collaboration most significant for determining the date of the sequences he had observed, with archaeological typologies of material culture offering the most secure means of doing so available to him (1913, p. 121). Today this relationship has shifted, with scientific dating techniques replacing material culture typology as the primary means of resolving chronology. However, as argued below, while the questions and methods may have changed, the need to work together has only become more apparent.

The importance of Reid's observations were not lost on archaeologists and geologists in the early twentieth century. In particular, Reid's (1913) work had a significant impact on O.G.S Crawford, J.G.D Clark and H. Godwin. The potential significance of submerged prehistory was such that Crawford (1927) dedicated the first article in what was to become the leading archaeological journal *Antiquity* to it, with a study of inter and sub-tidal prehistoric remains on the isles of Scilly (UK). Crawford was so taken with the significance of his finding that he stated;

> "It was one of those thrilling moments which occasionally occur in the life of an Archaeologist. Here before us was tangible proof that the land had sunk since prehistoric times."
>
> (1927, p. 6)

While the processes behind the inundation of the Isles of Scilly may have been more complex than Crawford imagined (Anderson-Whymark et al., 2015), he did not miss out on its broader significance. In his paper he links the finds on Scilly with submerged forests and megalithic sites in the Channel Islands and along the French coast (1927, p. 10). For Crawford, what he saw on Scilly spoke of wider processes and greater significance. The very face of the world had changed substantially but there was a resource located underwater that might allow an understanding of the processes behind that change, and, critically, provide answers to complex questions about the impact of those changes on our understanding of past societies.

While Crawford's paper echoes much of what was to come later, in terms of lasting impact Reid's legacy is more strongly seen in the work of Clark (1936, 1932), who was to transform research into late upper Palaeolithic and Mesolithic communities of North West Europe, and on Harry Godwin, a key figure in the development of Quaternary research in the United Kingdom. In particular, as a number of scholars have noted (Fagan, 2001, p. 51; Gaffney and Fitch, 2009) it was the recovery of a Mesolithic harpoon (Figure 2) from the Leman and Ower banks of the North Sea in 1931 (Burkitt, 1932) that set-in motion a series of events that transformed Clark's understanding of the past.

This is significant for two reasons. First, the recovery of the harpoon helped Clark to realise the importance of submerged landscapes for his understanding of prehistory and connectivity. It demonstrated that the now inundated extent of the North Sea had not only once joined Britain and continental Europe as a bridge, but that this space had been inhabited. Second, both Clark and Godwin realised that it would take their combined skills to investigate this locale, and perhaps more significantly, related landscapes across the region. It was with this in mind that they were integral to the formation of the Fenland Research Committee in 1932. As Burkitt (Burkitt, 1932, p. 453) commented, the consensus among the members was that "For a proper study of the fens, many different lines of investigation are required". As a part of this group Clark and Godwin carried out interdisciplinary research into both buried and submerged sequences on the margins of the North Sea (Clark, 1932). Both Clark and Godwin understood the dynamic nature of sea-level change and that thus, if they wanted to understand prehistory, modern land/sea boundaries were a meaningless distraction. In essence, for Clark and Godwin, submerged prehistory was simply ‘prehistory’ that afforded a different set of opportunities and challenges to researchers. They also embodied the move toward interdisciplinary study of submerged prehistory which we have seen re-occur in the last two decades. In this sense Clark and Godwin were true pioneers, with strong research questions leading them to transgress a land/sea boundary that was holding others back.

Whilst consciousness was raised in the 19th century in a number of different regions, and significant advances made early in the 20th, the variable nature of the marine environment around the world meant that the history of research played out very differently on a country by country basis. Broadly speaking, however, the early advances made by scholars such as Boule (1906) Reid (1913), Blanc (1940), and Clark (1932) were not to be followed up on in a meaningful manner for a number of years. In part this might have been because access to these contexts was relatively limited, with marine survey vessels and standard diving dress accessible only to small numbers of people. This, along with disruption to scholarship through the impact of the Second World War, slowed the pace of research. In effect, the opportunities for archaeologists to be confronted and challenged by material recovered offshore, such as the Leman and Ower harpoon, were limited and thus interest began to wane.

Things started to change in the late 1940s and early 1950s, when Gagnan and Cousteau’s self-contained underwater breathing apparatus (SCUBA) became a technology available to the general public. In areas around the globe benefitting from shallow coastal waters, good visibility and affluent economies, the underwater world suddenly became populated by a host of curious people. This led to a number of interesting archaeological discoveries, once again challenging archaeologists and geologists to explain their presence and consider the implications for societies in the past. This also helped to drive local interest in submerged prehistory. Three widely separated areas produced complex and well-preserved materials during the 1960's: these were Pavlopetri, a submerged Middle Bronze Age town in southern Greece (Flemming, 1968a, 1968b; Harding et al., 1969); the karstic sinkholes of southern Florida, where early Native American remains were found at depths of the order of 20m in situ close to the shore (Clausen et al., 1979, 1975; Cockrell and Murphy, 1978) and submerged Mesolithic settlements in the Baltic (Andersen, 1980). However, progress in other regions was otherwise slow or non-existent. The application of SCUBA searches varied between regions with a corresponding impact on site identification and engagement (discussed in more detail on a region by region basis below). To some extent the impact of this variability is visible in the number and nature of publications emerging from the 1960s onwards.

In figure three we provide a chart showing the number of publications on the topic of submerged prehistory from 1980 to present day. This data has been collected via searches of Web of Knowledge, Google Scholar and 'Publish or Perish' software. The search terms used were: submerged prehistory, submerged landscape and submerged forest. The data was augmented through a cited references search on key texts, and review by the authors. The full dataset (which includes 641 publications from 1753 onwards) is provided as supplementary material to this paper.

This dataset is acknowledged as partial and flawed: there are a range of earlier publications, grey literature reports and non-English language outputs that will have been missed in these searches. However, we are confident that the overarching trend is still informative, albeit proportional to the true complete figures. For example, between 1870 and 1960 there were eleven publications that directly discussed submerged prehistory. Between 1960 and 1980 this rose to seventeen. Equally strong regional biases can be seen, with four areas and global reviews accounting for 84.6% of the published material: North West Europe (29%), North America (14.7%) Global (15.9%,) the Baltic (13.9%) and Mediterranean (11.1%). The temporal and regional trends beyond this point are discussed in more detail in the sections below, but show a rapid development over the last decade with some interesting variations.

As an exemplar of this a strong history of research into submerged prehistory is apparent within North America, but the significance of this (particularly early) work has not been widely recognised. Thus, as we argue below, research into submerged prehistory has periodically been negatively affected by a 'siloed', regionally fixed, approach to the past. This is significant for any paper that is looking to the future, as the sophistication apparent in early regional studies is at times surprising. Through recognising this work fully we can reflect on the ways in which more significant progress can be made, and momentum maintained. What emerges most starkly from figure three is that one of the greatest challenges for research into submerged prehistory lies in maintaining enough critical mass to ensure sustainability. In this regard the impact of recent initiatives such as the European Commission funded SPLASHCOS network can clearly be seen, driving a spike of publications in 2017, a direct outcome of increased communication between researchers across Europe.

Figure four illustrates the number of known submerged prehistoric sites/areas of high potential identified globally. This dataset has been compiled from the publication data used to generate figure three (see supplementary data), and data held in the SPLASCHOS viewer database (http://splashcos.maris2.nl). Again, the dataset is acknowledged to be a flawed underestimate as it relies on published material. It is also variable with regard to what each record reflects, with some being references to broad landscapes, areas of dredged finds and fauna, as well as individual finds and excavated sites. It does, however, illustrate a changing interest in recording finds from offshore contexts by national agencies and increasing visibility of the variety of sites/material described in the literature. Taken together, figures three and four show a highly promising upward trend with regard to research in this field, and our ability to record and communicate sites of interest.

Global Narratives and Deep Time Potential

While figure 3 and the regional accounts given below show that investigation of submerged landscapes has been episodic and highly variable in terms of scale and approach, three key tropes have become established within the literature at a global scale. These relate to:

- discussions of population movement and colonisation
- significance of marine resources and coastal adaptation
- identification of potentially important areas or regions, but with no further action to evidence that potential.

During the late nineteenth and early twentieth centuries, with an improving understanding of sea-level change and knowledge of the extent of the shallow shelves which surrounded the continents, came an appreciation that these spaces may have proved pivotal in global population movement. In particular, discussion of the colonisation of the Americas (Dawson, 1894; Dixon and Monteleone, 2014; Fladmark, 1979; Heusser, 1960; Hopkins, 1967;

Johnston, 1933; Mandryk et al., 2001) and Australia (Elliot Smith 1914 (see Allen and O'Connell, 2008); Daly, 1910; Danes, 1925) saw explicit mention of the role that such submerged landmasses may have played. Critically this was not only seen in terms of movement over land, but also with regard to the changing nature of early seafaring.

While the attention and credence given to these observations fluctuated through time, they gradually began to be embedded within broader archaeological discourse (Mellars et al., 2013; Oppenheimer, 2012, 2003; Rockman and Steele, 2003; Stringer, 2000; Westley and Dix, 2006), touching on some of the most significant questions in archaeology. Here discussion often focuses on the hypothetical potential of the submerged continental shelves, that these spaces may have facilitated rapid movement along coastal corridors or supported large populations, helping to explain the gaps within a fragmented terrestrial record. However, as Flemming (2017, p. 272) notes, these discussions are at times matched to a belief that subsequent transgression by the sea will have removed that evidence (Apenzeller, 2012; Klein, 1999, p. 566; Mithen, 2003, p. 24) or that it is too costly and difficult to locate. Thus, within this context, submerged landscapes frequently exist as an heuristic device, allowing conjectural modelling to explain complex deep time phenomena (e.g. Oppenheimer, 2012; Romanowska et al., 2017; Stringer, 2000).

Related to this is recourse to discussion of the 'potential' of submerged landscapes to improve our understanding of prehistory. This trope is not highlighted in order to criticise individual studies, indeed this paper will fulfil many of the characteristics of the 'trope of potential'. Instead it is mentioned here to force us to recognise the importance of proving potential through excavation or extracting supporting evidence from sedimentary sequences, once its theoretical capacity has been documented. As will become clear through the regional discussions below, there is an embarrassment of data demonstrating the richness of the record that can, or could, be recovered and no shortage of questions to address. As such, we should look to move forward as quickly as possible from discussions of potential, which have been established in the literature since the early twentieth century, to ones which focus on realising that potential. Without this transition the subject will continue to make marginal advances in a limited manner.

For readers situated within an academic context (and perhaps outside of archaeology) this may seem like a facile statement. However, in large parts of the world, investigation of submerged prehistory is undertaken within commercial contexts. Here, as part of environmental impact assessments, the possibility for encountering submerged prehistoric archaeology is regularly quantified, but the actions needed to verify it are only taken in a small number of locations. As such there is an increasing literature discussing the high likelihood of discovering or impacting on submerged archaeology (e.g. Goodwyn et al., 2010), matched to a literature that discusses how important this record may be (Benjamin, 2010), but comparatively little of the required action to demonstrate it. This poses significant problems, ones which should not be underestimated or go undiscussed, for the development of research in this area. The sections below reflect on this variable history of action, offering regional accounts of past and present research into submerged prehistory, drawing out strengths, weaknesses and opportunities for the future.

Regional Contexts

The Baltic

The references given above in relation to early work on submerged prehistory might suggest that the UK (Reid, Clark, Godwin), France (Boule) and Italy (Blanc) proved pivotal in its initial formation as a subject of study. However, while it is possible to extract a few insightful articles from these countries, credit for pioneering development can more appropriately be seen to rest across a variety of regions, with the Baltic deserving special mention. This is in recognition of a long-standing interest in submerged prehistory by Baltic scholars, as well as the key methodological developments they pioneered.

Figure five provides a partial insight into how and why the Baltic came to have such an impact on research into submerged prehistory. Denmark and Southern Sweden share a swath of relatively shallow and clear water, punctuated with small islands. This landscape has changed considerably in relation to stadial and inter-stadial periods, with periodic glaciation deepening and eroding the Baltic Sea Basin (BSB) throughout the Pleistocene (Andrén et al., 2000; Berzins et al., 2016; Habicht et al., 2016). Given the proximity of the region to the major ice sheets (at times being completely covered), this sea-level history has been profoundly affected by complex glacio-isostatic adjustment factors, and the periodic isolation of the basin as a lake.

The history of the BSB since the Last Glacial Maximum (LGM) stands as a good example of this, with the Scandinavian Ice Sheet fluctuating in response to climatic oscillations (e.g. the Bölling/Alleröd Interstadial (14,700- 12,700 yr BP) and the Younger Dryas cold period (12,800-11,500 yr BP) (Andrén et al., 2011, p. 84)). The non-monotonic retreat of the ice-sheet saw a large lake (the Baltic Ice Lake) forming at its southern extent c. 16,000 BP (Andrén et al., 2011, p. 83), with a glacier remaining over what is now the northern Baltic Sea until c. 10,500 BP (Jöns and Harff, 2014; Lindén et al., 2006).

This variation between retreat and expansion of the ice-sheet saw subtle shifts in the rate of isostatic rebound in relation to eustatic sea-level rise. The result was switching between freshwater (the Baltic Ice Lake 16,000 – 11,700 yr BP, the Ancylus Lake 10,700-9,800 BP) and marine (Ylodina Sea and Littorina Sea) systems within the BSB. As a consequence of this, much of the current Danish Sea territory was dry land during the early Holocene, but became submerged during the Littorina Transgression (c.9000-4000 BP (Flemming, 2014; Kostecki et al., 2015, p. 227; Rosentau et al., 2017, p. 113; Sander et al., 2016)), leaving many Mesolithic and Early Neolithic coastal sites on the newly formed sea floor. Significantly, the comparatively moderate nature of sea level change in Danish waters over the last 6 millennia (due to isostatic rebound almost keeping pace with eustatic sea-level change) means that these sites are located at a maximum depth of 10m, but with most found between 2 and 6m, and in relatively low, and very low, energy environments. This represents a large proportional area relative to the current dryland extent (c. 11%).

Denmark a history of research

Given the significant role that marine resources have played within Baltic societies, and the clear nature of the water, it is perhaps unsurprising that the submerged prehistoric sites described above had long been noted by fishermen and holiday makers. Such was the level of general awareness, and with an increasing number of people owning scuba sets, that in 1957 the Danish weekly magazine Hjemmet launched a competition for divers to find Denmark's earliest submerged site.

The frenzy of activity that followed the competition launch resulted in the public identification of a number of Mesolithic sites, including what was to become the famous site of Tybrind Vig (Andersen, 2013, p. 11), firmly placing the reality (rather than the potential) of submerged prehistoric archaeology in social consciousness. Interestingly, Andersen (2013, p. 11) records that although new material was found through the competition, there was a sense of disappointment amongst professionals, as the majority of sites belonged to the comparatively well-known Ertebølle phase of the Mesolithic. As such, the antiquity of inhabitation had not been pushed back by this early example of community archaeology, even if the total number of known sites had grown.

This slight sense of disappointment might explain the gap of two decades before professional archaeologists became more engaged with recording submerged sites in Denmark. In the mid 1970s, inspired by the positive results of amateur diving activities in the waters around the Danish islands, Langeland Museum established a close working relationship with recreational divers. The scientific exploration of the Ertebølle site Møllegabet I in 1976 delivered their first success story (Grøn and Skaarup, 2004). Led by professional archaeologists, amateur divers carried out much of the fieldwork, including survey and systematic excavation. The success of this project in turn helped pave the way for the excavation of the Ertebølle site of Tybrind Vig in 1979 (Andersen, 2013). The finds made as part of this excavation (human remains, fishing gear, canoes, paddles and midden material) were so spectacular that they set the bar for the 'potential' so often talked about with regard to submerged prehistory at a global scale. Significantly, the work at Møllegabet I and Tyrbrind Vig demonstrated that achieving this potential was relatively straightforward in Danish waters.

The success of these projects in the late 1970s helped to raise the profile of submerged prehistory in Denmark and across the world. Most importantly they also served to demonstrate that academic standards equivalent to those maintained on land could be achieved underwater; controlled excavation carried out by trained specialists. As such, within Denmark the necessity for investigation of potential submerged prehistoric sites came to be built into the development process.

Thus, just as development-led archaeology revolutionized our understanding of the distribution of prehistoric sites terrestrially, so to it came to have an impact underwater in Denmark. This can be seen particularly well in capital infrastructure projects such as; the link between the Danish island of Funen to Sealand over the Great Belt (1988– 1998); from Sealand to Skåne in Sweden crossing the Øresund (1991–2000) and in the more recent work on the Fehmarnbelt tunnel project. In each case research into prehistoric landscapes and archaeological sites on land, as well as underwater, was an integrated part of the construction works. The results gained in each project has widened the basis of information about the prehistoric settlement history of Denmark and surrounding coast (Fischer, 2004, 1997). Thus, as was the case for Clark and Godwin, within Denmark the study of prehistory transcends current land/sea boundaries, due to an understanding of what can be achieved through the adoption of a rigorous approach offshore. This is important, as it means that unified research designs can be constructed, focusing on what can be gained from investigation of submerged sites in comparison to sites on land. The majority of work undertaken falls within the commercial sphere (with only a limited number of academic excavations (e.g. Uldum et al., 2017)), and it is this work that is adding most to our understanding of the submerged archaeological record in Denmark. This is an issue, and an opportunity, that is returned to in the conclusion to this paper.

North and Eastern Baltic

The above only shortly summarises the remarkable results achieved by Danish researchers on submerged prehistoric sites and landscapes over the last 30 years. As one might expect this work also had a great impact on global research strategies, and in particular on Denmark's closest neighbours. A good example of this can be seen in Sweden. As in Denmark, searching for prehistoric remains on the seabed has a long tradition starting in the 19th Century. However, while the entirety of the Danish coastline has been subject to slow submergence, the rest of the Baltic to the North and East has a more complicated picture of sea-level change, with isostatic rebound lifting coastlines in northern Sweden, Finland, Russia, Estonia and Latvia (Harff et al., 2011; Jöns, 2011). The result of this has been that in these regions underwater archaeological work has focused on shipwrecks rather than looking to smaller areas of submerged coastline (Larsson, 1983).

Only in the southernmost part of Sweden has sea level rise outpaced isostatic uplift, so that prehistoric settlements along the coasts became submerged (Hansson et al., 2016). Currently more than sixty stone age sites are known from Swedish waters in depths between 3 and 23 meters below current sea level (Hansson et al., 2016; Holmlund et al., 2017). Frequently they were discovered in and amongst submerged tree trunks and rooted stumps (Hansson et al., 2016). The majority of these sites are dated to the period between 8,600 and 6,000 BC (Hansson et al., 2017).

Over the last ten years underwater research on submerged prehistoric landscapes and sites has intensified. It has principally focused on the Häno Bay in eastern Scania, off the coast of Haväng (Hansson et al., 2017). The research area is positioned near a fossil river valley at a depth of 15 m. The sites consist of remains of a 10,500-year-old pine forest (shown in figure six) and well-preserved large fish traps, dating to 7000 cal BC that were found together with artefacts of bone and flint. This research has built on the developing trend of integration of high resolution geophysical data, with geotechnical data to create improved understanding of palaeogeographic change. However, crucially it has incorporated extensive underwater archaeological survey on SCUBA, with use of scooters to allow large areas to be covered. Within this project there has been a commitment by the research team to spend time looking at the seabed first hand to help identify archaeological material and better understand the detail given by the geophysical data.

The southern Baltic

Both past research and the current state of affairs in the countries along the southern Baltic rim differ enormously from that in southern Scandinavia. Due to climatically controlled sea level rise and isostatic uplift in central and northern Scandinavia following the last deglaciation, prehistoric sites submerged in Baltic waters may only be expected in the national waters of Germany, Poland, Kaliningrad (Russia) and Lithuania (Harff and Meyer, 2011). Knowledge of submerged sites varies from country to country, reflecting not necessarily the actual inventory of sites, but rather differing traditions and priorities in research and heritage management (Jöns, 2011).

This variability is perhaps best illustrated in Germany. Although the whole German Baltic coast was, and still is, affected by sea level rise, systematic research on submerged prehistoric sites did not begin until the early 1990s. Influenced by the impressive results from underwater work in Denmark (Skaarup, 1995), but also by that carried out in the area of the Lake Constance in southern Germany (Schlichtherle, 1997), the first investigations on submerged sites were done offshore of the western Mecklenburgian Bight, in Schleswig-Holstein (Hartz and Lübke, 1995). In the waters of the neighbouring area of Mecklenburgs-Western pommerania underwater research on submerged landscapes and stone age sites was not previously possible, as prior to German reunification, non-military actions in the coastal areas between the Lübeck bight and the Odre-river were strictly forbidden. However, over the twenty five years in which investigations have been taking place numerous submerged Mesolithic and Neolithic sites have been discovered at different localities in the waters of the Mecklenburgian and Pomeranian Bights.

An important facilitating factor in this transition has been close cooperation between archaeological museums, heritage authorities and geological research institutes. With the support of the German research foundation (DFG), a solid network for systematic under water research was built up that finally formed the Research-unit Sinking coast – better known under the acronym SINCOS (2002-2010). SINCOS created an umbrella for common interdisciplinary research by Geologists, Archaeologists, Palaeobotanists, Archaeozoologists, Dendrochronologists and experts in Climate Development. The general target of this research-unit was to develop a model of the relation between geosystem, eco-system, climate, and socio-economic system for the south-western Baltic Sea area from the mid-Holocene Mesolithic and Neolithic period to the Early Medieval Age (Harff and Luth, 2007; Harff and Lüth, 2014).

Within the SINCOS-research area between the Oder-estuary and the Oldenburg rift ("Oldenburger Graben") the intensity of shoreline displacement varied regionally (Lampe et al., 2007). SINCOS paid particular attention to a group of more than 20 submerged settlements, located at the bottom of the Wismar Bight at depths between 2.5 and 11 m below the present sea level. Most of these were discovered during side-scan and Hyball surveys and, in a second stage, partly excavated underwater. The information gained from these sites led not only to a detailed reconstruction of the settlement pattern and chronology of sites, but also of ancient coastlines and the dynamics of the sea-level rise. This facet of research into submerged prehistory, its need to address wider climate and marine processes in order to understand the record, has added to its academic impact. In attempting to understand the nature of submerged prehistory in the Baltic it has been necessary to refine models of complex palaeoenvironmental change at a scale and resolution beyond that offered by previous research. Since the end of the SINCOS-Project, investigations on submerged sites in German waters have been limited to small scale investigations that became necessary due to construction work. Only on rare occasions have research investigation been carried out e.g. ongoing research on the Ertebølle site Strande, positioned in the Bay of Kiel (Goldhammer and Hartz, 2017).

Research in Baltic waters has clearly shaped our understanding of what the investigation of submerged prehistory can offer, not only to archaeologists but a range of ocean and earth science disciplines. Through excavation of Mesolithic sites the value of a complementary organic record has been proven, shedding new light on cultural groups who were previously predominantly known through their lithic technologies. In attempting to place these sites in context new data have been generated on complex regional processes of sea-level change, which in turn feed into broader global issues. However, as noted above, much of this hinged on a conducive environment (physical, economic and political) within which research could establish early success stories. Furthermore, it has focused almost exclusively on the Holocene, with occasional forays into the Late Pleistocene. In other parts of the world the history of research has played out differently, offering alternative approaches to understanding the past.

The North Sea, English Channel, Irish Sea and Atlantic Coast of Europe

Along the North Sea, English Channel/La Manche, Irish Sea and Atlantic coasts of Europe the murkier waters, complex tidal regimes, sedimentary sequences and erosion patterns meant that the diving community became better acquainted with the wreck record rather than the submerged prehistoric resource. As such, the profile of submerged prehistory was not raised in the same way it had been in the Baltic. Thus, while prehistoric submerged sites were being discovered and excavated around the world (Baltic, Mediterranean and Americas) prehistoric maritime archaeology in the UK was in a nascent form. In some senses it was as if the advances and observations made in the 1930s had been forgotten.

In this light it is notable that Muckelroy's (1978, Figure 1.1) foundational text on Maritime Archaeology focused on wrecks and maritime infrastructure, deliberately excluding non-coastal regions of submerged terrestrial landscapes. In doing this Muckelroy strove to carve out a logical and well defined area of study. As such, the exclusion of the majority of submerged prehistoric landscapes was understandable. From Muckelroy's perspective these spaces and the archaeology they contained may offer little insight into past maritime activity. Just because a landscape was now underwater did not mean that it was automatically of 'maritime' interest. However, while logical, this division may also have resulted in a lack of transfer of knowledge and skills between archaeologists working on land and those engaging with marine and maritime survey. Without clear communication between groups it was hard for researchers to envisage what was ‘knowable’ from submerged contexts, or indeed to recognise how important the coastal zone might have been to prehistoric communities. The small numbers of people engaged with submerged prehistoric archaeology lent it an air of an esoteric specialism incorporating complex terms and a difficult working environment, when in reality the types of data generated and methods used were relatively straightforward and well understood within the oceanographic community.

Figure seven shows that the continental shelf in this region is largely flat and low lying. Elevations above -130m (and thus potential relict landscapes) represent c. 40% of the total land area shown. The -130m contour shown on figure seven is only a first order indicator of possible land extent, with lowstand sea-levels corresponding with increased glacial coverage, reducing the habitable area available. The shelf in this region has been significantly altered by processes of erosion and sedimentation. One of the most significant changes to have occurred is the erosion and removal of a chalk ridge (part of the Weald-Artois anticline) which provided a high ground link between the modern countries of Britain and France. The ridge is thought to have been removed by c. 478-424,000 BP (Cohen et al., 2017, p. 159; Collier et al., 2015; Gibbard and Cohen, 2015; Gupta et al., 2007; Hijma et al., 2012; Toucanne et al., 2009). Prior to this removal it is thought that Britain would have remained joined to the continent during sea-level highstands. Subsequent to its removal high stand situations result in Britain becoming an island. The elevation at which this happens (based on current bathymetry) is c. -35m. However, as discussed for the Baltic, this figure can be misleading as both tectonic and isostatic factors have played a significant role in determining relative sea-level histories (Cohen et al., 2014, 2011; Dix and Sturt, 2011; Lagarde et al., 2003; Sturt, 2015; Sturt et al., 2013)

The North Sea is home to a number of large Holocene transgressive sand banks, such as those at the mouth of the Thames estuary. These have little relationship to the past terrestrial landscapes they cover and conceal, beyond possibly being anchored on earlier topographic highs. This illustrates the importance of understanding past and present marine processes when discussing the nature of submerged prehistoric landscapes. These features are often noted as problems in the text of papers discussing current models of palaeogeographic change and submerged landscapes (e.g. Sturt et al., 2013), but in the reproduction of these images this detail can become lost. The result is that time averaged geological processes become concealed within broader conceptions of landscape change. These features are best seen as representing an unrealised opportunity. First, they could be targeted to examine if they preserve deposits underneath them. Second, modelling work to strip out Holocene marine features from geophysical datasets could be done to improve our understanding of past landforms across the region. Above all, these features help to remind us of the need for chronological control when discussing submerged prehistoric landscapes, their extent, potential for areas of surviving sites/sedimentary archives, as well as discussion of connectivity and population movement.

The UK, Ireland and Norway

Despite Boyd Dawkins (1870), Reid (1913), Crawford (1927) and Clark (1936, 1932) clearly demonstrating the significance of the offshore zone for understanding the prehistory of the region, it was not actively pursued as an area of research by the broader archaeological community, or public at large, for close to one hundred years. Although sport SCUBA diving became popular in the late 1950's in the UK, the strong tidal currents, stormy conditions, and low visibility underwater delayed the realisation that submerged prehistoric sites could be directly located or studied in this manner. As such, the sporadic dredged finds of lithics, massive quantities of Pleistocene faunal material and numerous near shore sites failed to get the broader recognition they deserved, despite high quality academic publications making explicit calls to do so (Jacobi, 1976; Louwe Kooijmans, 1971; Scuvée and Veragué, 1978). The result has been only a few cases of direct ground-truthing offshore in the UK and Ireland; the Mesolithic site of Bouldnor Cliff from 1999 onwards (Momber et al., 2011) the Palaeolithic finds from Area 240 in 2008 (Bicket, 2011; Bicket and Tizzard, 2015; Firth, 2011; Tizzard et al., 2014) and recent work by Westley (2015) at Eleven Ballyboes in Ireland, Sturt et al (2016) in the Bristol Channel and Gaffney et al. (Gaffney et al., 2017) in the North Sea. However, the lack of work offshore is countered by a long history of research into prehistoric sites within the inter-tidal zone (visible in the sites shown in figure 7) that points to the possibilities lying in deeper waters (Bell and Warren, 2013; Ransley et al., 2013; Sturt et al., 2016).

While site level investigations did not develop in the same way as they did in the Baltic and Mediterranean, archaeologists working within the North Sea and along its coasts did re-engage with the broader topic of submerged prehistory. Coles' (1998) seminal 'speculative survey' of the submerged North Sea demonstrated the potential of offshore contexts. Importantly this potential was shown to extend beyond recovery of material and into broad scale narratives of landscape change and social impact. This played to the strengths of British archaeology and its longstanding fascination with landscape (Johnson, 2008). Furthermore, through choosing this focus, and the familiar language it used, Coles (1998) found a way to engage the broader academic community. In effect, submerged prehistory could be explored through a map, encouraging archaeologists to consider the impact of large scale geographic change on past populations. The awareness this article generated was timely as it coincided with increased offshore development and acquisition of new data. Pioneering work by Fitch et al (2005) and Gaffney et al. (2007; 2009) on the submerged landscapes of the North Sea allowed visualisation of these offshore sedimentary sequences giving a tantalising glimpse of the landscapes Coles (1999, 1998) had discussed. Here, the scale and resolution of academic debate meshed well with the scale and resolution of data obtainable through large scale geophysical survey. Critically, Coles's (1998) hypothetical spaces became semi-materialised through the geophysical work of Gaffney et al. (2007). This helped to move discussion forward from the abstract to those facts rooted within specific sedimentary sequences.

In 2001 English Heritage's (since 2015 called Historic England) responsibilities were extended out from the low water mark to the 12 mile nautical limit, triggering a change in approach and funding. Through the Aggregates Levy Sustainability Fund (ALSF) a range of projects were supported between 2002 and 2011 that specifically sought to help better resolve our understanding of submerged archaeological resources that might be impacted on by development. The majority of this work again operated at the large regional scale (Bicket, 2011; Bicket and Tizzard, 2015; Dix and Sturt, 2011; Sturt et al., 2013; Sturt and Dix, 2009), making best use of the data that the offshore industries supplied. The fund also sought to develop new approaches through considering the applicability of sampling methods and predictive modelling (Bicket, 2011; Sturt et al., 2016). This has seen a convergence on deposit modelling, based on geophysical and geotechnical data, as the key first step in any assessment of submerged prehistoric landscapes. Figure eight provides an example of this first stage of archaeological enquiry offshore.

Despite the impressive amounts of data gathered and analysed, significant conceptual and methodological problems remain with the UK's approach to the offshore record (Sturt and Standen, 2013). The crux of this critique centres on the point of engagement (a focus on landscape level research), and a struggle to downscale from generalised large-scale hypothesis to smaller scale archaeological realities. As Lucas (2012) has noted, the way in which we practice archaeology fundamentally shapes how we understand the potential of the resource and the products of our enquiry. Though worthwhile and profitable, the focus on landscape reconstruction could be seen to be helpful only up to a point. Through not ground-truthing (beyond cores or limited grab samples) the deposit models and hypotheses put forward, it became difficult to establish the veracity of claims made about archaeological potential offshore in UK waters, and limits evaluation to very broad statements (e.g. Goodwyn et al., 2010). Within the UK, discourse has been forced to draw on the single known and excavated underwater Mesolithic site of Bouldnor Cliff (Momber et al., 2011), and Palaeolithic finds made within dredged aggregate material from Area 240 (Tizzard et al., 2014) or refer back to the spread of inter-tidal sites. This stands in contrast to the confidence gained in the Baltic through their experience of working at a range of scales, that developed by the SINCOS project over a similar period during the mid to late 2000s, and recent developments in the Netherlands (discussed below).

All of the landscape work carried out within UK and Irish waters, matched to the rich intertidal record, points to the high potential for encountering significant archaeological remains offshore, but archaeologists have yet to be facilitated to take the next important step to realise it. Crucially, at present there are no geophysical methods that have been shown to robustly identify sub-surface archaeological features and artefacts at the scale seen on prehistoric sites. This is despite significant advances such as the development of 3D chirp technology (Plets et al., 2009; Vardy et al., 2008), able to create sub decimetre resolution volumes for interpretation. Furthermore, even if a geophysical approach could identify sites, this would serve to aid knowing where to excavate or carry out high frequency coring, but would not remove the need to do so. This is due to the fact that many archaeological questions require particular forms of material cultural and environmental evidence to answer. In effect, to have more impact the archaeology of submerged prehistory needs to be able to contribute on a similar level to that gained through terrestrial research. In no instance would a geophysical and geotechnical landscape interpretation be considered as the definitive product onshore without further testing. This is not to detract from the value or necessity of this research, but to force recognition of the need to be willing to go beyond it, a topic we return to below.

Denmark, Germany, France, Belgium, The Netherlands, Spain, Portugal

Research on settlement remains within the North Sea has been shaped by sediment transport regimes. Both vary regionally and are highly dependent on the tidal range, which differs between 1.5 m (e.g. in Alkmaar in the Netherlands and Blåvandshuk in Denmark) and 3.8 m (Wilhelmshaven, Germany; Behre, 2007). This large tidal range and high sediment transport load means that one not only has to reckon with poor visibility but also high rates of erosion. The result of this is that any organic structures and objects that are exposed are extremely threatened and can be destroyed in very short periods. As such, the window of opportunity for identification and investigation is short, and necessitates regular repeat survey.

Given the above conditions it is hardly surprising that to date the majority of prehistoric sites recorded off the coasts of Belgium, the Netherlands, Germany, Denmark and the Atlantic coast of France are represented by single finds or collections of finds exposed on the surface. This has reduced their perceived significance to researchers as it is unclear what they represent. This is especially the case as the context for these finds is often uncertain. Aggregate extraction activities (dredging) can not only result in localized removal of sediment, but wider reaching disturbance and sediment redeposition. Thus, extraction in one area may encounter in-situ archaeological material, but then redeposit it to a secondary location (Hosfield, 2007). The result of this is a heightened recognition of the importance of understanding the taphonomy of offshore assemblages.

A long history of private collection of faunal and archaeological material from the North Sea has further complicated our understanding of how representative and secure the offshore record is. Over the last decade cooperation between amateur palaeontologists, archaeologists and professional researchers and heritage managers has sought to address this, bringing to light a wealth of information that had previously been undervalued (Peeters, 2011). The success of this initiative in the Netherlands has resulted in similar projects in the UK (Bynoe et al., 2016) which are rapidly expanding our knowledge of the submerged resource through assessing extant, but under-researched, collections. This work also serves to highlight the potential for submerged landscapes to contribute to deeper time (Pleistocene) questions, balancing out the predominant focus on Holocene sequences.

While the UK may only have recently extended the remit of their Heritage regulation to their territorial waters, the cost-by-cause principle has been well anchored in Dutch heritage law.

The result of this has been that economic activities in coastal waters of the North Sea have been subject to archaeological evaluation where possible. Furthermore, rather than rely on a single approach Dutch researchers and industry have worked together to develop techniques and approaches beneficial for both parties.

A common thread in the above discussion is the difficulty that researchers have had with how to resolve sites or artefacts at finer scale than the landscape in order to realise and prove the potential that is being discussed. Much time has been spent in consideration of ‘if and how’ predictive models might be used to achieve this (e.g. Flemming et al., 2014). In part this has been due to the perceived success of the ‘fishing site model’ (Benjamin, 2010; Fischer, 1993; Fischer et al., 2007) for predicting site locations in Denmark. As Benjamin (Benjamin, 2010, p. 262) has argued:

> “predictive models applied to areas where the archaeological record is particularly lacking can be seen as a strategy for beginning the challenging task of locating prehistoric sites underwater.”

Recent work in Bulgaria (Prahov et al., 2011) has demonstrated how this can be productive in areas where there is known submerged prehistoric archaeology to work out from. However, whilst the desire to adopt this strategy is understandable, the occasions on which it has been attempted for regions with little past history of underwater excavation (from which to construct a comparative database) have proven highly problematic. Weerts et al. (Weerts et al., 2012) came to this conclusion after attempting to move the long established Dutch ‘indicatie kaart van archaeologische waarden’ (IKAW – indicative map of archaeological values) offshore. They rapidly became aware that the success of the IKAW on land was directly related to the density of information held. When extrapolated out to an area of low/no information the system struggled. Similar research in the UK (Sturt et al., 2016) highlighted this further, arguing that without a robust dataset to base predictions on, the application of a predictive model risked negatively impacting on the archaeological knowledge base. As such, the emerging consensus is that while tempting, socio-ecological predictive models are highly problematic with regard to submerged prehistory, due to our low level baseline knowledge. In contrast, the creation of detailed chronostratigraphic deposit models, based on geological and geophysical data are highly useful with regard to more accurately resolving where deposits of interest may be located.

The work at Yangtze Harbour (Rotterdam) stands as an excellent example of this approach (Moree and Sier, 2015). Close cooperation between industry, and the interdisciplinary team assembled to consider archaeological impacts, led to the development of an innovative approach to intensive mapping, characterization and sampling. Adopting a staged 'geogenetic' approach (Vos et al., 2015) researchers carried out high resolution geophysical and geotechnical mapping. The identification of archaeological material (burnt bone and flint) within the cores was used to narrow down areas for further investigation. Bulk samples were collected through use of a grab sampler (taking 2x3x0.2m volumes), with pre and post sample multi-beam surveys used to accurately map the sample location. The sampled material was then assessed to check its context, and if appropriate sieved and analysed. This method resulted in the recovery of 46067 finds (Moree and Sier, 2015) relating to Mesolithic activity in the area. As Vos et al (Vos et al., 2015, p. 22) note, "this was the first site from which in-situ Mesolithic archaeology has been uncovered on the lower Rhine-Meuse valley floor". In previous research finds had been limited to the tops of relict dune systems. The new results have helped to create an alternative understanding of Mesolithic lifeways in the region, a significant advancement of knowledge.

The work at Yangtze Harbour is important for demonstrating what can be gained through taking the next step with regard to verifying deposit models and artefact density plots. This research established that the potential so openly discussed in the academic literature was physically demonstrable, but at considerable cost. The use of the grab sampler also poses questions. While this enabled recovery of artefactual material, confirming site presence and vastly improved knowledge of the region, it was not capable of capturing or recording the contextual information (pits, postholes, hearth features) that traditional excavation reveals. If a developer were to suggest approaching a site in this manner on land approval would not be given. As such, as a community we have accepted that in order to move forward this loss of information was acceptable. This point is not insignificant, as our capability to investigate submerged landscapes is considerable. We have the technologies to survey, sample and excavate if we so choose, but the costs we are willing to incur are socially determined and proportional to the significance of the insights generated. Thus, taking this initial step maybe a crucial step forward in allowing a wider audience to better understand if and when a more detailed approach might be justified.

Although the cost-by-cause principle is also enshrined in the heritage laws of Germany and Denmark, comparable projects have yet to be carried out at this scale. However at least from the German Wadden Sea area, intense surveys aiming a registration of cultural remains have begun (Goldhammer and Karle, 2015; Jöns et al., 2013). This work led not only to the discovery of numerous prehistoric artefacts but also to extraordinary features. As an example the discovery of a late Neolithic Aurochs has been made off the North Frisian Islands, when a package of frozen sediments was washed away by the current that must have covered the site for thousands of years. (As such, the successes achieved at Yangtzhe harbour are only unusual due to the lack of projects at a comparable scale. The success of this work, and the indications from the large number of landscape based projects carried out, all highlight the need for more direct interventions of this type.

Work across the North Sea and Atlantic coasts of Europe differs to that seen within the Baltic due to its explicit consideration of greater time-depths. Since the early work of Scuvée and Verague (1978) at the site of Fermanville, researchers have been aware of the potential for discovering Palaeolithic material underwater. This, when matched to the fact that the earliest evidence for Hominin activity (c. 1 million years ago) west of the Alps is found at the coastal site of Happisburgh, UK (Parfitt et al., 2010), has forced researchers (Bynoe et al., 2016; Cohen et al., 2014; Dix and Sturt, 2011; Hijma et al., 2012; Roebroeks et al., 2014; Sturt, 2015; Tizzard et al., 2014, 2011) to consider the potential for a submerged record of greater antiquity. The surviving deposits found in the North Sea are complex, with outcrops of Pleistocene surfaces found in close proximity to Holocene sequences (Dix and Sturt, 2011; Hijma et al., 2012). The challenge this poses is that researchers working offshore need to critically assess the chronology of deposits prior to any investigation. A simple elevation based assessment of offshore sequences will not conclusively reveal their date. Thus, any attempt to evaluate archaeological potential offshore must first begin with a chronologically considerate deposit model.

Research within the North Sea, Channel and along the Atlantic Coast has had to grapple with a difficult physical environment and complex geological sequence. This has encouraged the development of sophisticated landscape and deposit modelling techniques to better understand the changing form and current archaeological potential. Discourse at the landscape level has helped to focus researchers on the need to understand the European record as a whole, rather than rely on the fragments recovered within national boundaries.

The Mediterranean and Black Sea

While the overall drivers of sea-level change (Isotasy and Eustacy) remain the same, the distance of the Mediterranean and Black Sea from glaciated regions, matched to its tectonically and volcanically active nature, mean that the impact of these drivers is markedly different. Within both the Mediterranean and Black Seas' eustatic sea-level rise has played a major role in determining palaeoshoreline location, along with more localised tectonic and volcanic patterns, with glacio isostatic adjustment (GIA) having a much smaller impact (Lambeck et al., 2010). The impact of tectonic and volcanic activity should not be underestimated, with the potential for rapid vertical shifts in the region of several metres. This means that while the -130m contour shown in figure nine is a useful guide, it is far from definitive (Flemming, 2014). However, there is a considerable area of submerged continental shelf that could potentially have been previously exposed at times of lower sea-level. In particular, the major island groups (Balearic Islands, Golf de Lions, Greek Islands, Croatia, Sardinia, Scilly, Malta, Gulf of Sirte and Cyprus) stand out as regions of potential, along with other parts of the North African coast.

The Black Sea

The Black Sea basin and associated continental shelf are in many ways unique within the context of this paper. This is the only marginal sea in the whole European area not to have revealed any new submerged prehistoric archaeological material in the last 20 years. This is not due to a lack of interest or lack of investigation, but perhaps to where the focus of research has been drawn. Promising discoveries of Bronze Age and Chalcolithic submerged sites were found on the Bulgarian coast in the 1980s and early 90s (see figure nine), but little material has come to light until recent work at Ropotamo, Bulgaria (see below). In a trend similar to that seen in the UK, resolving important issues related to palaeolandscape change have been at the forefront of researchers minds (Caraivan et al., 2017; Lericolais, 2017; Yanko-Homback et al., 2017). However, this has meant that academic debate, from an archaeological perspective, has become skewed.

The significance of the region, and the importance of understanding the extent and possible nature of the sedimentary archive and associated archaeological resource of the continental shelf, is clear. The earliest Palaeolithic site outside of Africa is found at Dmanisi in Georgia (Mgeladze et al., 2011) dating to c. 1.85-1.78 million years ago (Ferring et al., 2011), with a well recognised additional spread of Palaeolithic and Mesolithic material found across Greece and Turkey (Runnels and Özdoğan, 2001). In turn, the apparent low number of known Palaeolithic and Mesolithic sites from Bulgaria is often attributed to the impact of the inundation of the Black Sea shelf and associated aggradation of current inland river valleys, focusing attention out to sea.

There is little doubt that the continental shelf of the Black Sea preserves submerged palaeolandscapes of great interest. As recent publications have documented (Giosan et al., 2009; Lericolais, 2017, 2004, Lericolais et al., 2013, 2009; Yanchilina et al., 2017; Yanko-Hombach et al., 2007a, 2007b; Yanko-Hombach, 2007; Yanko-Homback et al., 2017) both geophysical (sub-bottom) and geotechnical data have demonstrated the presence of submerged meandering river systems (Ryan, 2007), peat deposits (Yanko-Hombach et al., 2007a), coastal dune-like formations (Lericolais, 2017; Lericolais et al., 2007) and erosion surfaces (Yanchilina et al., 2017) extending across the region.

Currently a water exchange exists within the Black Sea, with the freshwater inputs from the major river systems flowing into the basin exiting out through the Bosporus, and saline water flowing in from the Mediterranean via the same route. This occurs across a sill located c. 35m below sea level (Yanchilina et al., 2017, p. 14). During glacial periods, when sea-levels are lower than the sill, the Black Sea forms a lake with water level dictated by variation in freshwater input and evaporation rates, until the sill level is reached. This is a complex hydrological system, tightly tied to global and regional climate and weather variability.

The timing and nature of lake/sea transition and associated rates of inundation have been a hotly debated topic (A. E. Aksu et al., 2002; Constantinescu et al., 2015; Giosan et al., 2009; Hiscott et al., 2007; Lericolais, 2017; Ryan, 2007; Ryan et al., 2003; Turney and Brown, 2007; Yanchilina et al., 2017; Yanko-Hombach et al., 2007a; Yanko-Hombach, 2007). As (Yanchilina et al., 2017, p. 15) note, four differing hypothesis are currently offered:

1. a drop in lake level until c. 18,0000 14C years ago, with a gradual refilling with freshwater, reaching the sill level prior to saline ingress via the Mediterranean (Pirazzoli, 1996; Sorokin and Kuprin, 2007).
2. the maximum regression happens at 11,000 14C during the Younger Dryas, followed by a rapid freshwater transgression ending at c. 10,000 14C, again prior to reconnection with the Mediterranean (Ali E. Aksu et al., 2002; Hiscott et al., 2007)– with Yanko-Hombach et al. (Mudie et al., 2014) arguing that the lake never falls below the sill level

3. the Younger Dryas regression continues into the Preboreal, but ends with an abrupt transgression from the Mediterranean due to eustatic sea-level rise (Lericolais et al., 2007)
4. large scale (more pronounced than in hypothesis 3) regression until the Preboreal, followed by significant transgression from the Mediterranean due to eustatic sea-level rise causing a failure of the Bosphorous sill (Dimitrov, 2010; Ryan et al., 1997; Yanchilina et al., 2017).

While a considerable amount of attention has been focused on resolving the above debate, as Bikoulis (2015) has recently argued, its connection to archaeological perspectives has at times been problematic and misleading. When discussing the timing and tempo of change, and its possible impact on prehistoric societies, there is a need to carefully consider both the lifestyles of the groups being considered and the area of impact at annual to sub-decal level. Bikoulis (2015, p. 757) notes that early papers (Ballard et al., 2001; Coleman and Ballard, 2007) attributing inundation of the Black Sea with fundamentally shaping the nature and distribution of Neolithic activity in the region are evidentially hard to support, yet persistent within the literature due to their dramatic and romantic nature. In part this mismatch can be attributed to shifts between thinking on geological and archaeological timescales. Essentially, rapid is a relative term that needs to be contextualised within a broader geographical and socio-cultural context. When this is taken into consideration and the archaeological record looked at more broadly, as Bikoulis (2015, p. 769) notes, the dramatic argument has to be seen as “not very probable”.

The result of this is that we are left with an ongoing debate as to the specifics of water-level change within the Black Sea basin over the last 20,000 years. However, the presence of preserved palaeolandscapes and deposits of distinct archaeological interest have been documented by numerous researchers. Archaeologists thus have the opportunity to further contribute to our understanding of the region through resolving why the submerged terrestrial record appears limited to sites dating back c. 6500 years, and are limited to shallow waters close to modern coastlines (at depths of up-to 10m). As with research in the North Sea, the 'potential' of this area has been heavily discussed for decades (Buynevich et al., 2011; Coleman and Ballard, 2007; Peev and Hristova, n.d.), but a change in investigative methods and focus was clearly required for that potential to be realised.

Happily this has begun to happen, with the *Black Sea Maritime Archaeology Project* directly addressing the issues described above. This multi-national, interdisciplinary project has carried out three seasons of offshore survey in the Bulgarian Territorial Sea and EEZ, two seasons of coring in transects across the Bulgarian Shelf, as well as one season of excavation at the submerged prehistoric (EBA) site of Ropotamo, in southern Bulgaria. Significantly it has capitalised on cutting edge technologies used within offshore industries to produce a step change in data quality (Adams et al., n.d.). Remotely operated vehicles (ROVs) have allowed for collection of bathymetric and sub-bottom data at depth, improving the quality and resolution of the models that can be produced. In turn, this has allowed for more carefully targeted coring, and thus results which speak directly to archaeological concerns. With regard to the excavations, advances in underwater photography, software and computer power, have allowed for ultra-high resolution modelling of excavation and deposit sequences, permitting the 'shallow water' story of submerged prehistoric activity to be joined meaningfully to the deep time account of sea-level change and inundation gained from vessel based work (Pacheco-Ruiz et al. in prep). It is international collaborative projects such as this, working across scales and beyond the landscape level alone, which are making the most rapid gains.

The Mediterranean

As with the Baltic and North Sea areas, observations of the presence of submerged prehistory were made in both the Mediterranean and Black Sea during the late nineteenth and early twentieth centuries, by scholars whose interests moved easily between geology and antiquity. For example, Donati (1750) commented on the presence of submerged sites from antiquity along the Croatian coast, while Negris (1904, pp. 362–3) documented archaeological material in shallow waters in the Bay of Vatika (Greece). However, as in other regions the wider academic community did not engage with the significance of these observations. In the case of Negris, it was not until Flemming (1968; 1968) revisited the area that the value of the submerged site (Pavolopetri) was realised. Thus, in many respects the story of submerged prehistory in the Mediterranean mirrors that in other areas; important initial observations in the early twentieth century followed by a period of relative inactivity, prior to re-engagement in the 1960s and 70s.

Harding's (Harding et al., 1969) research built on Flemming's observations at Pavlopetri, leading to survey and recording of an extensive submerged Bronze Age settlement. This work helped to add weight to the idea that exacting and productive work could be carried out on submerged prehistoric sites. This mantle was to be picked up in the 1970s by Raban (1983) and Gallili (1988) through their investigation of submerged prehistoric settlements along the coast of Israel, and in particular the sites along the Carmel coast, such as Atlit Yam (Galili et al., 1993). Continuing work along this coastline has helped to recover important archaeological data, and also contributed to understandings of sea-level change within the region (Galili et al., 1988). Again, the key developments have been derived from seabed archaeological investigation of deposits by divers.

As in other areas attention has varied through time, with interest being ignited and reignited at different points in time. However, shared themes and areas of interest can be identified, speaking to larger pan regional issues. The first of these relate to issues of colonization and population movement during the Pleistocene and Early Holocene. Due to the complex tectonic history of the region and the presence of large offshore islands and archipelagos archaeologists have long had an interest in determining the degree to which changes in sea-level impact on the ease and /or technological capabilities required to reach different locations (e.g. Sciliy (Antonioli et al., 2014), Malta (Foglini et al., 2015) Cyprus (Galili et al., 2015)) and the previous extent of dryland areas (e.g. the Aegean (Sakellariou and Galanidou, 2015)). The significance of these questions for our understanding of patterns of communication and interaction are such that they have remained at the forefront of research for over forty years. However, the highly regionally variable nature of both the tectonic and archaeological record means that at times work at a given location is seen as parochial rather than of international relevance. It is only through joining these local records into a more coherent regional view that we can begin to reflect on some of the larger questions; from Eurasian Palaeolithic dispersals through to the spread of ideas and or people associated with the onset of the Neolithic.

Significant holes remain with regard to our knowledge of local and regional records across the region, and overall there is a worrying paucity of stratified sites in context. This is important due to the fact that an appreciation in the variability (timing, intensity and evidence for connectivity/shared attributes) of the archaeological record is often fundamental for evaluating the veracity of current explanations (Anderson-Whymark et al., 2015; Broodbank, 2013, 2006, 2000). As such, the second key issue that emerges is the significance of local records in the light of pan regional trends. In this sense the archaeological records of the Balearic Islands, Greek Islands, Croatia, Sardinia, Scilly, Malta and Cyprus are as significant for what they tell us about the process of Holocene population movement and cultural change as any other, and the comparative lack of direct survey of their submerged extents poses a wonderful opportunity. Similarly there are considerable expanses of the Mediterranean shoreline and continental shelf that remain understudied. The Golf de Lions, Gulf of Sirte and Albanian coastline all stand out as still being heavily understudied. While an increasing amount of desktop and landscape level work is carried out, there is still a comparative lack of ground truthing, with recent work indicating the significant rewards such work can produce (Benjamin et al., 2011; Henderson et al., 2011).

The Americas

The Americas have a long a history of research into submerged prehistory, with pioneering work in the 1960s that often fails to get the recognition it deserves. During the last half century, multidisciplinary research and offshore industrial development has enabled the building of a remarkable body of scientific knowledge concerning submerged prehistoric sites. Diverse Archaic and some Paleoindian period sites are known from both the Atlantic and Pacific shelves, mainly from North America. These sites feature prominently in the principal recent reviews of the region (Bailey and Parkington, 1988; Evans et al., 2014; Faught and Gusick, 2011; Johnson and Stright, 1992; Masters and Flemming, 1983) and are shown in figure ten. However, over the last decade there has been a renewed interest in late Pleistocene sites with regard to the light they may shed on the colonization of the new world (Goldberg et al., 2016; Pedersen et al., 2016).

North America

The prehistoric implications of the submerged Atlantic continental shelf of North America was first underscored in a seminal work by Emery and Edwards (1966). Drawing on large scale sediment sampling, radiocarbon dates and seismic profiling data they concluded that by ~11,000 years ago most of the continental shelf was exposed, with the shoreline lying as far as 150 km seaward and sea level about 60 m below present sea level. Evidence of Paleoindian and Archaic cultures, well documented along the Atlantic coast, was expected to be found on the sea floor in relict sand areas, most probably adjacent to former rivers (Emery and Edwards, 1966, p. 736). Emery and Edwards's (1966) work built on the equally significant, but less frequently cited research carried out by Goggin (1960) and Shepard (1964). Both researchers had clearly identified the value of submerged prehistoric sites at water depths accessible via SCUBA diving (within 60m water depth). This, added to the periodic discovery of Late Pleistocene continental fauna including bones, teeth and skulls of mastodon and mammoth by deep-sea fishermen (Whitmore et al., 1967), helped researchers move from a conceptual idea of potential to one with recognised associated physical material.

Whilst lithic artefacts and Pleistocene faunal material have been recovered for decades by local fishermen and clammers along the coast of the Middle Atlantic (Blanton, 1996; Stanford et al., 2014) evidence of submerged prehistoric sites remains scarce (Johnson and Stright, 1992; Stright, 1990). However, as Standford et al. (2014, p. 90) argue, the significance of these stray finds should not be underestimated. They indicate the quantity of material that might be recovered and the high potential for information rich submerged terrestrial deposits to be encountered.

For decades the eastern continental shelf of North America has been the focus of systematic oceanography and geomorphology based research strategies for palaeogeographic reconstruction, detecting and mapping relict landform features, and assessing archaeological value (Blanton, 1996; Coleman and McBride, 2008; Emery and Edwards, 1966; Garrison et al., 2016; Kraft et al., 1983). Thus in many ways the work in North America prefigured approaches and ideas later developed in North West Europe. However, they have also encountered the same issues with regard to the difficulty of moving beyond large area landscape survey. It is for this reason that historical review of research into submerged prehistory is so important. The research carried out in North America in the early 1960s is very similar in terms of scope and method to landscape scale investigations being carried out across the world today. In turn it can be seen to have stalled following this promising start due to the difficulties in detecting and resolving actual sites and small artefacts. This being said, regulations regarding pre-disturbance surveys in commercial licenses have forced a new interest in the subject, with a re-emergent community of scholars apparent at major conferences such as the Society for American Archaeology.

Recent investigation in lakes and riverine environments reflects this new community, building up a significant skillset and experience of identification and excavation of submerged prehistoric sites. In Damariscotta River, Maine, Leach et al (2007) successfully developed a method for characterizing relict beds of oyster and inferring probable location of inundated shell midden sites, using shallow marine geophysics, vibracoring and comparative archaeological data from excavated terrestrial middens. In Lake Huron, a research strategy based on remote sensing, ROV and diver ground-truthing operations combined with computer simulation has been successfully applied to provide archaeological and paleoenvironmental evidence of complex terrestrial hunting structures (O'Shea et al., 2014; O'Shea and Meadows, 2009). The finds made at these sites include submerged 9,000-year-old caribou stone drive lanes and associated artefacts. Together these provide unprecedented insight into the social and seasonal organization of early hunters in the Great Lakes region (O'Shea et al., 2013, 2014).

The discovery of an in-situ human burial at Manasota Key (Florida) has helped affirm the continued argument for the finding sites of this nature offshore (FBAR, 2018). An amateur diver reported the discovery of possible human remains to the Florida Bureau of Archaeological Research in June 2016. Subsequent research proved the material to be in-situ and date from the archaic period (7200 years ago). As such, the tools and techniques for the investigation of submerged prehistoric sites can be seen to have been developed and applied, although in a very restricted number of cases. The challenge now lies in ensuring widespread dissemination of this work as well as adapting and applying these methods for more widespread use. Initial signs are encouraging, with the Bureau of Ocean Energy and Management once again funding proactive research into submerged landscapes (this time off Oregon and California, led by Braje and Davis (Watson, 2018, p. 232)).

South America

As in North America, the eastern continental shelf of South America is relatively wide and presents a very low gradient (see figure eleven). Extensive coastal plains were exposed as dry land during the LGM due to lower sea levels, thus offering substantial potential for inundated archaeological sites. It is a remarkable fact that, in spite of this, prehistoric archaeology on the submerged Atlantic continental shelf is virtually unknown. However, there is a rapidly improving palaeoenvironmental and paleontological picture which can be used to inform our understanding of archaeological site discovery. It is here that the contrast between North and South America is clear. The first order work to describe areas of interest was well underway in the North by the late 1960s, within the South these steps have still yet to be taken.

The limited understanding of submerged palaeolandscapes once suitable for Late Pleistocene plant and animal life is based primarily on chance finds. Fossils of terrestrial mammals along the coasts of southern Brazil are found associated with large concentrations of fossil shellfish and other marine organisms from the inner continental shelf. These have been removed and transported from the submarine deposits to the coast during storm events, thus forming large konzentrat-lagerstätte on the beach called concheiros (Aires and Lopes, 2012; Lopes and Buchmann, 2011). In addition, terrestrial megamammal fossils of this period have been trawled up from the outer continental shelf at depths of 20 m and between 20 to 36 km offshore (Aires and Lopes, 2012). Thus, in a similar fashion to the incidence of Pleistocene megafauna identified by trawling in the North Sea (Bynoe et al., 2016) and the eastern seaboard of the United States of America (Stanford et al., 2014), the factual habitability of the continental shelf of South America has been verified through industrial activity.

Sambaquis, well-known Brazilian shell mounds built by fisher-gatherer groups between 7,000 and 3,000 years ago, typically occur in highly productive bay and lagoon ecotones, and are widely distributed along the coast (Gaspar, 2014; Gaspar et al., 2008). The connection between the spatial distribution of these large constructed funerary monuments – some of them located more than ~30 km inland- and the Holocene sea-level variation has been underscored and attributed to lagoonal extents being larger in the past than today (Martin et al., 1996, p. 305). Whilst it has been suggested that the older sambaquis were destroyed by marine transgression since the late Pleistocene, this remains little more than a plausible argument (Figuti et al., 2013, p. 1219). Conducting innovative investigations Calippo (Calippo, 2006) was able to test and date sambaquis in the Cananéia area. These sites had drowned components, confirming that preservation of shell mounds during Holocene sea level-rise is highly variable and dependent on local conditions(Ayup, 1991; Martin et al., 1996).

A major coastal landscape feature of Atlantic South America is the Río de la Plata estuary. During the LGM, sea-level reached a maximum variation of ~130 m and the PaleoParaná river flowed into the Atlantic. By 11,000 years ago the continental shelf adjacent to the Río de la Plata featured an extensive coastal plain controlled by a drainage system with deltaic branches, coastal lagoons and sand dune systems (Ayup, 1991). As suggested by López et al. (López Mazz et al., 2003), this paleodeltaic environment was a highly productive ecosystem attracting large herbivores seasonally, and hence, a very probable location for the earliest human inhabitants of the region. However, remarkably little investigation has been made of this area.

No submerged prehistoric sites have been detected on the continental shelf of Uruguay, but both the potential biases introduced by postglacial sea-level rise on the Atlantic coastal archaeological record and the strong connection between human occupations to lowland environments and Holocene eustatic variations have been acknowledged (Bracco and Ures, 1998; López Mazz and Gascue, 2007) Isolated finds of prehistoric artefacts attributable to the Pleistocene-Holocene transition have been recovered from beaches and are interpreted as redeposited reworked material from submerged sites disturbed by storm events. Thus again, the high likelihood of sites being preserved has been noted, but not demonstrated.

Besides isolated artefact finds, the only submerged prehistoric site reported for the southern Atlantic coast is La Olla (Bayón and Politis, 2014). Located in the southern Pampa region, the site is placed at the limit of the low tide line, in an inter-tidal environment, almost permanently covered by sand sediments and water. La Olla exhibits exceptional site integrity with remarkable high-resolution archaeological deposits containing well preserved organic materials, thus yielding an important assemblage of bone and wooden artefacts employed by Pampean hunter-gatherers. Sustained multidisciplinary research conducted at the site has provided substantial new data on early human adaptation to the southern Atlantic by the Early and Middle Holocene (ca.7.400 to ca. 6,480 14C) (Bayón and Politis, 2014).

In contrast to the Atlantic coast the Pacific continental shelf of South America exhibits a relatively narrow width, with the high relief of the Andes and the Nazca-South America plate subduction zone running parallel to the coastline. No evidence of submerged prehistoric sites has been reported so far for the Andean Pacific coasts of Colombia, Ecuador or Perú, while only a single Late Pleistocene submerged site has been detected within nearshore Central Chile.

Since the early 1980's postglacial Holocene sea-level rise was used to explain the scarcity of pre-5,000 BP coastal archaeological record found along the shorelines of Perú (Richardson III, 1981). According to this hypothesis the majority of early maritime sites had been inundated and removed from sight. Those that did survive (such as Quebrada Jaguay (Sandweiss et al., 1998)) were thought to be located at interior seasonal resources zones, or at freshwater sources (Richardson III, 1998, p. 44). Alternatively, Bailey and Flemming (2008, p. 6) proposed that rapid tectonic uplift caused by subduction activity has preserved coastal sites in land along raised palaeoshorelines. The complexity of uplift patterns, and sea-level change along this coastline means that it is possible for both explanations to be true of different regions. As such, this coastline stands as an area in much need of additional research, particularly in light of recent work on submerged Pleistocene sites in Chile.

Site GNL Quintero 1 (GNLQ1), located on the central coast of Chile (32° S) represents the only documented Late Pleistocene drowned terrestrial site along the Pacific Coast of South America at a depth of 13 m and 650 m offshore. Largely undisturbed deposits on the seabed contain a primary stratigraphic record of continental faunal remains have been systematically excavated and dated to 21-27,000 cal BP. Considering the exceptional preservation of the evidence, research has primarily focused on investigating terrestrial and marine taphonomic agents and developing improved methodologies for contextual data and bone recovery (Cartajena et al., 2013; López et al., 2012). A new phase of paleolandscape research strategy, including the comprehensive application of remote sensing technologies, geological interpretation of industrial land and offshore coring, isotopic paleoecology reconstruction and extensive underwater archaeological excavations is currently being conducted (Carabias et al., 2014). Conclusive evidence supporting human activity at GNLQ1 is scarce, only represented by two bone cut-marks (López et al., 2016; López Mendoza et al., 2016). This fact locates GNLQ1 according to Borrero (Borrero, 2016, p. 8) within the "ambiguity" cases that usefully contribute to the debate on the early peopling of South America, but will require further research.

GNLQ1 provides the first conclusive evidence for the existence and preservation of a drowned landscape viable for both extinct megafauna and early human occupation and movement along the Pacific coast of South America during the Late Pleistocene (Carabias et al., 2014). It demonstrates that this evidence can survive on a relatively narrow and steep continental shelf, on an open exposed oceanic coast, and that further investigations are urgently required. This is particularly important given the heated nature of the debate surrounding the colonization of the Americas and the potential role that the seaways and coastal margin may have played (Anderson and Bissett, 2015; Dixon and Monteleone, 2014).

Africa & Arabia

Given the size of the continent and the centrality of developments within Africa to our understanding of humanity's past, it is perhaps surprising how little research has been carried out into the archaeology of its submerged continental shelf. Dingle and Rogers (1972) first drew attention to the impact that sea-level change could have had on terrestrial site distributions. They argued this could go someway to explain apparent discrepancies in intensity of activity between the Middles Stone Age and Holocene Later Stone Age. They argued that contemporary interpretations were likely skewed due to sites now being submerged offshore on what was once an extensive low lying coastal plain. This point was picked up on by Van Andel (1989; 1989) who pushed the idea further narrowing the temporal window under which the exposed shelf would have been wide enough to provide a substantial area for occupation and exploitation. Van Andel (T. van Andel, 1989, p. 742) went onto argue that providing temporally appropriate palaeogeographic maps was essential for any work that wanted to better understand histories of occupation or migration patterns at a global scale. These considered and well supported arguments, however, failed to generate the additional research into the submerged shelf that would logically have followed. This was despite the discovery of a hand axe and additional lithic material at the bottom of 3.5m test pit dug 8m underwater offshore of Table Bay in the early 1990s (Werz et al., 2014, p. 234; Werz and Flemming, 2001). These finds were made as part of project investigating two shipwrecks, and were thus an unexpected discovery. Geotechnical pits had been dug to reveal the stratigraphy and geomorphology of the area in order to better understand wreck-site formation process. Towards the base of one of these pits lithic materials were recovered, some from a gravel deposit, but also from a red brown sand thought to reflect a submerged terrestrial deposit (Werz and Flemming, 2001).

Reflecting the trend in other regions, this topic has now been re-engaged with. Cawthra et al.'s
(2015) in Mossel Bay, South Africa, has mapped the seafloor and taken sediment samples to ground truth geophysical readings. This work has identified relict terrestrial features, a submerged drowned coastal barrier system (Cawthra et al., 2015, p. 228) and identified that the submerged coastal plain would have represent a very different environment to that on offer in the currently terrestrial exposed adjacent region (Cawthra et al., 2015, p. 231). Thus, taken together, Dingle and Rogers (1972) and Van Andel's (1989) agenda setting work, matched to Werz et al.'s (2014) artefact recovery and Cawthra et al.'s (2015) regional survey,

reflects a documented and proven potential. As Cawthra et al (2015, p231) argue, this all points to the rapid gains that could be made if additional research were facilitated.

Discussion of the contribution that the submerged continental shelf could make to our understanding of hominin migrations has received renewed interest in recent years (Bailey, 2009; Flemming, 2017; Groucutt et al., 2015). As Flemming (2017, p.270) has argued, these have at times relied on sweeping arrows and assumptions as to the uniformity and productivity of the submerged shelf. However, more recent investigation (Groucutt et al., 2015) have become more specific in their attempts to understand the role and form that submerged landscapes could have taken. In particular, Bailey et al. (2017b, 2015, 2007) have taken up the challenge to not only model the landscape, but carry out ground-truthing activities (from geotechnical (Bailey et al., 2017b) to diver survey (Bailey et al. 2007). Focusing on the southern Red Sea Farasan islands, they have identified that the now inundated landscape would have had many characteristics thought to be attractive to early human populations (narrow connecting valleys and topographic bottlenecks) for their ability to capture water and provide habitat for large mammals (Bailey et al. 2017, p. 368). This work thus deliberately sought to move beyond the 'trope of potential' alone. In so doing it also revealed the considerable difference in expenditure of effort vs. reward with regard to vessel borne landscape survey and diver investigations. Given the paucity of previous data in the area the gains made from the regional survey were rapid and significant. In contrast the diver based survey provided a different quality of information, but should be viewed as part of a longitudinal effort to resolve hypothetical discussion with material cultural evidence.

Figure thirteen is a very telling image. For the continent of Africa and the region of Arabia only three locations are drawn out as having had significant investigation. It is highly likely that some regional surveys have been missed, however, the lack of investigation as opposed to the potential to answer key archaeological questions with regard to hominin behaviour and dispersal is striking.

Australia and South East Asia

As within other regions, the late nineteenth and early twentieth century saw an explicit awareness of the enormity of geographical change that had occurred due to changing sea-levels. Daly (1910) realised coral reefs could be used as proxies for sea-level change, and that these indicated the extent to which sea-levels had been lower in the past, creating a greater extent of exposed land on Sunda and Sahul. As Allen and O'Connell (Allen and O'Connell, 2008, p. 32) note, this was picked up on by Grafton Elliot Smith in 1914 at a meeting of the British Association of the Advancement of Science in Sydney, with the argument made that early colonization of New Guinea and Australia would have required a significant sea crossing. This idea was then developed by Danes (Danes, 1925, p. 292), who argued strongly that Pleistocene fluctuations in sea-level would have played a crucial part in human dispersal and colonisation, commenting specifically on the case of Australia.

As in other regions, this recognition of substantial coastline reconfiguration and its significance for archaeological research then receded into the background. When it did re-emerge as a topic for focused consideration it was directly related to discussion of the role seafaring in the colonization of Australia (Allen et al., 1977; Balme, 2013; Birdsell, 1977).

This in turn began to feed into what has become the polarized debate as to when colonization occurred. Broadly this can be split into two camps, those in favour of a short chronology (with colonization occurring from c. 45,000 BP (Allen and O'Connell, 2008; Hiscock et al., 2016; O'Connell and Allen, 2015, 2007)) and those who argue for a longer period of occupation (typically argued to be >50,000 BP (Clarkson et al., 2017; Roberts et al., 1994; Thorne et al., 1999).

Active research into the submerged prehistory of Sunda and Sahul again becomes a story of long periods of inactivity punctuated by investigations led by highly motivated individuals. Key amongst this work was that of Flemming (Flemming, 1983, 1982) at Cootamundra Shoals (see figure 14 and 15). Here an active attempt was made at selecting areas thought to be of high potential with regard to preservation of Pleistocene landscapes and possible cave sites 200 miles offshore along palaeoshorelines corresponding to presumed dates of early colonization. The work was agenda setting and ambitious, mobilising a team of researchers to work at depth (from 30-60m below sea-level). Sadly no anthropogenic material or rock shelters suitable for habitation were discovered, although the terrain would have provided calm sheltered embayments rich with vegetation and shellfish. Thus, rather than marking the beginning of a series of investigations seeking to build on one another, the lack of recovery led to a lack of follow-on research. However, this highlights importance of managing expectations. Effectively this was a targeted sampling of the seabed, with a well-constructed rationale. Given the sparse nature of Pleistocene sites, to hope for success from a single project is to ignore the experience we have gained from decades of terrestrial research.

This has recently been recognised through a reengagement with the topic (Nutley et al., 2016; Veth et al., 2017a, 2017b, 2016, Ward et al., 2015, 2014, 2013). Two distinct strands of work can be seen to have emerged; site specific investigations looking at potential survival of submerged rock shelter that might have been used by prehistoric populations (Nutley, 2014) and landscape/process driven research (Brooke et al., 2017; Ward et al., 2015, 2014) seeking to better understand context and potential. This latter body of work adopts an approach similar to that seen in recent years in the Northern hemisphere, integrating onshore and offshore records to create an improved understanding of what the submerged resource might offer. In particular Ward et al. (2015) take a holistic view, through considering what offshore sedimentary regimes indicate about past coastal resource availability. In this sense their engagement with submerged landscapes goes beyond an attempt to identify 'sites' but considers the submerged shelf as a larger, and potentially more valuable, scientific resource. In addition, through considering these processes we not only engage with what the landscape might have been like, but also the seascape. This appears crucial if discussions of likely routes of maritime colonization are to be resolved.

With the data that is being collected by academic research groups and offshore industry, the possibility now exists to extend Ward et al's (2015) work and to consider how changes in sea-level may have impacted on currents in the sea and bioproductivity. In combining these data the implications of the long and short chronology in relation to maritime environments at the time can be considered. What distance of sea-crossing is envisaged and where might early settlers have landed? As figure 15 illustrates, in both chronological scenarios the land/sea boundaries would have been radically different, as may have been the currents that could have carried settlers to Australia. Thus, just as in other regions, this recent work on submerged prehistory focuses on removing the modern land sea boundary in order to give a more coherent picture of the past. As Ward et al (2015) demonstrate, this approach allows for regions where multiple questions can be answered to be identified allowing for efficient research, with the Dampier archipelago and Barrow island coming to the fore. Work at these locations demands an understanding of changing palaeogeography in order to interpret the record encountered. In turn it also helps focus attention on the potentially significant blank that the submerged region of the continental shelf currently represents, both with regard to possible environmental archives and site locations. This is particularly important due to the growing record indicating the significance of marine resources during this period across the region (Samper Carro et al., 2016). Research into the archaeological record of the submerged continental shelf of Australia has recently taken a leap forward with the funding of the Deep History of Sea Country (Benjamin et al., 2017) and ACROSS (Farr et al., 2018) projects. Benjamin et al. (2017) are deliberately seeking to address the lack of targeted survey and ground-truthing that has taken place in recent years. Through an interdisciplinary project they are adopting new (bathymetric LIDAR) and traditional technologies to create data of the resolution required for resolving archaeological sites and features. Such work is fundamental if discussion is to move beyond the 'if's but's and maybes' of broader hypothetical synthesis.

Technological developments and increased capacity

From the discussion above it could be possible to conclude that little technological or methodological progress has been made since the 1960s. Goggin's (1960) research in North America combined geophysical, geotechnical and radiocarbon data to account for the potential of submerged landscapes in a similar way to work carried out in 2017. This however, is far from the truth. Increases in computing power have radically altered the amount of and speed at which data can be processed, with geotechnical software packages and geographical information systems allowing for easier integration and visualisation of datasets (figure sixteen). In a similar vein, developments in swath bathymetry and sub-bottom profiling, controlled by differential GPS technologies and motion reference units on board vessels allow for significantly improved precision and accuracy in data collection (figure seventeen). This in turn allows for more careful selection of appropriate locations for geotechnical sampling, and application of the new and emergent techniques discussed below.

Smith et al’s (2015) extraction and interpretation of DNA from sediment samples recovered from the submerged site of Bouldnor Cliff has proven both controversial and disruptive. Through a combination of microgeomorphological, more traditional microfossil and sedimentary DNA (sedaDNA) analysis, Smith et al (2015) argued for the presence of wheat in southern England around 8000 BP. This was startling due to the fact that it predated all other indicators for wheat in the region by almost 2000 years. The reliability of the result was questioned on a number of grounds (the reliability of dating (Bennett, 2015) and potential for contamination (Weiß et al., 2015)). Whilst there may be issues that need to be resolved with regard to sampling and interpretation, the potential for SedaDNA to reconfigure what we can hope to recover from submerged sedimentary archives is considerable. It is in this sense that it is viewed as a disruptive technology with potential application across the globe. To this end Gaffney et al. (2017, p. 311) are continuing to explore the potential for SedaDNA through a large scale investigation of the submerged landscapes of the North and Irish seas.

The discussion above has made clear that one of the most complex challenges facing submerged prehistory relates to moving from large scale discussions of landscape and environment, to ones which generate site data which is commensurate with more traditional archaeological research. SedaDNA may offer one way in which this gap can be bridged through providing a richer insight into the makeup of past environments, and the people who lived there. The heated nature of the debate surrounding the limited use of sedaDNA for archaeological purposes offshore clearly demonstrates the need for caution and further research. However, the potential gains make this endeavour highly compelling. Through developing these techniques and refining their application it will be possible to move away from use of submerged prehistory as a 'black box' to explain away absences in the record. In this manner, we will move from a discourse of potential to one of realisation.

Technologically, advances in remotely operated vehicle (ROV) and autonomous underwater vehicle (AUV) capability is slowly transforming possible modes of data collection. The mounting of sub-bottom, swath bathymetry, high resolution cameras and push core sampling systems on ROVs and AUVs is allowing for capture of higher resolution datasets at greater depths. In turn this enables more accurate deposit modelling, core location targeting and landscape reconstruction. It is also now possible to view and sample sites at depths and in conditions which might make diving unfavourable. Continued developments in this area are now also making it possible to carry out excavation remotely, further extending our reach as archaeologists.

As the accounts of global and regional research trends make clear, however, technological and scientific capability has not been the major constraint on research into submerged prehistory. The fundamental issue can be seen to lie with conservation of momentum, sharing of data, innovation in research approaches and, critically, the creating opportunities for large scale excavation and sampling programmes. As such, the technological innovations that might have the biggest impact are those that enable data sharing, both geophysical and archaeological. The SPLASHCOS viewer which went live in 2016 allows open access to the location of submerged prehistoric sites across Europe. If extended to a global scale the ability to track developments and reconsider best practice would be greatly enhanced. Similarly, national agencies are increasingly making geophysical datasets freely available (e.g. the European marine observation and data network and the National Oceanographic and Atmospheric Administration in the U.S.A.). If this trend were extended to geotechnical and chronometric data, rapid advances could be made in first order assessments of offshore regions. This in turn would allow for more detailed consideration as to how, where and when to take the next critical step towards ground-truthing. As Moree and Sier (2015) have shown, this does not require a transformation in technological capability, more a clearly articulated argument for its necessity.

Discussion

At the start of this paper we suggested there were four unifying themes that worked across the areas we considered: strength through diversity, the significance of context, clear opportunities and the need for coordinated action. In the sections below we reflect on each of these themes before considering how, when taken together with the historical sense of trajectory given above, they help map out the future frontiers for the discipline.

Strength through diversity:

As the regional reviews demonstrate, a variety of different approaches to the study of submerged prehistory have been developed. In many respects these reflect the nature of the marine environments being investigated; from development of excavation techniques in the clear and shallow waters of the Baltic and the Mediterranean, through to geophysical and geotechnical landscape reconstruction in the murkier depths of the North Sea and the anoxic waters of the Black Sea. In addition, they speak to the different motivations for work, from academic research to development led projects. However, this variability in approach now represents one of the community's assets; collectively we are able to operate at both large and small scales and have significant experience in doing so.

It has been demonstrated that in-situ material can be carefully excavated and recovered underwater in a similar way to that practiced terrestrially. Thus, if sites scan be identified they can be excavated. The challenge thus lies in sampling these spaces at a frequency and in a manner which mirrors the scale of intervention on land. Over one hundred years of terrestrial archaeological practice has shown us that large scale sampling is the way to encounter archaeological sites to the point that, if we so wish, predictive modelling can be used to further enhance the process. At present there are no geophysical techniques that will allow for a shortcut to be taken, as there is no capability to detect the lithic scatters and shallow pits that make up the majority of the prehistoric record. If we are unwilling to accept the challenge this represents, we must recognise that the submerged record will yield different streams of data and address different questions to those traditionally explored on land. In essence, the potential we talk of will never be recognised in the manner which we envisage.

This has reached a critical point in the UK and North America where there needs to be recognition that landscape reconstruction alone cannot answer all the questions we are currently asking of the submerged prehistoric record. This might mean adopting sampling approaches similar to those seen in the work of Moree and Sier (2015), committing to the long term gradualistic methodologies such as those established in Israel, or making stronger calls for far reaching projects with the resources to address both landscape and site level issues on compressed timescales, as seen in the Black Sea MAP or Lost Frontiers Projects (Gaffney et al., 2017). This is not to suggest that continued landscape and environmental survey is not required in these regions, rather, that if we want to answer the questions that the archaeological community has identified as of central importance, we need to make progress in other ways as well.

The lesson that Moree and Sier (2015) and Gaffney et al.'s (2017) work teaches us is that radical gains can be made by deliberately seeking to move away from established modes of practice for a given region. Experimentation and efforts to capture data of different qualities can serve to positively disrupt the discipline and re-ignite debate. What we need to avoid is stagnation, through regional practices becoming established as the only means of knowing the submerged prehistoric record. If we submit to this line of thinking, the potential discussed in each area will never fully be realised. The positive emerging out of this discussion is that globally we have a community of researchers with the shared capability to resolve any issues we may encounter, be they landscape or site based.

The significance of context:

While the discovery of in-situ sites may be the gold standard of archaeological investigation, work on submerged prehistory has helped to focus attention on the necessity of understanding broader contexts in detail. In order to manage expectations, as encountering sites can never be guaranteed, concepts of 'value' attributed to offshore sequences need to be given greater significance. In essence, the 'trope of potential' needs to move away from the image of

Tybrind Vig, to one of a fine grained spatially and temporally sensitive appreciation of context. The construction of detailed and chronologically refined deposit models are crucial to all archaeological work, be it site investigation or regional narratives of shifting palaeogeography. Achieving this, is no small matter and does not preclude the site level investigations described above.

One thing that has clearly emerged through drawing the data together for this paper is the transformative impact that open access data can have. The SPLASHCOS viewer has allowed us to see the location of known sites across Europe. This, when matched to bathymetric data from GEBCO and EMODNET allows for an understanding of context. However, while it is possible to gain access to core logs and geophysical datasets, it is considerably harder to do at a scale which allows for rapid investigation. As such, sharing of these datasets and encouraging commercial operations to also release non-sensitive information will yield significant results. This can already be seen in impact of Gaffney et al's (2007) work on Doggerland, and the potential readily apparent in the 3D geophysical datasets made freely available for areas off the Australian coast. To achieve this level of data sharing will require a combined effort by marine scientists and archaeologists. As an action it is of the utmost importance if we wish to accelerate the rate at which advances are made, rather than waste time replicating surveys or failing to locate information already in the public domain.

Advances in SedaDNA offer an additional value to these archives, and have the potential to speak to long standing, large scale stories of colonisation and population movement. As such, the information we hold on offshore sedimentary archives need to be more accessible and more highly valued within the literature.

Clear Opportunities:

While wide ranging in scope, this review cannot encompass all developments and sites that have been discovered. It is interesting to reflect on what has not been said as much as what has been addressed. For all its geographical breadth the text above has not touched on areas within the tropics, Bay of Bengal, South China, East china and Yellow Seas, or the Sea of Japan. This is not to say that these areas are without high potential (Flemming, 2004), but that evidence for, or discussion of, that potential has not been widely circulated. With regard to the South China Sea, the recent recovery of a hominin jawbone by fishermen from the Penghu channel, 25km offshore from Taiwan and in a water depth of 60-120m has raised international awareness as to the potential for the submerged continental shelves of this region to contribute to our understandings of prehistory (Chang et al. 2015). As Hayashida et al. (2014, 289) argue, the story from this region is again of local antiquarians recognising this potential from the early twentieth century onwards, but with limited investigations serving to carry ideas forward. It is hard to look at the bathymetric maps of these extensive coastlines and not continue to see this potential.

The need for coordinated action:

It is this word, potential, that resurfaces most frequently in the texts related to study of submerged landscapes. Given the repetitive pattern of early recognition in the late nineteenth and early twentieth centuries, pioneering works in the 1930s, 50s and 60s and 70s, followed by regional 're-discoveries' and development, it could be possible to become pessimistic. This is a long period of time over which to have discussed potential, but to have rarely been seen to have delivered on it. However, such an interpretation would be misguided and based on a skewed perception of the field. As figure three demonstrates, the number of active researchers publishing on the topic of submerged landscapes is remarkably small. At this population density it is perhaps unsurprising that it has been hard to maintain momentum at a global level, with individual researchers making significant differences. As careers develop attention is focused and ground gained, and with retirements come potential loss of continuity. This is perhaps surprising as while the number of people who consider themselves to be investigating submerged landscapes within an archaeological context may be small, the numbers contributing through a larger geoscience context is significant. As such, future developments within the field depend on greater integration and communication with these groups, and the maintenance of a scholarly community working towards a set of shared goals.

In this light, how we manage the expectations and demands of funders needs to be carefully considered. Within academia there is increasing pressure to document how the research being conducted will radically transform the field of study. This leads for continued pushes towards identification of 'the earliest' sites or claims as to definitive insights into the most significant changes to society. The result is a focus on particular narratives from submerged contexts; catastrophic events, exceptional preservation or migration pathways. In reality we need to prepare people for the fact that in some instances this is a long-term project, where significant gains can be foreseen but will take time to develop. The only way to speed this up is to encourage greater data sharing and communication between researchers across academia and industry at a global scale.

Conclusion

Writing at the start of 2018 there is a palpable sense that this field of research stands poised to transform our understanding of the prehistoric past. This is in spite of the fact that in recent decades the subject has suffered from a geographical and temporal stop-start of effort that has repeatedly led to a loss of capability and institutional knowledge.

Cumulatively, over three thousand seabed prehistoric sites have been identified in the last 50 years, with examples off the coast of every continent, and ranging in age from 5000 years old to about 1 million years. In some regions a sufficient number of sites have been found to address key archaeological questions, while in others research is only beginning. Improvements in seabed survey technology in recent decades, and access to data of commercial origin, present the opportunity to reconstruct palaeo-environments at a spatial resolution of a few metres, and thanks to Bayesian modelling, a chronological resolution nearing the generational. Added to this national and international regulations now require coastal states to consider protection of submerged prehistoric sites, encouraging further survey and investigation.

What holds us on the knife-edge between realising this opportunity and failing to capitalise on it is accepting what that challenge means. Lapsing back into a patchwork of local and sub-regional ad-hoc projects will ensure that the subject collapses again, as it has done so often in the past. First, there is a need to reconceptualise what constitutes submerged prehistory and how it contributes to archaeology. Giving equal weighting to environmental and material cultural contexts will move us some way towards this. It is only through improving our understanding of the nature, rate and variability of change that we will be able to understand the anthropogenic remains we do encounter. This will also help to manage expectations.

In some regions the extent of submerged continental shelf are significant, and while the potential to encounter in-situ material is apparent, the ability to pinpoint its location geophysically is beyond our capability. In these instances sites will only be discovered through a combination of chance finds and systematic sampling. In order to recover more material we will have to radically increase the rate of discovery via the number and increased area of direct interventions occurring. While we continue to carry out geophysical and geotechnical surveys but fail to recover large volumes of sediments in a controlled manner we will never be able to resolve our accounts of 'potential' beyond the hypothetical, we will only be telling half of the story. This is perhaps the lesson we can learn from previous research in the Baltic, and recent activity in the North Sea, Israel and the Gulf of Mexico.

The changes in the technology available for work offshore are significant. We should not focus on the fact they do not allow us to detect sites on purely deterministic measurements. When working terrestrially there are numerous contexts (deep stratigraphic sequences or areas of complex geology) where geophysical methods will not be sufficient to identify sites. Instead, we should focus on the positives of what we are gaining offshore. The ability to capture data over large areas at increasingly high resolutions is remarkable. The mounting of instruments on ROV and AUVs to enable targeted data collection from greater depths are complimenting shipboard sensors to enable high resolution imaging of the seabed and sub-surface from the mean low water mark to edge of the continental shelf (and beyond). In many respects we are now better able to rapidly survey and model landscape change offshore than we can onshore.

The next frontiers of research into submerged prehistoric sites and landscapes could thus be seen to rest in particular geographical areas, technological advancements or addressing key archaeological questions to do with migrations or social change. However, to pick any one of these themes would be to miss the critical lessons that we gain from looking into the discipline's past. The reality is that the next frontier lies in strengthening interdisciplinary links, enabling data sharing and forming a sustainable community of researchers. Without achieving this none of the exciting research potential detailed above will be achieved. In the rare instances where gains are made, they will too likely slip out of view and fail to have the impact that they should have. The means for us to achieve this lie in building the theme into undergraduate syllabi and increasing the number of collaborative grant applications. Finally, we also need to make sure we communicate with a wider audience. As Clark and Godwin would have argued, 'submerged prehistory' can be simplified to 'prehistory'. In this light rather than seeing work underwater as an esoteric sideshow, a failure to engage with it is a failure to explore the archaeological record to its fullest potential.

Acknowledgements

F. Sturt would like to thank the Leverhulme Trust, whose support via the award of a Philip Leverhulme Prize helped create the time and space to think and write about the topic. The authors would also like to thank the two anonymous reviewers for their constructive feedback which helped improve the paper

References

Adams, J., Angelova, H., Batchvarov, K., Dimitrov, K., Dix, J.K., Draganov, V., Farr, H., Grant, M., Garbov, D., Holmlund, J., Pacheco-Ruiz, R., Rönnby, J., Sakellariou, D., Sturt, F., Symons, W., Vagalinski, L., Velikovski, K., n.d. The Black Sea Maritime Archaeology Project (Black Sea MAP): Chronology and Process of Environmental Change in the Bulgarian Waters of the Black Sea:

Aires, A.S.S., Lopes, R.P., 2012. Representativity of quaternary mammals from the southern Brazilian continental shelf. Rev. Bras. Paleontol. 15, 57–66. doi:10.4072/rbp.2012.1.05

Aksu, A.E., Hiscott, R.N., Mudie, P.J., Rochon, A., Kaminski, M.A., Abrajano, T., Yaar, D., 2002. Persistent holocene outflow from the Black Sea to the eastern Mediterranean contradicts Noah's flood hypothesis. GSA Today 12, 4–10. doi:10.1130/1052-5173(2002)012<0004:PHOFTB>2.0.CO;2

Aksu, A.E., Hiscott, R.N., Yaşar, D., Işler, F.I., Marsh, S., 2002. Seismic stratigraphy of Late Quaternary deposits from the southwestern Black Sea shelf: Evidence for non-catastrophic variations in sea-level during the last ~10 000 yr. Mar. Geol. 190, 61–94.

doi:10.1016/S0025-3227(02)00343-2
Allen, J., Golson, J., Jones, R., 1977. Sunda and Sahul: prehistoric studies in southeast Asia, Melanesia and Australia. Academic Press.
Allen, J., O'Connell, J.F., 2008. Getting from Sunda to Sahul, in: Clark, G., Leach, F., O'Connor, S. (Eds.), Islands of Inquiry: Colonisation, Seafaring and the Archaeology of Maritime Landscapes. ANU Press, Canberra, pp. 31–46.
Andersen, S.H., 2013. Tybind Vig. Submerged Mesolithic settlements in Denmark. Jutland Archaeological Society, Højbjerg.
Andersen, S.H., 1980. Tybrind Vig. A Preliminary Report on a Submerged Ertebolle Settlement on the West Coast of Fyn. J. danish Archaeol. 4, 52–69.
Anderson-Whymark, H., Garrow, D., Sturt, F., 2015. Microliths and Maritime mobility: a continental European-style Late Mesolithic flint assemblage from the Isles of Scilly. Antiquity 89, 954–971. doi:10.15184/aqy.2015.77
Anderson, D.G., Bissett, T.G., 2015. The initial colonization of North America: Sea level change, shoreline movement, and great migrations, in: Mobility and Ancient Society in Asia and the Americas. pp. 59–88. doi:10.1007/978-3-319-15138-0_6
Andrén, E., Andrén, T., Sohlenius, G., 2000. The Holocene history of the southwestern Baltic Sea as reflected in a sediment core from the Bornholm Basin. Boreas 29, 233–250.
Andrén, T., Björck, S., Andrén, E., Conley, D., Zillén, L., Anjar, J., 2011. The Development of the Baltic Sea Basin During the Last 130 ka, in: Harff, J., Björck, S., Hoth, P. (Eds.), The Baltic Sea Basin. Springer, New York, pp. 75–98.
Antonioli, F., Lo Presti, V., Morticelli, M.G., Bonfiglio, L., Mannino, M.A., Palombo, M.R., Sannino, G., Ferranti, L., Furlani, S., Lambeck, K., Canese, S., Catalano, R., Chiocci, F.L., Mangano, G., Scicchitano, G., Tonielli, R., 2014. Timing of the emergence of the Europe–Sicily bridge (40–17 cal ka BP) and its implications for the spread of modern humans. Geol. Soc. London, Spec. Publ. 411, 111–144. doi:10.1144/SP411.1
Apenzeller, T., 2012. Eastern Odyssey. Nature 485, 24–26.
Argus, D.F., Peltier, W.R., Drummond, R., Moore, A.W., 2014. The Antarctica component of postglacial rebound model ICE-6G_C (VM5a) based on GPS positioning, exposure age dating of ice thicknesses, and relative sea level histories. Geophys. J. Int. 198, 537–563. doi:10.1093/gji/ggu140
Ayup, N., 1991. Avaliaçao das Mudanças do Nivel do Mar Durante o Holoceno na Plataforma Continental Adjacente ao Río de la Plata. UFRGS, Porto Alegre.
Bailey, G., 2009. The Red Sea, Coastal Landscapes, and Hominin Dispersals, in: Petraglia, M.D., Rose, J.I. (Eds.), The Evolution of Human Populations in Arabia, Vertebrate Paleobiology and Paleoanthropology. Springer, pp. 15–37.
BAILEY, G., FLEMMING, N., 2008. Archaeology of the continental shelf: Marine resources, submerged landscapes and underwater archaeology. Quat. Sci. Rev. 27, 2153–2165. doi:10.1016/j.quascirev.2008.08.012
Bailey, G., Parkington, J., 1988. The archaeology of prehistoric coastlines: an introduction. Archaeol. Prehist. coastlines.
Bailey, G.N., Devès, M.H., Inglis, R.H., Meredith-Williams, M.G., Momber, G., Sakellariou, D., Sinclair, A.G.M., Rousakis, G., Al Ghamdi, S., Alsharekh, A.M., 2015. Blue Arabia: Palaeolithic and underwater survey in SW Saudi Arabia and the role of coasts in Pleistocene dispersals. Quat. Int. 382, 42–57. doi:10.1016/j.quaint.2015.01.002
Bailey, G.N., Flemming, N.C., King, G.C.P., Lambeck, K., Momber, G., Moran, L.J., Al-Sharekh, A., Vita-Finzi, C., 2007. Coastlines, Submerged Landscapes, and Human Evolution: The Red Sea Basin and the Farasan Islands. J. Isl. Coast. Archaeol. 2, 127–160.
Bailey, G.N., Harff, J., Sakellariou, D., 2017a. Archaeology and Palaeolandscapes of the

Continental Shelf: An Introduction, in: Bailey, G., Harff, J., Sakellariou, D. (Eds.), Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf. Springer, Cham, pp. 1–17.
Bailey, G.N., Sakellariou, D., Alsharekh, A., Al Nomani, S., Devès, M., Georgiou, P., Kallergis, M., Kalogirou, S., Manousakis, L., Mantopoulos, P., 2017b. Africa-Arabia connections and geo-archaeological exploration in the southern Red Sea: preliminary results and wider significance, in: Bailey, G.N., Harff, J., Sakellariou, D. (Eds.), Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf. Springer, Cham, pp. 361–373.
Ballard, R.D., Hiebert, F.T., Coleman, D.F., Ward, C., Smith, J.S., Willis, K., Foley, B., Croff, K., Major, C., Torre, F., 2001. Deepwater Archaeology of the Black Sea: The 2000 Season at Sinop, Turkey. Am. J. Archaeol. 105, 607. doi:10.2307/507409
Balme, J., 2013. Of boats and string: The maritime colonisation of Australia. Quat. Int. 285, 68–75. doi:10.1016/j.quaint.2011.02.029
Bayón, M.C., Politis, G.G., 2014. The inter-tidal zone site of la olla: Early-middle holocene human adaptation on the pampean coast of Argentina, in: Prehistoric Archaeology on the Continental Shelf: A Global Review. pp. 115–130. doi:10.1007/978-1-4614-9635-9
Behre, K.-E., 2007. A new Holocene sea-level curve for the southern North Sea. Boreas 36, 82–102. doi:10.1080/03009480600923386
Bell, M., Warren, G., 2013. The Mesolithic, in: Ransley, J., Sturt, F. (Eds.), People and the Sea: A Maritime Archaeological Research Agenda for England. Council for British Archaeology, York, pp. 30–49.
Benjamin, J., 2010. Submerged Prehistoric Landscapes and Underwater Site Discovery: Reevaluating the “Danish Model” for International Practice. J. Isl. Coast. Archaeol. 5, 253–270. doi:10.1080/15564894.2010.506623
Benjamin, J., Bonsall, C., Pickard, C., Fischer, A., 2011. Submerged Prehistory, Submerged Prehistory. Oxbow Books, Oxford. doi:10.1029/2004PA001071
Benjamin, J., Ward, I., Ulm, S., Veth, P., O’Leary, M., Hacker, J., McDonald, J., Holst, M., Bailey, G.N., 2017. Deep History of Sea Country [WWW Document].
Bennett, K.D., 2015. Comment on “Sedimentary DNA from a submerged site reveals wheat in the British Isles 8000 years ago.” Science (80-.). 349, 247.
Berzins, V., Lübke, H., Berga, L., Cerina, A., Kalnina, L., Meadows, J., Muizniece, S., Paegle, S., Rudzite, M., Zagorska, I., 2016. Recurrent Mesolithic-Neolithic occupation at Sise (western Latvia) and shoreline displacement in the Baltic Sea Basin. The Holocene 1–7. doi:10.1177/0959683616638434
Bicket, A., 2011. Submerged Prehistory : Marine ALSF Research in Context. Marine ALSF Science Monograph Series No. 5, Archaeology. MALSF.
Bicket, A., Tizzard, L., 2015. A review of the submerged prehistory and palaeolandscapes of the British Isles. Proc. Geol. Assoc. 7–9. doi:http://dx.doi.org/10.1016/j.pgeola.2015.08.009
Bikoulis, P., 2015. Evaluating the impact of Black Sea flooding on the Neolithic of northern Turkey. World Archaeol. 47, 756–775. doi:10.1080/00438243.2015.1078740
Birdsell, J.B., 1977. The recalibration of a paradigm for the first peopling of greater Australia. Sunda Sahul Prehist. Stud. Southeast Asia, Melanes. Aust. 113–167.
Blanc, A.C., 1940. Industrie musteriane e paleolithice superior nelle dune fossile e nelle grotte litorannee del Capo Palinuro. Rend. della R. Accad. d’Italia 10, 1.
Blanton, D., 1996. Accounting for submerged Mid-Holocene archaeological sites in the southeast: a case study from the Chesapeake Bay estuary, Virginia, in: Sassaman, K.E., Anderson, D.G. (Eds.), Archaeology of the Mid-Holocene Southeast. University of Alabama Press, Tuscaloosa, pp. 200–217.

Borlase, W.C., 1758. Natural History of Cornwall. W. Jackson, Oxford.
Borrero, L.A., 2016. Ambiguity and Debates on the Early Peopling of South America. PaleoAmerica 2, 11–21. doi:10.1080/20555563.2015.1136498
Boule, M., 1906. Les grottes de Grimaldi (Baousse'-Rousse). Etude geologique et paleontologiuqe. Imprimerie de Monaco, Monaco.
Boyd Dawkins, W., 1870. On the Discovery of Flint and Chert under a Submerged Forest in West Somerset. J. Ethnol. Soc. London 2, 141–146.
Bracco, R., Ures, C., 1998. Las variaciones del nivel del mar y el desarrollo de las culturas prehistóricas del Uruguay. Rev. do Mus. Arqueol. e Etnol. 8, 109–115.
Broodbank, C., 2013. The Making the Middle Sea: A History of the Mediterranean from the Beginning to the Emergence of the Classical World. Thames and Hudson, London.
Broodbank, C., 2006. The origins and early development of Mediterranean maritime activity. J. Mediterr. Archaeol. 19.
Broodbank, C., 2000. An island archaeology of the early Cyclades. Cambridge University Press, Cambridge.
Brooke, B.P., Nichol, S.L., Huang, Z., Beaman, R.J., 2017. Palaeoshorelines on the Australian continental shelf: Morphology, sea-level relationship and applications to environmental management and archaeology. Cont. Shelf Res. 134, 26–38. doi:10.1016/j.csr.2016.12.012
Burkitt, M.C., 1932. A Maglemose Harpoon dredged up recently from the North Sea. Man 32, 118. doi:10.2307/2790963
Buynevich, I., Yanko-Hombach, V., Gilbert, A.S., Martin, R.E., 2011. Geology and Geoarchaeology of the Black Sea Region: Beyond the Flood Hypothesis - Google Books. The Geological Society of America, Boulder.
Bynoe, R., Dix, J.K., Sturt, F., 2016. Of mammoths and other monsters: historic approaches to the submerged Palaeolithic. Antiquity 90, 857–875. doi:10.15184/aqy.2016.129
Calippo, F.R., 2006. The submerged shell mounds of Cananéia, São Paulo, Brazil: a case study of underwater archaeology, in: Proceedings of the XVth Congress of theUISPP, Colloquia Coastal Geoarcheology.
Carabias, D., Cartajena, I., Simonetti, R., López, P., Ortega, C., 2014. Submerged paleolandscapes: Site GNL quintero 1 (GNLQ1) and the first evidences from the pacific coast of South America, in: Prehistoric Archaeology on the Continental Shelf: A Global Review. pp. 131–149. doi:10.1007/978-1-4614-9635-9
Caraivan, G., Voinea, V., Popescu, D., Cerchia, C., 2017. Submerged Prehistoric Heritage Potential of the Romanian Black Sea Shelf, in: Flemming, N.C., Harff, J., Moura, D., Burgess, A., Bailey, G.N. (Eds.), Submerged Landscapes of the European Continental Shelf : Quaternary Paleoenvironments. Wiley Blackwell, Oxford, pp. 497–517.
Cartajena, I., López, P., Carabias, D., Morales, C., Vargas, G., Ortega, C., 2013. First evidence of an underwater Final Pleistocene terrestrial extinct faunal bone assemblage from Central Chile (South America): Taxonomic and taphonomic analyses. Quat. Int. 305, 45–55. doi:10.1016/j.quaint.2012.12.041
Cawthra, H.C., Compton, J.S., Fisher, E.C., MacHutchon, M.R., Marean, C.W., 2015. Submerged shorelines and landscape features offshore of Mossel Bay, South Africa. Geol. Soc. London, Spec. Publ. 411, 219–233. doi:10.1144/SP411.11
Clark, J.G.D., 1936. The Mesolithic Settlement of Northern Europe: A study of the food-gathering peoples of Northern Europe during the early post-glacial period. Cambridge University Press, Cambridge.
Clark, J.G.D., 1932. The Mesolithic Age in Britain. Cambridge University Press, Cambridge.
Clarkson, C., Jacobs, Z., Marwick, B., Fullagar, R., Wallis, L., Smith, M., Roberts, R.G., Hayes, E., Lowe, K., Carah, X., Florin, S.A., McNeil, J., Cox, D., Arnold, L.J., Hua, Q.,

Huntley, J., Brand, H.E.A., Manne, T., Fairbairn, A., Shulmeister, J., Lyle, L., Salinas, M., Page, M., Connell, K., Park, G., Norman, K., Murphy, T., Pardoe, C., 2017. Human occupation of northern Australia by 65,000 years ago. Nature 547, 306–310. doi:10.1038/nature22968

Clausen, C.J., Brooks, H.K., Wesolowsky, A.B., 1975. The early man site at Warm Mineral Springs, Florida. J. F. Archaeol. 2, 191–213.

Clausen, C.J., Cohen, A.D., Emiliani, C., Holman, J.A., Stipp, J.., 1979. Little Salt Spring, Florida: a unique underwater site. Science (80-.). 203, 609–614.

Cockrell, W.A., Murphy, L., 1978. Pleistocene man in Florida. Archaeol. East. North Am. 6, 1–13.

Cohen, K.M., Gibbard, P.L., Weerts, H.J.T., Cohen, K.M., Gibbard, P.L., Weerts, H.J.T., 2014. North Sea palaeogeographical reconstructions for the last 1 Ma. Geol. en Mijnbouw/Netherlands J. Geosci. 93, 7–29. doi:10.1017/njg.2014.12

Cohen, K.M., MacDonald, K., Joordens, J.C.A., Roebroeks, W., Gibbard, P.L., 2011. The earliest occupation of north-west Europe: a coastal perspective. Quat. Int. doi:10.1016/j.quaint.2011.11.003

Cohen, K.M., Westley, K., Erkens, G., Hijma, M., Weerts, H.J.T., 2017. The North Sea, in: Flemming, N.C., Hard, J., Moura, D., Burgess, A., Bailey, G.N. (Eds.), Submerged Landscapes of the European Continental Shelf : Quaternary Paleoenvironments. Wiley Blackwell, Oxford, pp. 147–186.

Coleman, D.F., Ballard, R.D., 2007. Submerged paleoshorelines in the southern and western Black Sea–Implications for inundated prehistoric archaeological sites, in: The Black Sea Flood Question: Changes in Coastline, Climate, and Human Settlement. Springer Netherlands, pp. 671–696. doi:10.1007/978-1-4020-5302-3_28

Coleman, D.F., McBride, K., 2008. Underwater Prehistoric Archaeological Potential of the Southern New England Continental Shelf off Block Island, in: Ballard, R. (Ed.), Archaeological Oceanography. Princeton University Press, Princeton, pp. 200–223.

Coles, B.J., 1999. Doggerland’s Loss and the Neolithic, in: Coles, B., Coles, J., Schon Jorgensen, M. (Eds.), Bog Bodies, Sacred Sites and Wetland Archaeolgoy. Wetlands ARchaeolgoical Research Project Occasional Paper 12, Exeter, pp. 51–67.

Coles, B.J., 1998. Doggerland: a Speculative Survey. Proc. Prehist. Soc. 64, 45–81.

Collier, J.S., Oggioni, F., Gupta, S., García-Moreno, D., Trentesaux, A., De Batist, M., 2015. Streamlined islands and the English Channel megaflood hypothesis. Glob. Planet. Change 135, 190–206. doi:10.1016/J.GLOPLACHA.2015.11.004

Constantinescu, A.M., Toucanne, S., Dennielou, B., Jorry, S.J., Mulder, T., Lericolais, G., 2015. Evolution of the Danube deep-sea fan since the last glacial maximum: new insights into Black Sea water-level fluctuations. Mar. Geol. 367, 50–68.

Crawford, O.G.S., 1927. Lyonesse. Antiquity 1. doi:10.1017/CBO9781107415324.004

Daly, R.A., 1910. Pleistocene glaciation and the coral reef problem. Am. J. Sci. 30, 297–308.

Danes, J. V., 1925. Pleistocene changes of sea-level and the distribution of man. Scott. Geogr. Mag. 41, 289–298. doi:10.1080/00369222508734494

Dawson, G.M., 1894. Geological notes on some of the coasts and islands of the Bering Sea and vicinity. Geol. Soc. Am. Bull. 5, 117–146.

Dimitrov, P., 2010. Geology and Non-traditional resources of the Black Sea. LAP. Lambert Acad. Publ. AG). ISBN 978, 8383.

Dingle, R. V, Rogers, J., 1972. Effects of sea-level changes on the Pleistocene palaeoecology of the Agulhas Bank. Palaeoecol. Africa 6, 55–58.

Dix, J.K., Sturt, F., 2011. The Relic Palaeo-landscapes of the Thames Estuary, Management. MEPF/ALSF.

Dixon, J.E., Monteleone, K., 2014. Gateway to the Americas: Underwater Archeological

Survey in Beringia and the North Pacific, in: Evans, A., Flatmsan, J.C., Fleming, N.C. (Eds.), Prehistoric Archaeology on the Continental Shelf: A Global Review. Springer, New York, pp. 95–114.
Donati, V., 1750. Della storia naturale marina dell' Adriatico: saggio. Francesco Storti, Venice.
Emery, K.O., Edwards, R.L., 1966. Archaeological Potential of the Atlantic Continental Shelf. Am. Antiq. 31, 733–737. doi:10.2307/2694497
Evans, A., Flatman, J., Flemming, N.C., 2014. Prehistoric Archaeology on the Continental Shelf. Springer New York, New York, NY. doi:10.1007/978-1-4614-9635-9
Fagan, B., 2001. Grahame Clark: An Intellectual Life of an Archaeologist. Westview Press, Boulder.
Farr, H., Dix, J., Haigh, I., Marsh, R., Richards, M., Veth, P., Gamble, C., 2018. ACROSS [WWW Document].
Faught, M.K., Gusick, A.E., 2011. Submerged Prehistory in the Americas, in: Benjamin, J., Bonsall, C., Pickard, C., Fisher, A. (Eds.), Submerged Prehistory. Oxbow, Oxford, pp. 145–157.
FBAR, 2018. Manasota Key [WWW Document].
Ferring, R., Oms, O., Agustí, J., Berna, F., Nioradze, M., Shelia, T., Tappen, M., Vekua, A., Zhvania, D., Lordkipanidze, D., 2011. Earliest human occupations at Dmanisi (Georgian Caucasus) dated to 1.85-1.78 Ma. Pnas 108, 10432–10436. doi:10.1073/pnas.1106638108
Figuti, L., Plens, C., DeBlasis, P., 2013. Small sambaquis and big chronologies: shellmound building and hunter-gatherers in Neotropical highlands. Radiocarbon 55, 1215–1221.
Firth, A., 2011. Submerged Prehistory in the North Sea, in: Catsambis, A., Ford, B., Hamilton, D. (Eds.), The Oxford Handbook of Maritime Archaeology. Oxford Univeristy Press, Oxford, pp. 786–808.
Fischer, A., 2004. Submerged Stone Age - Danish examples and North Sea potential. Submar. Prehist. Archaeol. North Sea. Res. Priorities Collab. with Ind. CBA Res. Rep. 141.
Fischer, A., 1997. Arkæologer på dybt vand, in: Pedersen, L., Fischer, A., Aaby, B. (Eds.), Storebælt I 10.000 År. Mennesket, Havet Og Skoven. A/S Storebæltsforbindelsen, København, pp. 63–77.
Fischer, A., 1993. Stenalderbopladser på bunden af Øresund. Afprøvning af en model. Del 1, det centrale Øresund. Miljøministeriet, Skov- og Naturstyrelsen, Hørsholm.
Fischer, A., Olsen, J., Richards, M., Heinemeier, J., Sveinbjornsdottir, A., Bennike, P., 2007. Coast–inland mobility and diet in the Danish Mesolithic and Neolithic: evidence from stable isotope values of humans and dogs. J. Archaeol. Sci. 34, 2125–2150. doi:10.1016/j.jas.2007.02.028
Fitch, S., Thomson, K., Gaffney, V., 2005. Late Pleistocene and Holocene depositional systems and the palaeogeography of the Dogger Bank, North Sea. Quat. Res. 64, 185–196. doi:10.1016/j.yqres.2005.03.007
Fladmark, K.R., 1979. Routes: Alternate Migration Corridors for Early Man in North America. Am. Antiq. 44, 55–69. doi:10.1525/aa.1961.63.5.02a00100
Flemming, N.C., 2017. The Role of the Submerged Prehistoric Landscape in Ground-Truthing Models of Human Dispersal During the Last Half Million Years, in: Bailey, G.N., Harff, J., Sakellariou, D. (Eds.), Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf. Springer, Cham, pp. 269–283.
Flemming, N.C., 2014. Land Beneath the Waves Submerged landscapes and sea level change.
Flemming, N.C., 2004. Submarine prehistoric archaeology of the Indian continental shelf: A

potential resource. Curr. Sci. 86, 1225–1230.
Flemming, N.C., 1983. A survey of the late Quaternary landscape of the Cootamundra Shoals, north Australia: a preliminary report, in: Proceedings of the Seventh International Diving Science Symposium of CMAS. p. 149e180.
Flemming, N.C., 1982. Sirius Expedition-Cootamundra Shoals Survey 1982: Expedition Reports.
Flemming, N.C., 1968. Holocene earth movements and eustatic sea level change in the Peloponnese. Nature. doi:10.1038/2171031a0
Flemming, N.C., 1968. Mediterranean sea level changes. Sci. J. 51–55.
Flemming, N.C., Cagatay, M.N., Chiocci, F.L., Galandiou, N., Lericolais, G., Jons, H., Missiaen, T., Moore, F., Rosentau, A., Skellarious, D., Skar, B., Stevenson, A., Weerts, H., 2014. Land Beneath the Waves Submerged landscapes and sea level change: a joint geoscience-humaniteis strategy for European Continental Shelf Prehistoric Research, in: Chu, N.C., McDonough, N. (Eds.), Position Paer 21 of the European Marine Board. European Marine Board, Ostend, p. 171.
Foglini, F., Prampolini, M., Micallef, A., Angeletti, L., Vandelli, V., Deidun, A., Soldati, M., Taviani, M., 2015. Late Quaternary coastal landscape morphology and evolution of the Maltese Islands (Mediterranean Sea) reconstructed from high-resolution seafloor data. Geol. Soc. London, Spec. Publ. 411, 77–95. doi:10.1144/SP411.12
Gaffney, V., Allaby, R., Bates, R., Bates, M., Ch'ng, E., Fitch, S., Garwood, P., Momber, G., Murgatroyd, P., Pallen, M., Ramsey, E., Smith, D., Smith, O., 2017. Doggerland and the Lost Frontiers Project (2015-2020), in: Bailey, G.N., Harff, J., Sakellariou, D. (Eds.), Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf. Springer, Cham, pp. 305–319.
Gaffney, V., Fitch, S., 2009. Europe's lost world: The rediscovery of Doggerland, Council for British Archaeology Research Report.
Gaffney, V., Thomson, K., Fitch, S., Finch, S., 2007. Mapping Doggerland: The Mesolithic Landscapes of the Southern North Sea. Archaeopress, Oxford.
Galili, E., Şevketoğlu, M., Salamon, A., Zviely, D., Mienis, H.K., Rosen, B., Moshkovitz, S., 2015. Late Quaternary beach deposits and archaeological relicts on the coasts of Cyprus, and the possible implications of sea-level changes and tectonics on the early populations. Geol. Soc. London, Spec. Publ. 411, 179–218. doi:10.1144/SP411.10
Galili, E., Weinstein-Evron, M., Hershkkovitz, I., Gopher, A., Kislev, M., Lernau, O., Kolska-Horwitz, L., Lernau, H., 1993. Atlit-Yam: A Prehistoric Site on the Sea Floor off the Israeli Coast. J. F. Archaeol. 20, 133–157.
Galili, E., Weinstein-Evron, M., Ronen, A., 1988. Holocene sea-level changes based on submerged archaeological sites off the northern Carmel coast in Israel. Quat. Res. 29, 36–42. doi:10.1016/0033-5894(88)90069-5
Garrison, E.G., Cook Hale, J., Cameron, C.S., Smith, E., 2016. The archeology, sedimentology and paleontology of Gray's Reef National Marine Sanctuary and nearby hard bottom reefs along the mid continental shelf of the Georgia Bight. J. Archaeol. Sci. Reports 5, 240–262. doi:10.1016/j.jasrep.2015.11.009
Gaspar, M.D., 2014. Archaeology of Sambaquis Shell Mounds, in: Smith, C. (Ed.), Encylclopedia of Global Archaeology. Springer, New York, pp. 6449–6454.
Gaspar, M.D., DeBlasis, P., Fish, S.K., Fish, P.R., 2008. Sambaqui (Shell Mound) Societies of Coastal Brazil, in: The Handbook of South American Archaeology. pp. 319–335. doi:10.1007/978-0-387-74907-5_18
Gibbard, P.L., Cohen, K.M., 2015. Quaternary evolution of the North Sea and the English Channel. Proc. Open Univ. Geol. Soc. 1, 65–75.
Giosan, L., Filip, F., Constatinescu, S., 2009. Was the Black Sea catastrophically flooded in

the early Holocene? Quat. Sci. Rev. 28, 1–6. doi:10.1016/j.quascirev.2008.10.012
Goggin, J.M., 1960. Underwater archaeology: its nature and limitations. Am. Antiq. 25, 348–354.
Goldberg, A., Mychajliw, A.M., Hadly, E.A., 2016. Post-invasion demography of prehistoric humans in South America. Nature 532, 232–235. doi:10.1038/nature17176
Goldhammer, J., Hartz, S., 2017. Fished up from the Baltic Sea: A New Ertebølle Site near Stohl Cliff, Kiel Bay, Germany, in: Bailey, G.N., Hard, J., Sakellariou, D. (Eds.), Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf. Springer, Cham, pp. 145–154. doi:10.1007/978-3-319-53160-1_9
Goldhammer, J., Karle, M., 2015. Geoarchäologie im Schlick: Das Projekt "Besiedlungs- und Kulturgeschichte des niedersächsischen Wattenmeerraumes. Coastline Reports 25, 1–9.
Goodwyn, N., Brooks, A.J., Tillin, H., 2010. Waterlands : Developing Management Indicators for Submerged Palaeoenvironmental Landscapes. Marine Aggregate Levy Sustainability Fund, London.
Grant, K.M., Rohling, E.J., Ramsey, C.B., Cheng, H., Edwards, R.L., Florindo, F., Heslop, D., Marra, F., Roberts, A.P., Tamisiea, M.E., Williams, F., 2014. Sea-level variability over five glacial cycles. Nat. Commun. 5, 1–9. doi:10.1038/ncomms6076
Grøn, O., Skaarup, J., 2004. Submerged Stone Age Coastal Zones in Denmark: investigation strategies and results., in: Flemming, N.C. (Ed.), Man and Sea in the Mesolithic. English Heritage, pp. 53–56.
Groucutt, H.S., Petraglia, M.D., Bailey, G., Scerri, E.M.L., Parton, A., Clark-Balzan, L., Jennings, R.P., Lewis, L., Blinkhorn, J., Drake, N.A., Breeze, P.S., Inglis, R.H., Devès, M.H., Meredith-Williams, M., Boivin, N., Thomas, M.G., Scally, A., 2015. Rethinking the dispersal of Homo sapiens out of Africa. Evol. Anthropol. 24, 149–164. doi:10.1002/evan.21455
Gupta, S., Collier, J.S., Palmer-Felgate, A., Potter, G., 2007. Catastrophic flooding origin of shelf valley systems in the English Channel. Nature 448, 342–345. doi:10.1038/nature06018
Habicht, H.L., Rosentau, A., Jõeleht, A., Heinsalu, A., Kriiska, A., Kohv, M., Hang, T., Aunap, R., 2016. GIS-based multiproxy coastline reconstruction of the eastern Gulf of Riga, Baltic Sea, during the Stone Age. Boreas. doi:10.1111/bor.12157
Hansson, A., Björck, S., Linderson, H., Rundgren, M., Nilsson, B., Sjöström, A., Hammarlund, D., 2017. Early Holocene Landscape Development and Baltic Sea History Based on High-Resolution Bathymetry and Lagoonal Sediments in the Hanö Bay, Southern Sweden. Springer, Cham, pp. 197–209. doi:10.1007/978-3-319-53160-1_13
Hansson, A., Nilsson, B., Sjöström, A., Björck, S., Holmgren, S., Linderson, H., Magnell, O., Rundgren, M., Hammarlund, D., 2016. A submerged Mesolithic lagoonal landscape in the Baltic Sea, south-eastern Sweden – Early Holocene environmental reconstruction and shore-level displacement based on a multiproxy approach. Quat. Int. 1–14. doi:10.1016/j.quaint.2016.07.059
Harding, A.F., Cadogan, G., Howell, R., 1969. Pavlopetri, an underwater Bronze Age town in Laconia. Annu. Br. Sch. Athens 64, 112–142.
Harff, J.A.N., Bailey, G.N., Lu, F., 2016. Geology and archaeology : submerged landscapes of the continental shelf : an introduction, in: Harf, J., Bailey, G., Luth, F. (Eds.), Geology and Archaeology: Submerged Landscapes of the Continental Shelf. Geological Society, Special Publications 411, London, pp. 1–8. doi:10.1144/SP411.13
Harff, J., Björck, S., Hoth, P., 2011. The Baltic Sea Basin, Vasa. Springer, New York. doi:10.1007/978-3-642-17220-5
Harff, J., Luth, F., 2007. SINCOS - Sinking Coasts: Geosphere, Ecosphere and Anthroposphere of the Holocene Southern Baltic Sea. Bericht der Romish-Germanische

Kommission: Special Issue 88.
Harff, J., Lüth, F., 2014. SINCOS II – Sinking Coasts: Geosphere, Ecosphere and Anthroposphere of the Holocene Southern Baltic Sea. Cerlag Philipp von Zabern, Darmstadt.
Harff, J., Meyer, M., 2011. Coastlines of the Baltic Sea – Zones of competition between geological processes and a changing climate: Examples from the southern Baltic, in: Harff, J., Björck, S., Hoth, P. (Eds.), The Baltic Sea Basin. Springer, New York, pp. 149–164.
Hartz, S., Lübke, H., 1995. Erste Ansätze zur Prospektion submariner steinzeitlicher Küstenwohnplätze an der schleswig-holsteinischen Ostseeküste. Archäologische Nachrichten aus Schleswig-Holstein 7–32.
Henderson, J.C., Gallou, C., Flemming, N.C., Spondylis, E., 2011. Th e Pavlopetri Underwater Archaeology Project : investigating an ancient submerged town, in: Benjamin, J., Bonsall, C., Pickard, C., Fisher, A. (Eds.), Submerged Prehistory. Oxbow, Oxford, p. 17.
Heusser, C.J., 1960. Late-Pleistocene Environments of North Pacific North America: An elaboration of late-glacial and postglacial climatic, physiographic, and biotic changes, special publication 35. American Geographic Society, New York.
Hijma, M.P., Cohen, K.M., Roebroeks, W., Westerhoff, W.E., Busschers, F.S., 2012. Pleistocene Rhine-Thames landscapes: geological background for hominin occupation of the southern North Sea region. J. Quat. Sci. 27, 17–39. doi:10.1002/jqs.1549
Hiscock, P., Connor, S.O., Balme, J., Maloney, T., 2016. World ' s earliest ground-edge axe production coincides with human colonisation of Australia. Aust. Archaeol. 82, 2–11. doi:10.1080/03122417.2016.1164379
Hiscott, R.N., Aksu, A.E., Mudie, P.J., Kaminski, M.A., Abrajano, T., Yaşar, D., Rochon, A., 2007. The Marmara Sea Gateway since ~16 ky BP: non-catastrophic causes of paleoceanographic events in the Black Sea at 8.4 and 7.15 ky BP, in: The Black Sea Flood Question: Changes in Coastline, Climate, and Human Settlement. Springer Netherlands, pp. 89–117. doi:10.1007/978-1-4020-5302-3_5
Holmlund, J., Nilsson, B., Rönnby, J., 2017. Joint Explorations of the Sunken Past: Examples of Maritime Archaeological Collaboration Between Industry and Academia in the Baltic. Springer, Cham, pp. 53–63. doi:10.1007/978-3-319-53160-1_4
Hopkins, D.M., 1967. The Bering land bridge. Stanford University Press, Stanford.
Hosfield, R., 2007. Terrestrial implications for the maritime geoarchaeological resource: A view from the Lower Palaeolithic. J. Marit. Archaeol. 2, 4–23. doi:10.1007/s11457-007-9013-7
Jacobi, R., 1976. Britain inside and outside Mesolithic Europe. Proc. Prehist. Soc. 42, 67–84.
Johnson, L.L., Stright, M., 1992. Paleoshorelines and prehistory: an investigation of method. CRC Press.
Johnson, M., 2008. Ideas of Landscape, Ideas of Landscape. doi:10.1002/9780470773680
Johnston, W.A., 1933. Quaternary geology of North America in relation to the migration of man, in: Jenness, D. (Ed.), The American Aborigines, Their Origins and Antiquity. University of Toronto Press, Toronto, pp. 9–46.
Jöns, H., 2011. Settlement Development in the Shadow of Coastal Changes – Case Studies from the Baltic Rim, in: Harff, J., Björck, S., Hoth, P. (Eds.), The Baltic Sea Basin. Springer, New York, pp. 301–336.
Jöns, H., Harff, J., 2014. Geoarchaeological Research Strategies in the Baltic Sea Area: Environmental Changes, Shoreline-Displacement and Settlement Strategies, in: Evans, A., Flatman, J.C., Flemming, N.C. (Eds.), Prehistoric Archaeology on the Continental Shelf: A Global Review. Springer, New York, pp. 173–192.

Jöns, H., Karle, M., Kleingärtner, S., 2013. Das Nordseebecken und der Wattenmeerraum als Forschungsgebiet. Methodische Überlegungen, Strateg. und aktuelle Forschungsprojekte. Offa 69, 71–80.
Klein, R.G., 1999. The Human Career. The University of Chicago Press, London.
Kostecki, R., Janczak-Kostecka, B., Endler, M., Moros, M., 2015. The evolution of the Mecklenburg Bay environment in the Holocene in the light of multidisciplinary investigations of the sediment cores. Quat. Int. 386, 226–238. doi:10.1016/j.quaint.2015.07.007
Kraft, J.C., Bellknap, D.F., Kavan, I., 1983. Potentials of discovery of human occupation sites on the continental shelves and nearshore coastal zones, in: Masters, P.M., Flemming, N.C. (Eds.), Quaternary Coastlines and Marine Archaeology: Towards the Prehistory of Land Bridges and Continental Shelves. Academic Press, London, pp. 87–120.
Lagarde, J.L., Amorese, D., Font, M., Laville, E., Dugué, O., Dugu�, O., 2003. The structural evolution of the English Channel area. J. Quat. Sci. 18, 201–213. doi:10.1002/jqs.744
Lambeck, K., Woodroffe, C.D., Antonioli, F., Anzidei, M., Gehrels, W.R., Laborel, J., Wright, A.J., 2010. Paleoenvironmental records, geophysical modelling, and reconstruction of sea level trends and variability on centennial and Longer Timescales. Underst. sea Lev. rise Var.
Lampe, R., Meyer, H., Ziekur, R., Janke, W., Endtmann, E., 2007. Holocene evolution of the irregularly sinking southern Baltic Sea coast and the interactions of sea-level rise, accumulation space and sediment supply. Bericht der Romisch-Germanischen Kommission.
Larsson, L., 1983. Mesolithic Settlement on the Sea Floor in the Strait of Oresund. Quat. Coastlines Mar. Archaeol.
Leach, P.A., Belknap, D.F., Wilson, L., 2007. Marine geophysics and vibracoring applied to the search for submerged prehistory in Damariscotta River, Maine, USA. Reconstr. human-landscape Interact. Newcastle, UK, Cambridge Sch. Publ. 141–158.
Lericolais, G., 2017. Late Pleistocene Environmental Factors defining the Black Sea, and Submerged Landscapes on the Western Continental Shelf, in: Submerged Landscapes of the European Continental Shelf : Quaternary Paleoenvironments. Wiley Blackwell, Oxford, pp. 479–495.
Lericolais, G., 2004. Cruise Report MD139-ASSEMBLAGE-1, Research, European Commission, Thematic ….
Lericolais, G., Bourget, J., Popescu, I., Jermannaud, P., Mulder, T., Jorry, S., Panin, N., 2013. Late Quaternary deep-sea sedimentation in the western Black Sea: New insights from recent coring and seismic data in the deep basin. Glob. Planet. Change 103, 232–247. doi:10.1016/j.gloplacha.2012.05.002
Lericolais, G., Bulois, C., Gillet, H., Guichard, F., 2009. High frequency sea level fluctuations recorded in the Black Sea since the LGM. Glob. Planet. Change 66, 65–75. doi:10.1016/j.gloplacha.2008.03.010
Lericolais, G., Popescu, I., Guichard, F., Maria Popescu, S., 2007. A Black Sea lowstand at 8500 yr B.P. indicated by a relict coastal dune system at a depth of 90 m below sea level. Geol. Soc. Am. Spec. Pap. 426, 171–188. doi:10.1130/2007.2426(12)
Lindén, M., Möller, P., Björck, S., Sandgren, P., 2006. Holocene shore displacement and deglaciation chronology in Norrbotten, Sweden. Boreas 35, 1–22. doi:10.1111/j.1502-3885.2006.tb01109.x
Lopes, R.P., Buchmann, F.S., 2011. Pleistocene mammals from the southern Brazilian continental shelf. J. South Am. Earth Sci. 31, 17–27. doi:10.1016/j.jsames.2010.11.003

López, P., Cartajena, I., Carabias, D., Morales, C., Letelier, D., Flores, V., 2016. Terrestrial and maritime taphonomy: differential effects on spatial distribution of a Late Pleistocene continental drowned faunal bone assemblage from the Pacific coast of Chile. Archaeol. Anthropol. Sci. 8, 277–290. doi:10.1007/s12520-015-0275-y
López, P., Cartajena, I., Olivares, G., López, O., Carabias, D., Morales, C., 2012. Aplicación de Microscopio Electrónico de Barrido (MEB) y Espectroscopía de Energía Dispersiva (EDS) para distinguir alteraciones térmicas en restos osteofaunísticos de un sitio sumergido del Pleistoceno, in: Acosta, A., Loponte, D., Mucciolo, L. (Eds.), Temas de Arqueología: Estudios Tafonómicos Y Zooarqueológicos (II). Instituto Nacional de Antropología y Pensamiento Latinoamericano, pp. 25–44.
López Mazz, J., Gascue, A., 2007. El Valle del Arroyo Balizas: estructuras monticulares y sitios del litoral atlántico uruguayo. Cazadores-Recoloctores del Cono Sur Rev. Arqueol.
López Mazz, J.M., Gascue Amaral, A., Moreno Rudolph, F., 2003. La prehistoria del este de Uruguay: cambio cultural y aspectos ambientales. An. Prehist. y Arqueol. 19–20, 9–24.
López Mendoza, P., Cartajena, I., Carabias, D., Prevosti, F.J., Maldonado, A., Flores-Aqueveque, V., 2016. Reconstructing drowned terrestrial landscapes. Isotopic paleoecology of a late Pleistocene extinct faunal assemblage: Site GNL Quintero 1 (GNLQ1) (32 S, Central Chile). Quat. Int. doi:10.1016/j.quaint.2016.08.017
Louwe Kooijmans, L.P., 1971. Mesolithic Bone and Antler Implements from the North Sea and from the Netherlands. Ber. van Rijksd. voor het Oudheidkd. Bodemonderz. 20–21, 27–73.
Lucas, G., 2012. Understanding the Archaeological Record. Cambridge University Press, Cambridge.
Mandryk, C.A.., Josenhans, H., Fedje, D.W., Mathewes, R.W., 2001. Late Quaternary paleoenvironments of Northwestern North America: implications for inland versus coastal migration routes. Quat. Sci. Rev. 20, 301–314. doi:10.1016/S0277-3791(00)00115-3
Martin, L., Suguio, K., Flexor, J.M., Dominguez, J.M.L., Bittencourt, A.C.S.P., 1996. Quaternary Sea-level History and Variation in Dynamics along the Central Brazilian Coast: Consequences on Coastal Plain Construction. An. Acad. Bras. Cienc. 68.
Masters, P.M., Flemming, N.C.C., 1983. Quaternary Coastlines and Marine Archaeology. Academic Press, London.
Mellars, P., Gori, K.C., Carr, M., Soares, P.A., Richards, M.B., 2013. Genetic and archaeological perspectives on the initial modern human colonization of southern Asia. Proc. Natl. Acad. Sci. U. S. A. 110, 10699–704. doi:10.1073/pnas.1306043110
Mgeladze, A., Lordkipanidze, D., Moncel, M.H., Despriee, J., Chagelishvili, R., Nioradze, M., Nioradze, G., 2011. Hominin occupations at the Dmanisi site, Georgia, Southern Caucasus: Raw materials and technical behaviours of Europe’s first hominins. J. Hum. Evol. 60, 571–596. doi:10.1016/j.jhevol.2010.10.008
Mithen, S., 2003. After the Ice. Weidenfeld and Nicolson, London.
Momber, G., Tomalin, D.J., Scaife, R.J., Satchell, J., 2011. Mesolithic Occupation at Bouldnor Cliff and the Submerged Prehistoric Landscapes of the Solent. Council for British Archaeology, York.
Moree, J.M., Sier, M.M., 2015. Interdisciplinary Archaeological Research Programme Maasvlakte 2 , Rotterdam Harbour site – Rotterdam Maasvlakte , the Netherlands Early Holocene landscape development. Bureau Oudheidkundig Onderzoek Rotterdam, Rotterdam.
Muckelroy, K., 1978. Maritime Archaeology. Cambridge University Press, Cambridge.
Mudie, P.J., Kadurin, S., Larchenkov, E., 2014. Holocene marine transgression in the Black Sea: New evidence from the northwestern Black Sea shelf. Quat. Int. 345, 100–118.

doi:10.1016/j.quaint.2013.07.027
Negris, 1904. Vestiges antiques submergés. Mitteilungen des Dtsch. Archäologischen Instituts, Athenische Abteilung 29, 340–363.
Nutley, D., 2014. Inundated site studies in Australia, in: Flemming, N.C., Evans, A., Flatman, J.C. (Eds.), Prehistoric Archaeology on the Continental Shelf. Springer, New York, pp. 255–273.
Nutley, D.M., Coroneos, C., Wheeler, J., 2016. Potential submerged Aboriginal archaeological sites in South West Arm , Port Hacking , New South Wales , Australia 265–285.
O'Connell, J.F., Allen, J., 2015. The process, biotic impact, and global implications of the human colonization of Sahul about 47,000 years ago. J. Archaeol. Sci. 56, 73–84.
O'Connell, J.F., Allen, J., 2007. Pre-LGM Sahul (Pleistocene Australia-New Guinea) and the archaeology of early modern humans. Rethink. Hum. Revolut. 395–410.
O'Shea, J., Lemke, A.K., Reynolds, R.G., 2013. " Nobody Knows the way of the Caribou": Rangifer hunting at 45° North Latitude. Quat. Int. 297, 36–44. doi:10.1016/j.quaint.2013.01.010
O'Shea, J.M., Lemke, A.K., Sonnenburg, E.P., Reynolds, R.G., Abbott, B.D., 2014. A 9,000-year-old caribou hunting structure beneath Lake Huron. Proc. Natl. Acad. Sci. 111, 6911–6915. doi:10.1073/pnas.1404404111
O'Shea, J.M., Meadows, G.A., 2009. Evidence for early hunters beneath the Great Lakes. Proc. Natl. Acad. Sci. U. S. A. 106, 10120–3. doi:10.1073/pnas.0902785106
Oppenheimer, S., 2012. Out-of-Africa, the Peopling of Continents and Islands: Tracing Uniparental Gene Trees Across the Map. Philos. Trans. R. Soc. B Biol. Sci. 367, 770–784. doi:10.1098/rstb.2011.0306
Oppenheimer, S., 2003. Out of Africa's Eden: The peopling of the world. Robinson, London.
Parfitt, S. a, Ashton, N.M., Lewis, S.G., Abel, R.L., Coope, G.R., Field, M.H., Gale, R., Hoare, P.G., Larkin, N.R., Lewis, M.D., Karloukovski, V., Maher, B. a, Peglar, S.M., Preece, R.C., Whittaker, J.E., Stringer, C.B., 2010. Early Pleistocene human occupation at the edge of the boreal zone in northwest Europe. Nature 466, 229–33. doi:10.1038/nature09117
Pedersen, M., Ruter, A., Schweger, C., Friebe, H., Staff, R., 2016. Postglacial viability and colonization in North America's ice-free corridor. Nature.
Peeters, H., 2011. How Wet Can It Get ? – approaches to submerged prehistoric sites and landscapes on the Dutch continental shelf, in: Benjamin, J., Bonsall, C., Pickard, C., Fisher, A. (Eds.), Submerged Prehistory. Oxbow, Oxford, pp. 55–64.
Peev, P., Hristova, R., n.d. BLACK SEA CONTINENTAL SHELF IN THE CONTEXT OF OFFSHORE EUROPEAN PREHISTORY.
Peltier, W.R., Argus, D.F., Drummond, R., 2015. Space geodesy constrains ice age terminal deglaciation: The global ICE-6G-C (VM5a) model. J. Geophys. Res. B Solid Earth 120, 450–487. doi:10.1002/2014JB011176
Pirazzoli, P.A., 1996. Sea-Level changes: the last 20,000 years. Wiley, Chichester.
Plets, R.M.K., Dix, J.K., Adams, J.R., Bull, J.M., Henstock, T.J., Gutowski, M., Best, A.I., 2009. The use of a high-resolution 3D Chirp sub-bottom profiler for the reconstruction of the shallow water archaeological site of the Grace Dieu (1439), River Hamble, UK. J. Archaeol. Sci. 36, 408–418. doi:10.1016/J.JAS.2008.09.026
Prahov, N., Angelova, H., Kotsev, A., 2011. Predictive modeling in archaeology: world practice and Bulgarian perspectives. Bulg. e-Journal Archaeol. 1, 71–121.
Raban, A., 1983. Submerged Prehistoric Sites off the Mediterranean coast of Israel. Quat. Coastlines Mar. Archaeol.
Ransley, J., Sturt, F., Dix, J., Adams, J., Blue, L., 2013. People and the Sea: A Maritime

Archaeological Research Agenda for England. Council for British Archaeology, York.
Reid, C., 1913. Submerged Forests. Cambridge University Press, Cambridge.
Richardson III, J.B., 1998. Looking in the right places: pré-5,000 BP maritime adaptations in Peru and the changing environment. Rev. Arqueol. Am. 33–56.
Richardson III, J.B., 1981. Modelling the development of sedentary maritime economies on the coast of Peru: A preliminary statement. Ann. Carnegie Museum 139–150.
Roberts, R.G., Jones, R., Spooner, N.A., Head, M.J., Murray, A.S., Smith, M.A., 1994. The human colonisation of Australia: optical dates of 53,000 and 60,000 years bracket human arrival at Deaf Adder Gorge, Northern Territory. Quat. Sci. Rev. 13, 575–583.
Rockman, M., Steele, J., 2003. The colonization of unfamiliar landscapes: The archaeology of adaptation, The Colonization of Unfamiliar Landscapes: The Archaeology of Adaptation. doi:10.4324/9780203422908
Roebroeks, W., Antoine, P., Limondin-Lozouet, N., Auguste, P., Lamotte, A., Bahain, J.-J., Falguères, C., Laurent, M., Coudret, P., Locht, J.-L., Depaepe, P., Fagnart, J.-P., Fontugne, M., Hatté, C., Mercier, N., Frechen, M., Moigne, A.-M., Munaut, A.-V., Ponel, P., Rousseau, D.-D., Antoine, P., Catt, J., Lautridou, J.-P., Sommé, J., Antoine, P., Limondin Lozouet, N., Chaussé, C., Lautridou, J.-P., Pastre, J.-F., Auguste, P., Bahain, J.-J., Falguères, C., Galehb, B., Ashton, N., Lewis, S.G., Ashton, N., Lewis, S.G., Parfitt, S.A., Penkman, K.E.H., Russell Coope, G., Benazzi, S., Douka, K., Fornai, C., Bauer, C.C., Kullmer, O., Svoboda, J., Pap, I., Mallegni, F., Bayle, P., Coquerelle, M., Condemi, S., Ronchitelli, A., Harvati, K., Weber, G.W., Bischoff, J.L., Williams, R.W., Rosenbauer, R.J., Aramburu, A., Arsuaga, J.L., García, N., Cuenca-Bescós, G., Carbonell, E., Garcı´a-Anto´n, M., Mallol, C., Mosquera, M., Olle´, A., Rodrı´guez, X.P., Sahnouni, M., Sala, R., Verg`s, J.M., Carbonell, E., Bermúdez de Castro, J.M., Parés, J.M., Pérez-González, A., Cuenca-Bescós, G., Ollé, A., Mosquera, M., Huguet, R., van der Made, J., Rosas, A., Sala, R., Vallverdú, J., García, N., Granger, D.E., Martinón-Torres, M., Rodríguez, X.P., Stock, G.M., Vergès, J.M., Allué, E., Burjachs, F., Cáceres, I., Canals, A., Benito, A., Díez, C., Lozano, M., Mateos, A., Navazo, M., Rodríguez, J., Rosell, J., Arsuaga, J.L., Cohen, K.M., MacDonald, K., Joordens, J.C.A., Roebroeks, W., Gibbard, P.L., Crevecoeur, I., Bayle, P., Rougier, H., Maureille, B., Higham, T., van der Plicht, J., De Clerck, N., Semal, P., Fagnart, J.-P., Ferring, R., Oms, O., Agusti, J., Berna, F., Nioradze, M., Shelia, T., Tappen, M., Vekua, A., Zhvania, D., Lordkipanidze, D., Gibbard, P.L., Rose, J., Bridgland, D.R., Gibbard, P., Guipert, G., de Lumley, M.-A., Tuffreau, A., Mafart, B., Gupta, S., Collier, J.S., Palmer-Felgate, A., Potter, G., Hosfield, R., Hublin, J.J., Hublin, J.-J., Roebroeks, W., Hublin, J.-J., Weston, D., Gunz, P., Richards, M., Roebroeks, W., Glimmerveen, J., Anthonis, L., Jacobi, R.M., Higham, T.F.G., Jöris, O., Street, M., Meijer, T., Cleveringa, P., Parfitt, S.A., Barendregt, R.W., Breda, M., Candy, I., Collins, M.J., Coope, G.R., Durbidge, P., Field, M.H., Lee, J.R., Lister, A.M., Mutch, R., Penkman, K.E.H., Preece, R.C., Rose, J., Stringer, C.B., Symmons, R., Whittaker, J.E., Wymer, J.J., Stuart, A.J., Parfitt, S.A., Ashton, N.M., Lewis, S.G., Abel, R.L., Coope, G.R., Field, M.H., Gale, R., Hoare, P.G., Larkin, N.R., Lewis, M.D., Karloukovski, V., Maher, B.A., Peglar, S.M., Preece, R.C., Whittaker, J.E., Stringer, C.B., Preece, R.C., Parfitt, S.A., Bridgland, D.R., Lewis, S.G., Rowe, P.J., Atkinson, T.C., Candy, I., Debenham, N.C., Penkman, K.E.H., Rhodes, E.J., Schwenninger, J.-L., Griffiths, H.I., Whittaker, J.E., Gleed-Owen, C., Roebroeks, W., Roebroeks, W., Villa, P., Roebroeks, W., Conard, N.J., van Kolfschoten, T., Dennell, R.W., Dunnell, R.C., Gamble, C., Graves, P., Jacobs, K., Otte, M., Roe, D., Svoboda, J., Tuffreau, A., Voytek, B.A., Wenban-Smith, F., Wymer, J.J., Roebroeks, W., Hublin, J.-J., MacDonald, K., Semal, P., Rougier, H., Crevecoeur, I., Jungels, C., Flas, D., Hauzeur, A., Maureille, B., Germonpré, M., Bocherens, H., Pirson, S., Cammaert, L.,

De Clerck, N., Hambucken, A., Higham, T., Toussaint, M., van der Plicht, J., Stringer, C., Toro-Moyano, I., de Lumley, H., Fajardo, B., Barsky, D., Cauche, D., Celiberti, V., Grégoire, S., Martinez-Navarro, B., Espigares, M.P., Ros-Montoya, S., Toucanne, S., Zaragosi, S., Bourillet, J.F., Cremer, M., Eynaud, F., Van Vliet-Lanoë, B., Penaud, A., Fontanier, C., Turon, J.L., Cortijo, E., Trinkaus, E., Moldovan, O., Milota, s., Bilgar, A., Sarcina, L., Athreya, S., Bailey, S.E., Rodrigo, R., Mircea, G., Higham, T., Ramsey, C.B., van der Plicht, J., Tuffreau, A., Révillion, S., Sommé, J., Van Vliet-Lanoë, B., Verpoorte, A., Wenban-Smith, F.F., Bates, M.R., Schwenninger, J.-L., White, M.J., Jacobi, R.M., White, M., Pettitt, P., White, M., Ashton, N., Scott, B., 2014. Terra incognita: The Palaeolithic record of northwest Europe and the information potential of the southern North Sea. Netherlands J. Geosci. - Geol. en Mijnb. 93, 43–53. doi:10.1017/njg.2014.1

Romanowska, I., Gamble, C., Bullock, S., Sturt, F., 2017. Dispersal and the Movius Line: Testing the effect of dispersal on population density through simulation. Quat. Int. 431. doi:10.1016/j.quaint.2016.01.016

Rosentau, A., Bennike, O., Uscinowicz, S., Miotk-Szpiganowicz, 2017. The Baltic Sea Basin, in: Flemming, N.C., Hard, J., Moura, D., Burgess, A., Bailey, G.N. (Eds.), Submerged Landscapes of the European Continental Shelf : Quaternary Paleoenvironments. Wiley Blackwell, Oxford.

Runnels, C., Özdoğan, M., 2001. The Palaeolithic of the Bosphorus Region NW Turkey. J. F. Archaeol. 28, 69–92. doi:10.1179/jfa.2001.28.1-2.69

Ryan, W.B.F., 2007. Status of the Black Sea flood hypothesis, in: The Black Sea Flood Question: Changes in Coastline, Climate, and Human Settlement. Springer, New York, pp. 63–88. doi:10.1007/978-1-4020-5302-3_4

Ryan, W.B.F., Major, C.O., Lericolais, G., Goldstein, S.L., 2003. C ATASTROPHIC F LOODING OF THE B LACK S EA. Annu. Rev. Earth Planet. Sci. 31, 525–554. doi:10.1146/annurev.earth.31.100901.141249

Ryan, W.B.F., Pitman, W.C., Major, C.O., Shimkus, K., Moskalenko, V., Jones, G.A., Dimitrov, P., Gorür, N., Sakinç, M., Yüce, H., 1997. An abrupt drowning of the Black Sea shelf. Mar. Geol. 138, 119–126. doi:10.1016/S0025-3227(97)00007-8

Sakellariou, D., Galanidou, N., 2015. Pleistocene submerged landscapes and Palaeolithic archaeology in the tectonically active Aegean region. Geol. Soc. London, Spec. Publ. 411, 145–178. doi:10.1144/SP411.9

Samper Carro, S.C., O'Connor, S., Louys, J., Hawkins, S., Mahirta, M., 2016. Human maritime subsistence strategies in the Lesser Sunda Islands during the terminal Pleistocene–early Holocene: New evidence from Alor, Indonesia. Quat. Int. 416, 64–79. doi:10.1016/j.quaint.2015.07.068

Sander, L., Hede, M.U., Fruergaard, M., Nielsen, L., Clemmensen, L.B., Kroon, A., Johannessen, P.N., Nielsen, L.H., Pejrup, M., 2016. Coastal lagoons and beach ridges as complementary sedimentary archives for the reconstruction of Holocene relative sea-level changes. Terra Nov. 28, 43–49. doi:10.1111/ter.12187

Sandweiss, D.H., McInnis, H., Burger, R.L., Cano, A., Ojeda, B., Paredes, R., del Carmen Sandweiss, M., Glascock, M.D., 1998. Quebrada jaguay: early South American maritime adaptations. Science (80-.). 281, 1830–1832.

Schlichtherle, H., 1997. Pfahlbauten rund um die Alpen. Stuttgart.

Scuvée, F., Verague, J., 1978. Le gisement sous-marine du Paléolithique Moyen de l'anse de la Mondrée à Fermanville (Manche). Cherbourg.

Shepard, F.P., 1964. Sea level changes in the past 6000 years: possible archeological significance. Science (80-.). 143, 574–576.

Skaarup, J., 1995. Hunting the hunters and fishers of the Mesolithic - twenty years of

research on the sea floor south of Funen, Denmark. Man sea Mesolith.
Smith, O., Momber, G., Bates, R., Garwood, P., Fitch, S., Pallen, M., Gaffney, V., Allaby, R.G., 2015. Sedimentary DNA from a submerged site reveals wheat in the British Isles 8000 years ago. Science (80-.). 347, 998–1001.
Sorokin, V.M., Kuprin, P.N., 2007. On the character of Black Sea level rise during the Holocene. Moscow Univ. Geol. Bull. 62, 334–341. doi:10.3103/S0145875207050055
Stanford, D., Lowery, D., Jodry, M., Bradley, B.A., Kay, M., Stafford, T.W., Speakman, R.J., 2014. New evidence for a possible paleolithic occupation of the eastern North American continental shelf at the last glacial maximum, in: Prehistoric Archaeology on the Continental Shelf: A Global Review. pp. 73–93. doi:10.1007/978-1-4614-9635-9
Stright, M.J., 1990. Archaeological sites on the North American continental shelf, in: Lasca, N.P., Donahue, J. (Eds.), Archaeological Geology of North America, Centennial Special. Geological Society of America, pp. 439–465.
Stringer, C., 2000. Coasting out of Africa. Nature 405, 24–25. doi:10.1038/35011166
Sturt, F., 2015. From sea to land and back again: understanding the shifting character of Europe's landscapes and seascapes over the last million years, in: Anderson-Whymark, H., Garrow, D., Sturt, F.C. (Eds.), Continental Connections: Exploring Cross-Channel Relationships from the Lower Palaeolithic to the Iron Age. Oxbow, Oxford, pp. 7–27.
Sturt, F., Dix, J.K., 2009. The Outer Thames Estuary Regional Environmental Characterisation. ALSF/MEPF (DEFRA).
Sturt, F., Garrow, D., Bradley, S., 2013. New models of North West European Holocene palaeogeography and inundation. J. Archaeol. Sci. 40. doi:10.1016/j.jas.2013.05.023
Sturt, F., Standen, T., 2013. The social context of submerged prehistoric landscapes. Meeting Report July 2013. 1–19.
Sturt, F., Standen, T., Grant, M., Dix, J., 2016. Determining potential: onshore/offshore prehistory. Historic England, Southampton.
Thorne, A., Grün, R., Mortimer, G., Spooner, N.A., Simpson, J.J., McCulloch, M., Taylor, L., Curnoe, D., 1999. Australia's oldest human remains: age of the Lake Mungo 3 skeleton. J. Hum. Evol. 36, 591–612.
Tizzard, L., Baggaley, P.A., Firth, A.J., 2011. Seabed Prehistory: investigating palaeolandsurfaces with Palaeolithic remains from the southern North Sea, in: Benjamin, J., Bonsall, C., Pickard, C., Fisher, A. (Eds.), Submerged Prehistory. Oxbow, Oxford, pp. 65–74.
Tizzard, L., Bicket, A.R., Benjamin, J., Loecker, D. De, 2014. A Middle Palaeolithic site in the southern North Sea: Investigating the archaeology and palaeogeography of Area 240. J. Quat. Sci. 29, 698–710. doi:10.1002/jqs.2743
Toucanne, S., Zaragosi, S., Bourillet, J.F., Cremer, M., Eynaud, F., Van Vliet-Lano??, B., Penaud, A., Fontanier, C., Turon, J.L., Cortijo, E., Gibbard, P.L., 2009. Timing of massive "Fleuve Manche" discharges over the last 350 kyr: insights into the European ice-sheet oscillations and the European drainage network from MIS 10 to 2. Quat. Sci. Rev. 28, 1238–1256. doi:10.1016/j.quascirev.2009.01.006
Turney, C.S.M., Brown, H., 2007. Catastrophic early Holocene sea level rise, human migration and the Neolithic transition in Europe. Quat. Sci. Rev. 26, 2036–2041. doi:10.1016/j.quascirev.2007.07.003
Uldum, O., Benjamin, J., McCarthy, J., Feulner, F., Lübke, H., 2017. The Late Mesolithic Site of Falden, Denmark: Results from Underwater Archaeological Fieldwork and a Strategy for Capacity-Building Based on the SPLASHCOS Mission, in: Bailey, G.N., Harff, J., Sakellariou, D. (Eds.), Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf. Springer, Cham, pp. 65–84. doi:10.1007/978-3-319-53160-1_5
van Andel, T., 1989. Late Quaternary sea-level change and archaeology. Antiquity 63, 733–

745.
van Andel, T.H., 1989. Late Pleistocene Sea Levels and the Human Exploitation of the Shore and Shelf of Southern South Africa. J. F. Archaeol. 16, 135–155. doi:10.2307/529887
Vardy, M.E., Dix, J.K., Henstock, T.J., Bull, J.M., Gutowski, M., 2008. Decimeter-resolution 3D seismic volume in shallow water : A case study in small-object detection. Geophysics 73, 33–40. doi:10.1190/1.2829389
Veth, P., Ward, I., Manne, T., 2017a. Coastal Feasts: A Pleistocene Antiquity for Resource Abundance in the Maritime Deserts of North West Australia? J. Isl. Coast. Archaeol. 12, 8–23. doi:10.1080/15564894.2015.1132799
Veth, P., Ward, I., Manne, T., 2016. Coastal Feasts: A Pleistocene Antiquity for Resource Abundance in the Maritime Deserts of North West Australia? J. Isl. Coast. Archaeol. 4894, 1–16. doi:10.1080/15564894.2015.1132799
Veth, P., Ward, I., Manne, T., Ulm, S., Ditchfield, K., Dortch, J., Hook, F., Petchey, F., Hogg, A., Questiaux, D., Demuro, M., Arnold, L., Spooner, N., Levchenko, V., Skippington, J., Byrne, C., Basgall, M., Zeanah, D., Belton, D., Helmholz, P., Bajkan, S., Bailey, R., Placzek, C., Kendrick, P., 2017b. Early human occupation of a maritime desert, Barrow Island, North-West Australia. Quat. Sci. Rev. 168, 19–29. doi:10.1016/j.quascirev.2017.05.002
Vos, P.C., Bunnik, F.P.M., Cohen, K.M., Cremer, H., 2015. A staged geogenetic approach to underwater archaeological prospection in the Port of Rotterdam (Yangtzehaven, Maasvlakte, The Netherlands): A geological and palaeoenvironmental case study for local mapping of Mesolithic lowland landscapes. Quat. Int. 367, 4–31. doi:10.1016/j.quaint.2014.11.056
Ward, I., Larcombe, P., Mulvaney, K., Fandry, C., 2013. The potential for discovery of new submerged archaeological sites near the Dampier Archipelago, Western Australia. Quat. Int. 308–309, 216–229. doi:10.1016/j.quaint.2013.03.032
Ward, I., Larcombe, P., Veth, P., 2015. A new model for coastal resource productivity and sea-level change: The role of physical sedimentary processes in assessing the archaeological potential of submerged landscapes from the Northwest Australian continental shelf. Geoarchaeology 30, 19–31. doi:10.1002/gea.21498
Ward, I., Veth, P., Manne, T., 2014. To the islands born : the research potential of submerged landscapes and human habitation sites from the islands of NW Australia. Geol. Archaeol. Submerg. Landscapes Cont. Shelf 251–263. doi:10.1144/SP411.4
Watson, T., 2018. Inner Workings: Fishing for artifacts beneath the waves. Proc. Natl. Acad. Sci. 115, 231–233. doi:10.1073/pnas.1720823115
Weerts, H., Otte, A., Smit, B., Vos, P., 2012. Finding the Needle in the Haystack by Using Knowledge of Mesolithic Human Adaptation in a Drowning Delta. ETOPOS 3, 17–24.
Weiß, C.L., Dannemann, M., Pruefer, K., Burbano, H.A., 2015. Contesting the presence of wheat in the British Isles 8,000 years ago by assessing ancient DNA authenticity from low-coverage data. Elife 4.
Werz, B., Cawthra, H., Compton, J., 2014. Recent developments in african offshore prehistoric archaeological research, with an emphasis on South Africa, in: Evans, A.., Flatman, J.C., Flemming, N.C. (Eds.), Prehistoric Archaeology on the Continental Shelf: A Global Review. Springer, London, pp. 233–253. doi:10.1007/978-1-4614-9635-9
Werz, B.E.J.S., Flemming, N.C., 2001. Discovery in Table Bay of the oldest handaxes yet found underwater demonstrates preservation of hominid artefacts on the continental shelf. S. Afr. J. Sci. 97, 183–185.
Westley, K., 2015. Submerged Mesolithic Landscape Investigation, Eleven Ballyboes, Republic of Ireland. Int. J. Naut. Archaeol. 44, 243–257. doi:10.1111/1095-9270.12114
Westley, K., Dix, J., 2006. Coastal environments and their role in prehistoric migrations. J.

Marit. Archaeol. 1, 9–28.
Whitmore, F.C., Emery, K.O., Cooke, H.B.S., Swift, D.J.P., 1967. Elephant teeth from the atlantic continental shelf. Science (80-.). 156, 1477–1481. doi:10.1126/science.156.3781.1477
Yanchilina, A.G., Ryan, W.B.F., McManus, J.F., Dimitrov, P., Dimitrov, D., Slavova, K., Filipova-Marinova, M., 2017. Compilation of geophysical, geochronological, and geochemical evidence indicates a rapid Mediterranean-derived submergence of the Black Sea's shelf and subsequent substantial salinification in the early Holocene. Mar. Geol. 383, 14–34. doi:10.1016/j.margeo.2016.11.001
Yanko-Hombach, V., Gilbert, A.S., Dolukhanov, P., 2007a. Controversy over the great flood hypotheses in the Black Sea in light of geological, paleontological, and archaeological evidence. Quat. Int. 167, 91–113. doi:10.1016/j.quaint.2006.08.004
Yanko-Hombach, V., Gilbert, A.S., Panin, N., Dolukhanov, P.M. (Eds.), 2007b. The Black Sea Flood Question: Changes in Coastline, Climate, and Human Settlement. Springer Netherlands. doi:10.1007/978-1-4020-5302-3
Yanko-Hombach, V. V., 2007. Controversy over Noah's Flood in the Black Sea: Geological and foraminiferal evidence from the shelf, in: The Black Sea Flood Question: Changes in Coastline, Climate, and Human Settlement. pp. 149–203. doi:10.1007/978-1-4020-5302-3_7
Yanko-Homback, V., Schnyukov, E., Pasynkov, A., Sorokin, V., Kuprin, P., Maslakov, N., Montnenko, I., Smyntyna, O., 2017. Geological and Geomorphological Factors and Marine Conditions of the Azov-Black Sea Basin and Coastal Characteristics as they determine prospecting for seabed prehistoric sites on the continental shelf, in: Submerged Landscapes of the European Continental Shelf : Quaternary Paleoenvironments. Wiley Blackwell, Oxford, pp. 431–478.

Figure 1: map of the world at the last glacial maximum c. 26000 BP and at 12000 BP. Glacio Isostatic Adjustment data from ICE-6G (Argus et al., 2014; Peltier et al., 2015) was used to generate ice extents and region of the continental shelf exposed as land. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net). Eustatic sea-level curve from Grant et al. (2014).

Figure 2: Leman and Ower Harpoon (after Burkitt, 1932, p. 138)

Figure 3. Publications on the theme of submerged prehistory by year and region. The data used to produce this figure is given in the supplementary information.

Figure four: number of submerged prehistoric sites, landscapes and areas of potential noted in the literature and SPLASHCOS database

Figure 5: Bathymetric map of the Baltic Sea with known submerged prehistoric sites illustrated. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net) and Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community Site location data from SPLASHCOS viewer (http://splashcos.maris2.nl)

Figure 6: Submerged Mesolithic archaeology at Haväng. (A) Hazel rods, part of a probable fishing structure, found insitu within organic-rich sediments (B) rooted tree stump within submerged landscape context – photographs courtesy of Arne Sjöström

Figure 7: Bathymetry of North West Europe and known submerged prehistoric sites. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net) and Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community Site location data from SPLASHCOS viewer (http://splashcos.maris2.nl)

Figure 8 3D/4D deposit model: Top level shows current topographic/bathymetric surface, core data is shown on the second level, the isopachyte calculated from cores and sub-bottom data is on the third level, and the reconstructed pre-holocene landsurface on the bottom layer (after Sturt et al. 2016 figure 7.1)

Figure 9: Map of the Mediterranean and Black Seas. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net) and Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community Site location data from SPLASHCOS viewer (http://splashcos.maris2.nl)

Figure 10: Bathymetric map of North America with location of sites mentioned. Figure 9: Map of the Mediterranean and Black Seas. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net) and Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community

Figure 11: Bathymetric map of South America with location of sites mentioned. Figure 9: Map of the Mediterranean and Black Seas. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net) and Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community

Figure 12: Detail of GNLQ1: Detail of GNLQ1. (A) Site excavation and (B) in situ faunal remains of Cervidae.

Figure 13: Bathymetric Map of waters surrounding southern Africa (A) and Arabia (B) showing the location of sites mentioned in the text. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net) and Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community

Figure 14: Bathymetric map showing key sites for Australia and South East Asia showing sites mentioned in the text. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net) and Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community

Figure 15: palaeogeographic reconstructions of Sunda and Sahul at 65kya and 58kya with enlarged area for Cootramunda Shoals regions in both time slices. Underlying topographic and bathymetric data from gebco 2014 (www.gebco.net)

Figure 16: Computer model of sediment thickness of the surveyed portion of the Bulgarian shelf. Image generated from sub-bottom, swath bathymetry and core data, created by Dr Rodrigo Pacheco-Ruiz.

Figure 17: The 'Surveyor Interceptor' a revolutionary SROV conceived by Ola Oskarsson of MMT to travel between 4-6 knots. Chartered to the Black Sea MAP, it carries chirp sub-bottom, multibeam and sidescan sonars as well as HD still cameras synchronised with flash and a laser bathymetry system (Photo: Joakim Holmlund).

figure3.docx
Click here to view linked References

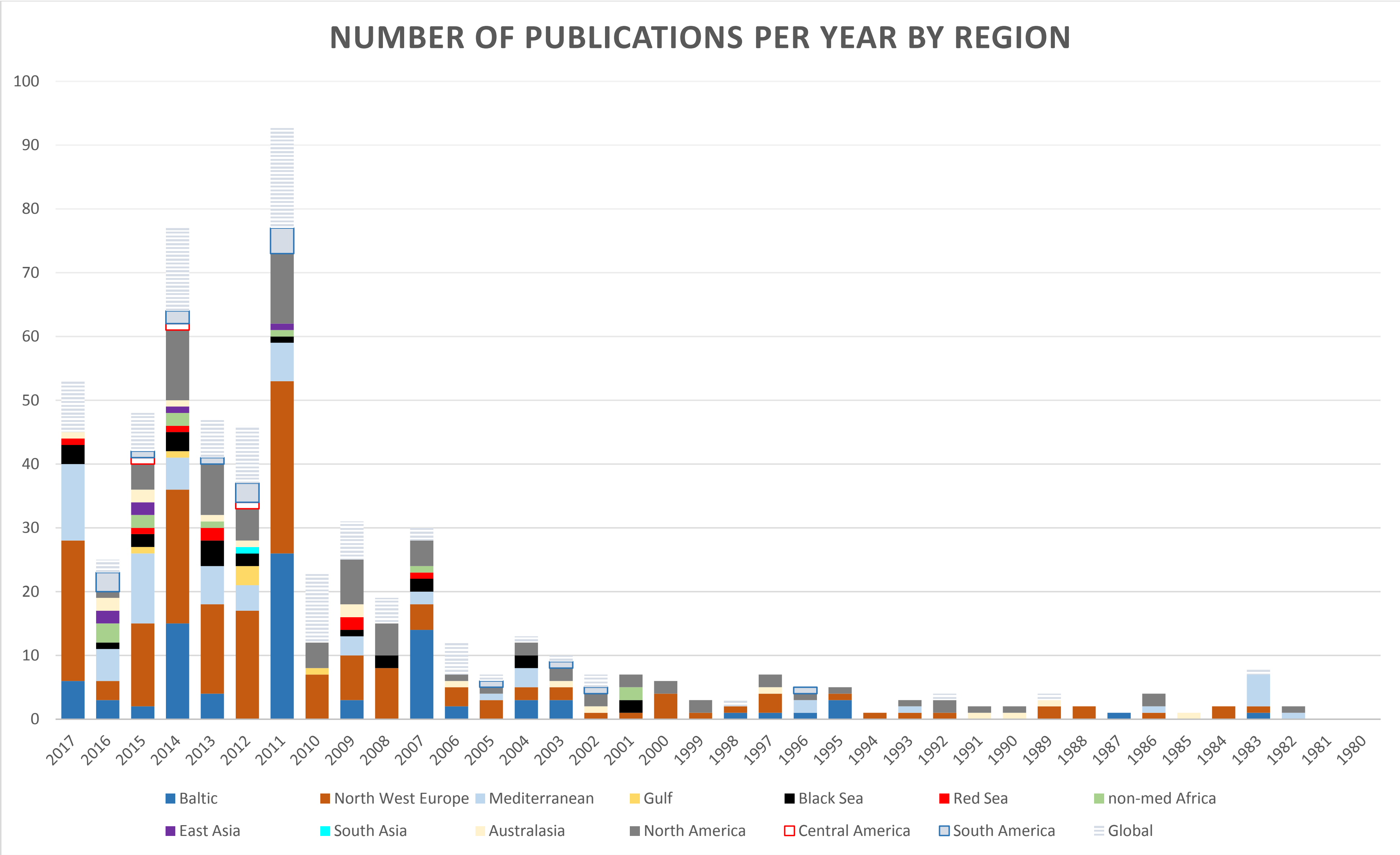

figure_1.tif
Click here to download high resolution image

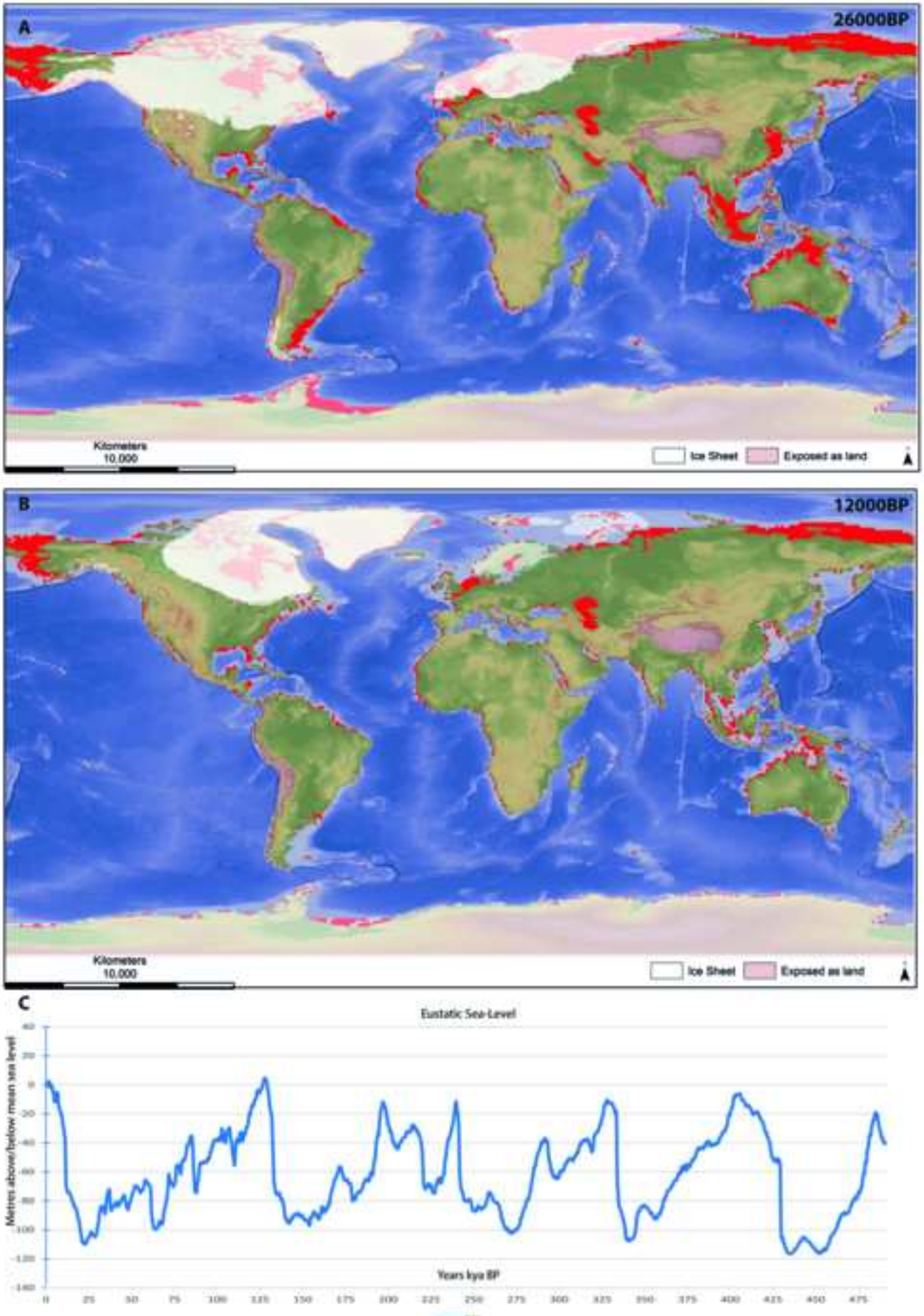

figure_2.tif

Click here to download high resolution image

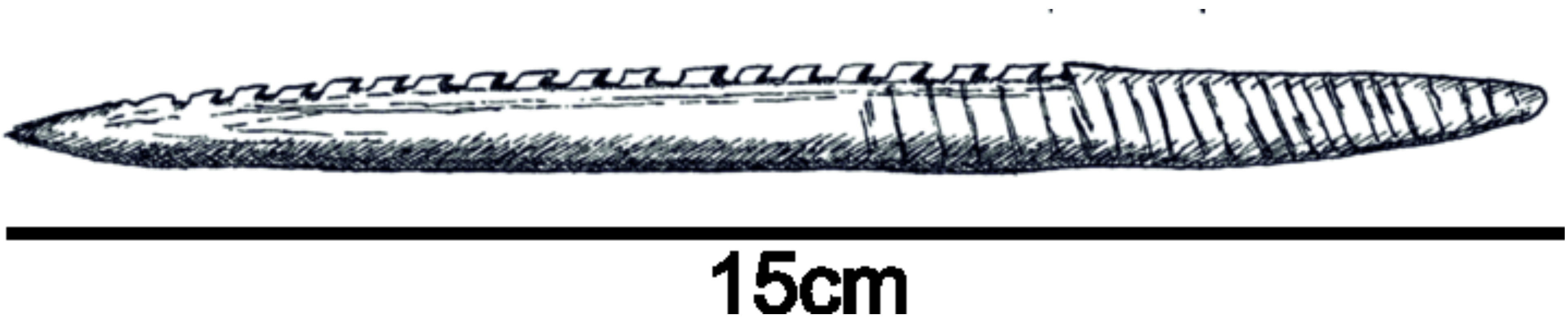

figure4.tif

Click here to download high resolution image

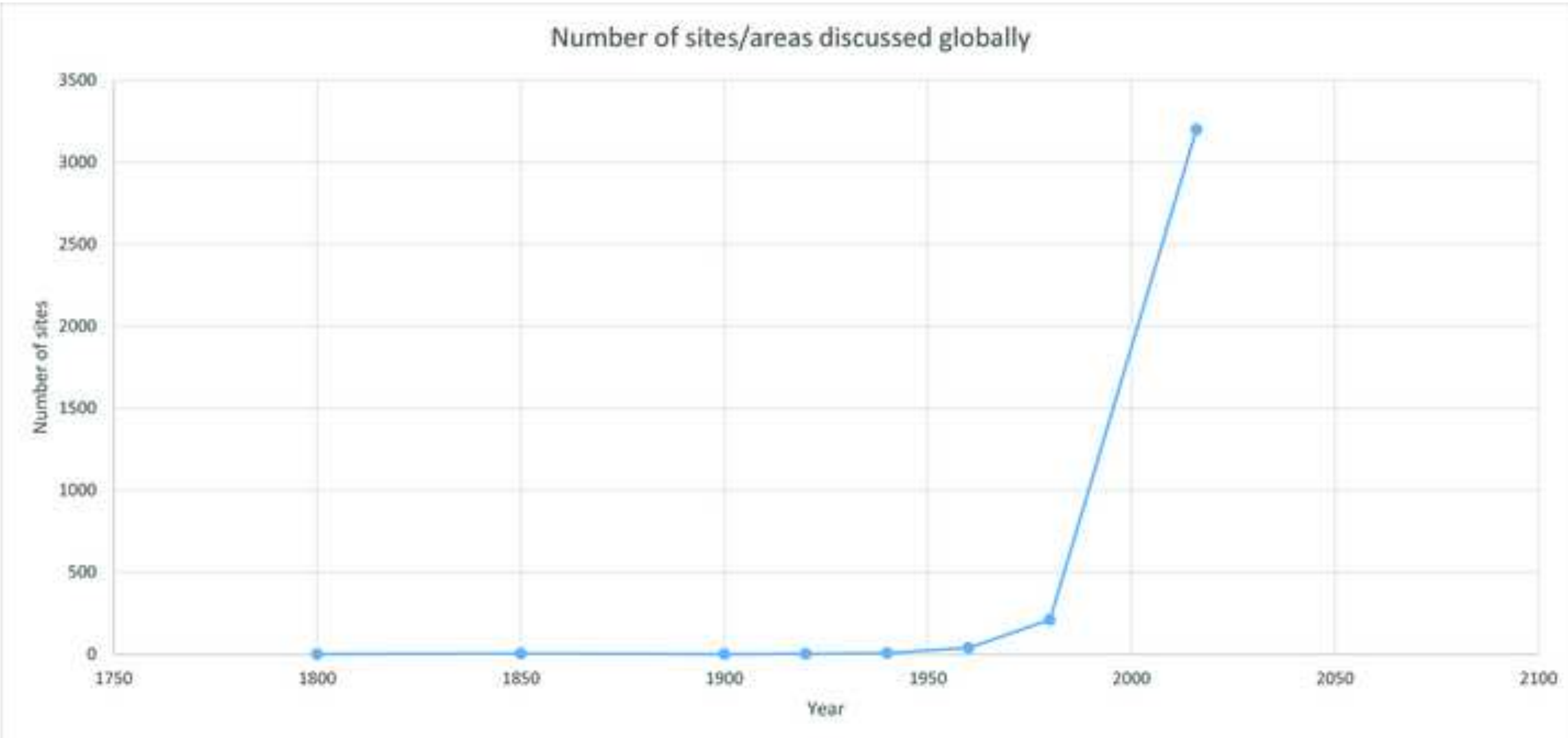

figure5.tif
Click here to download high resolution image

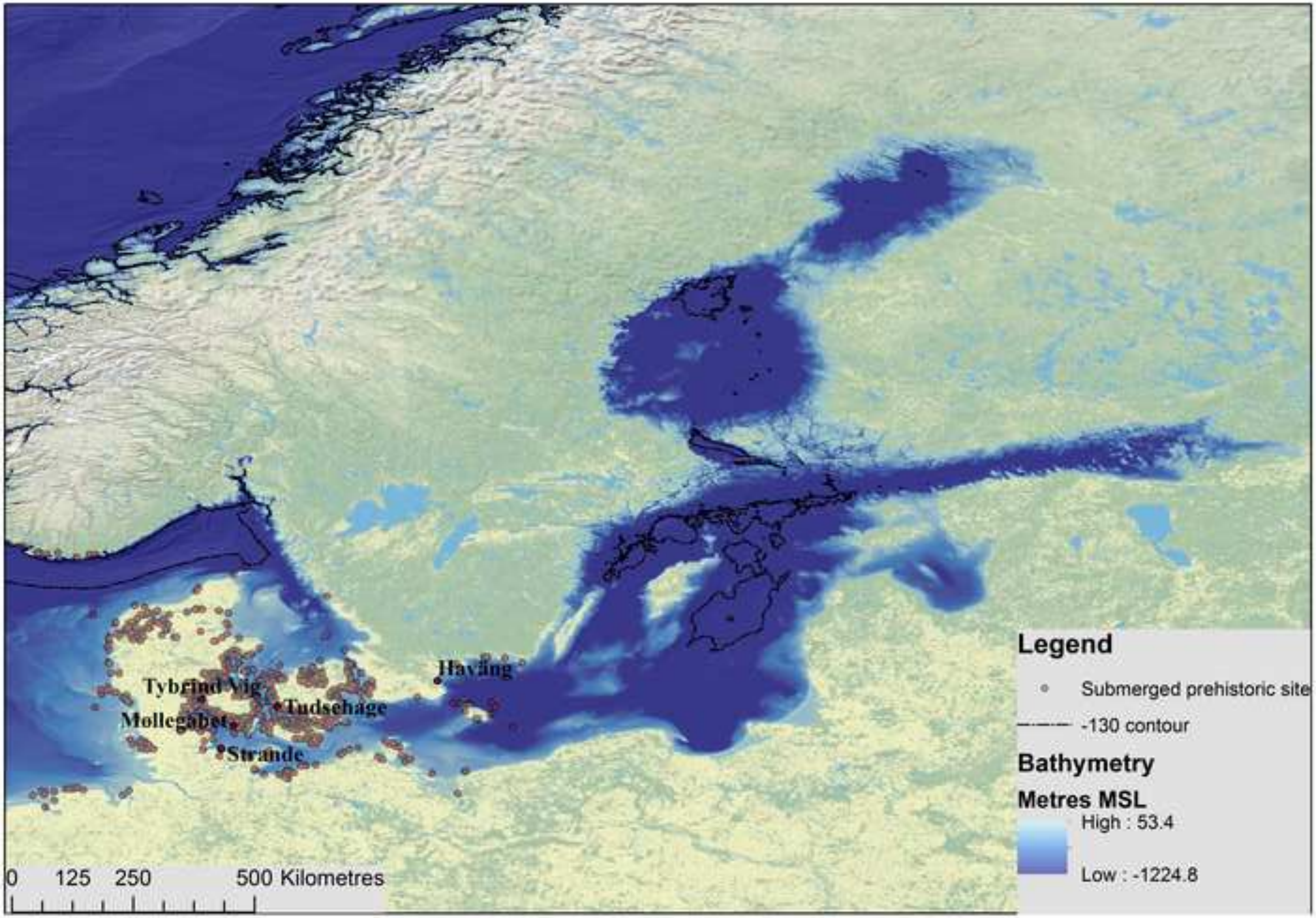

figure6.tif

Click here to download high resolution image

figure7.tif

Click here to download high resolution image

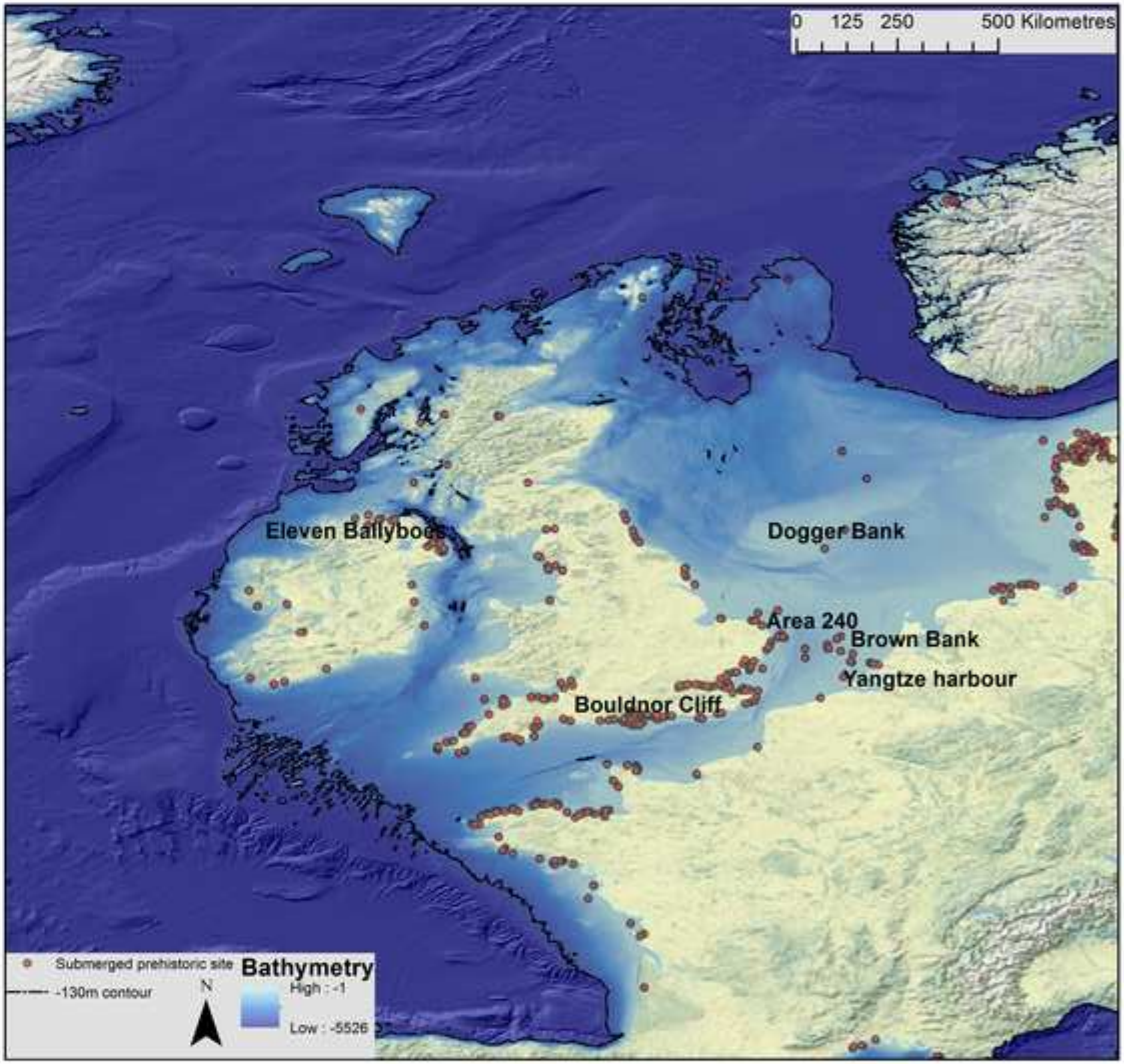

figure8.tif

Click here to download high resolution image

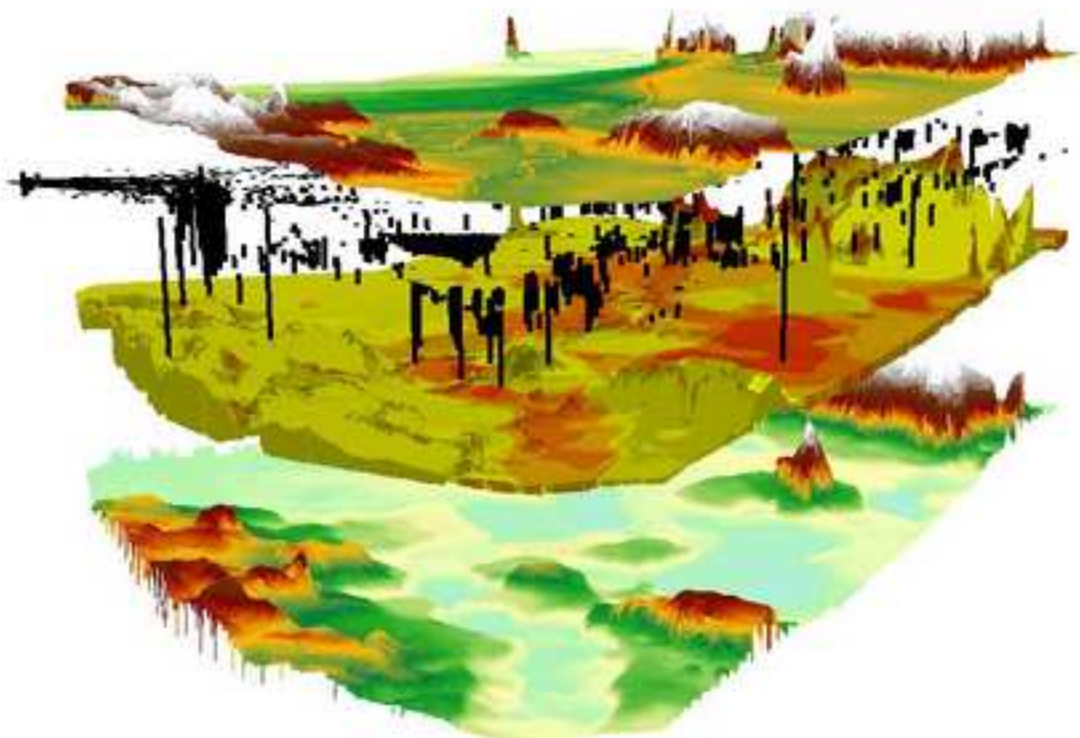

figure9.tif
Click here to download high resolution image

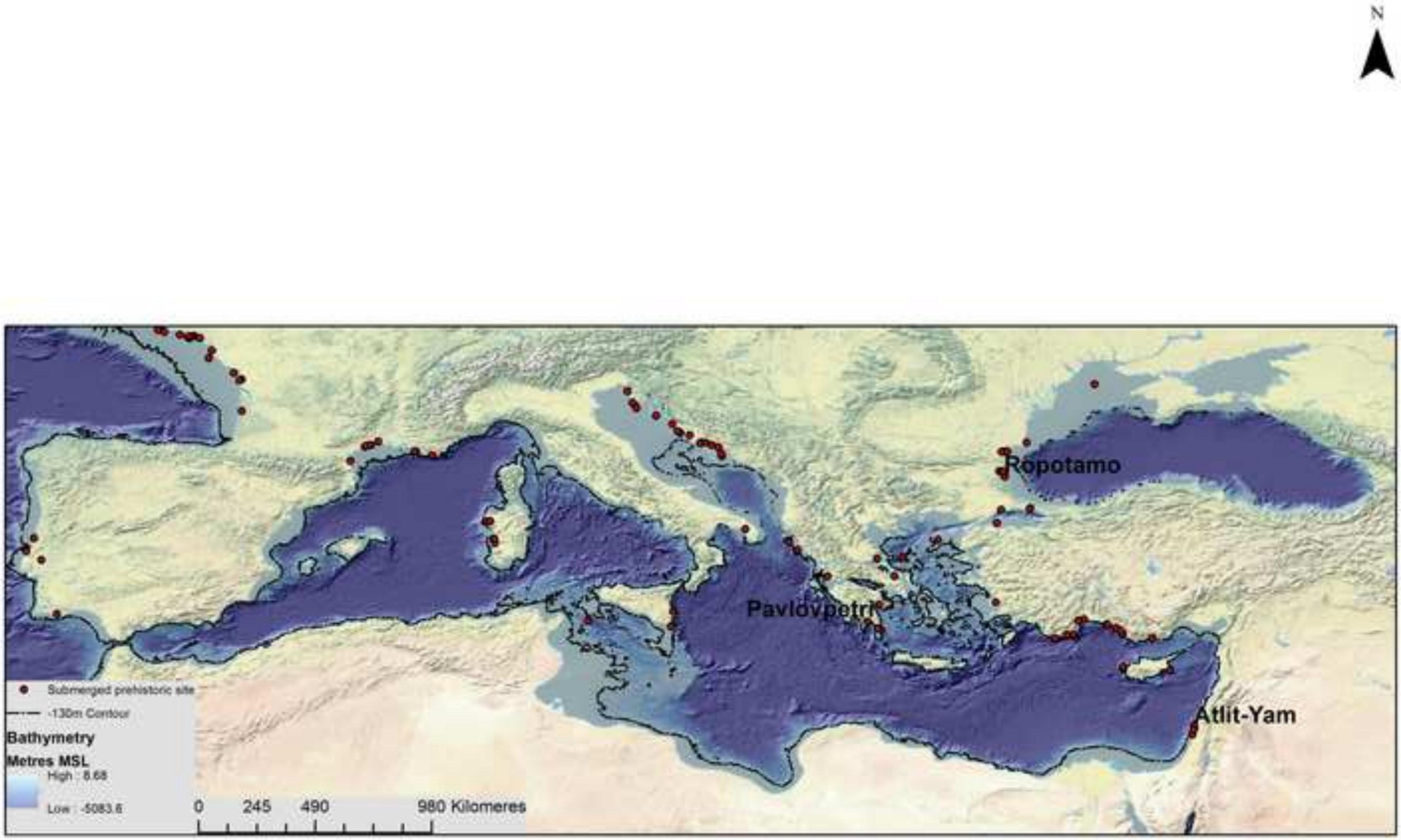

figure10.tif
Click here to download high resolution image

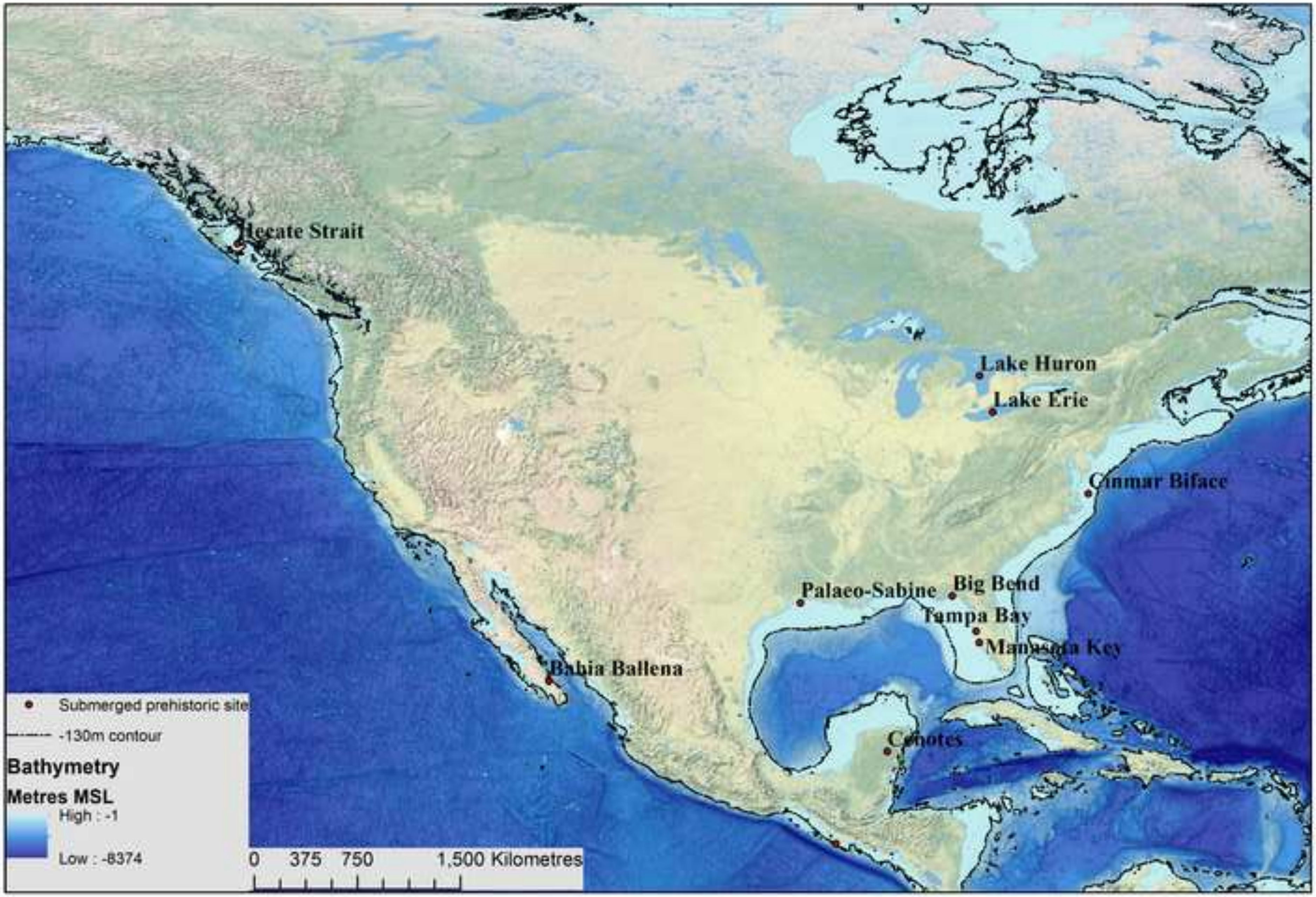

figure11.tif
Click here to download high resolution image

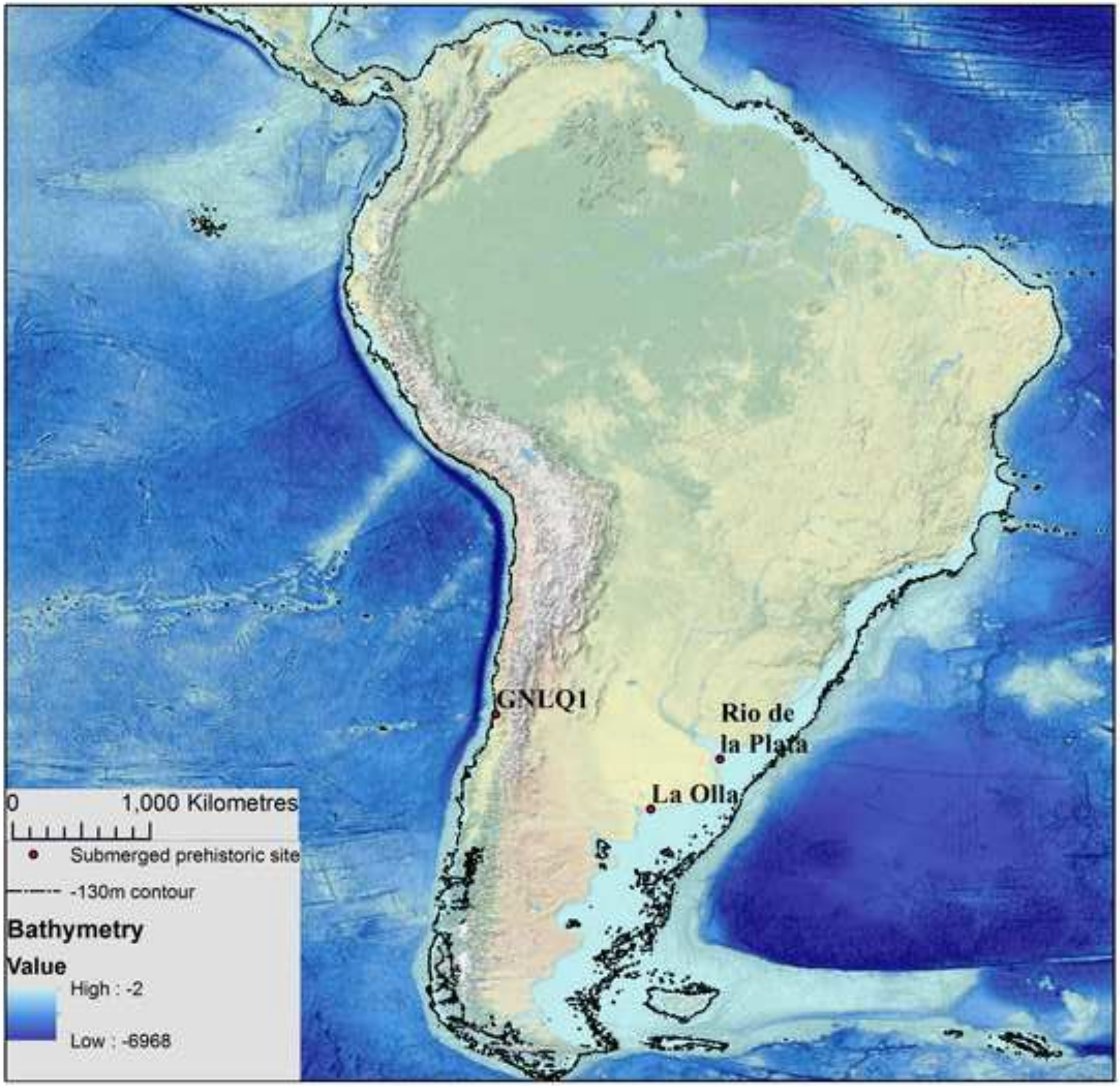

figure12.jpg

Click here to download high resolution image

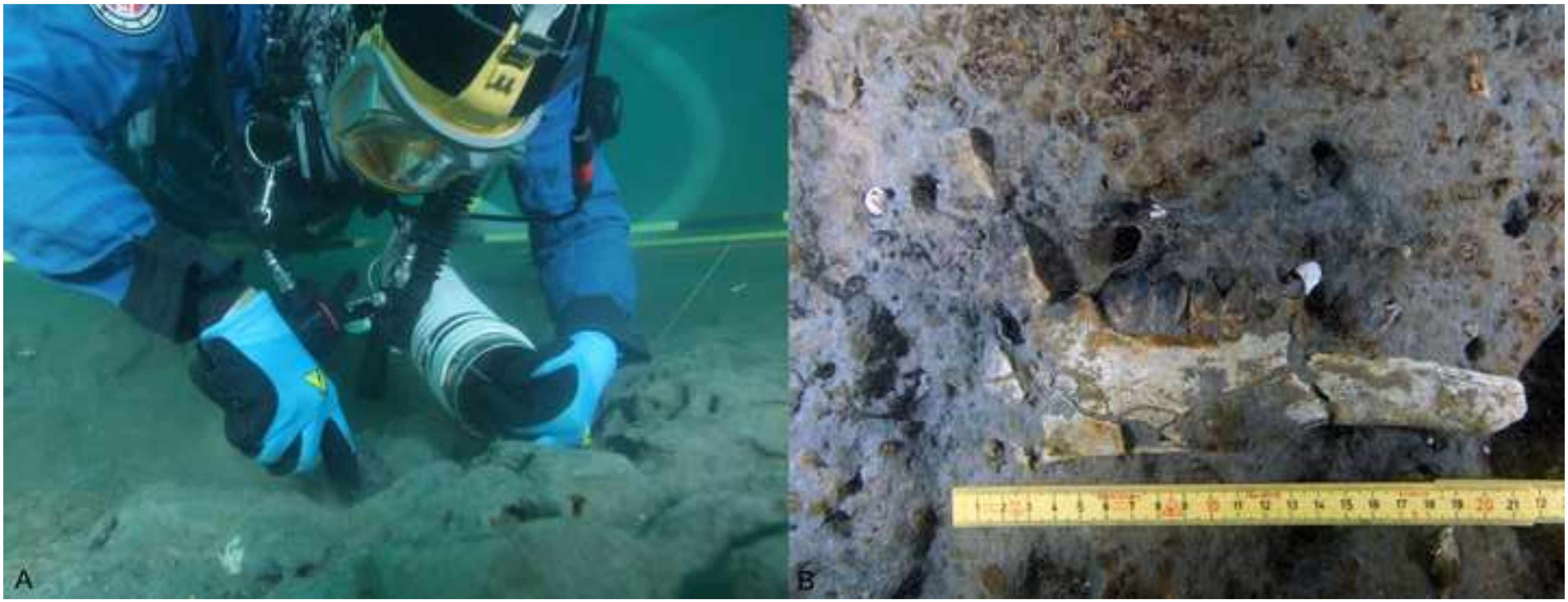

figure13.tif

Click here to download high resolution image

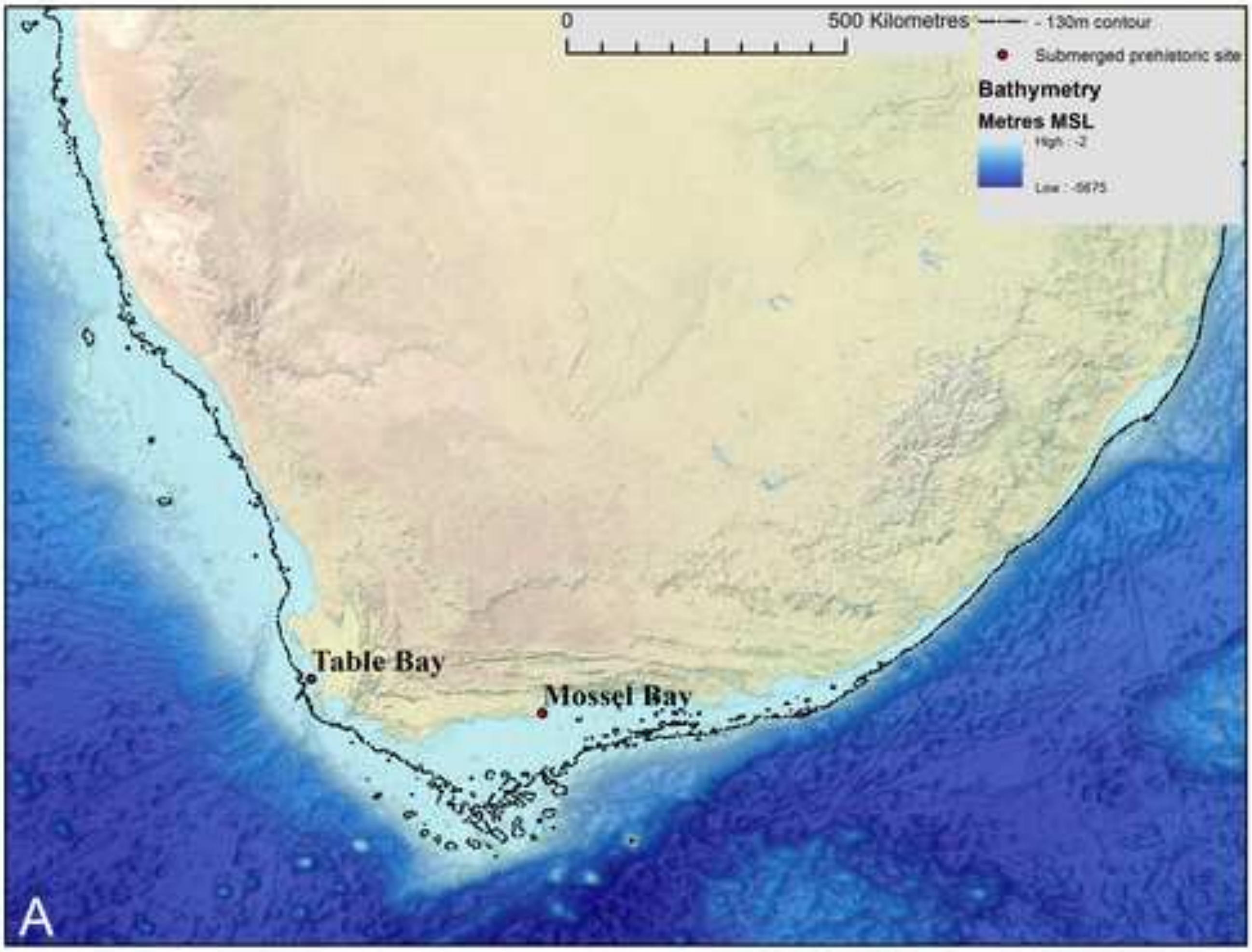

figure14.tif

Click here to download high resolution image

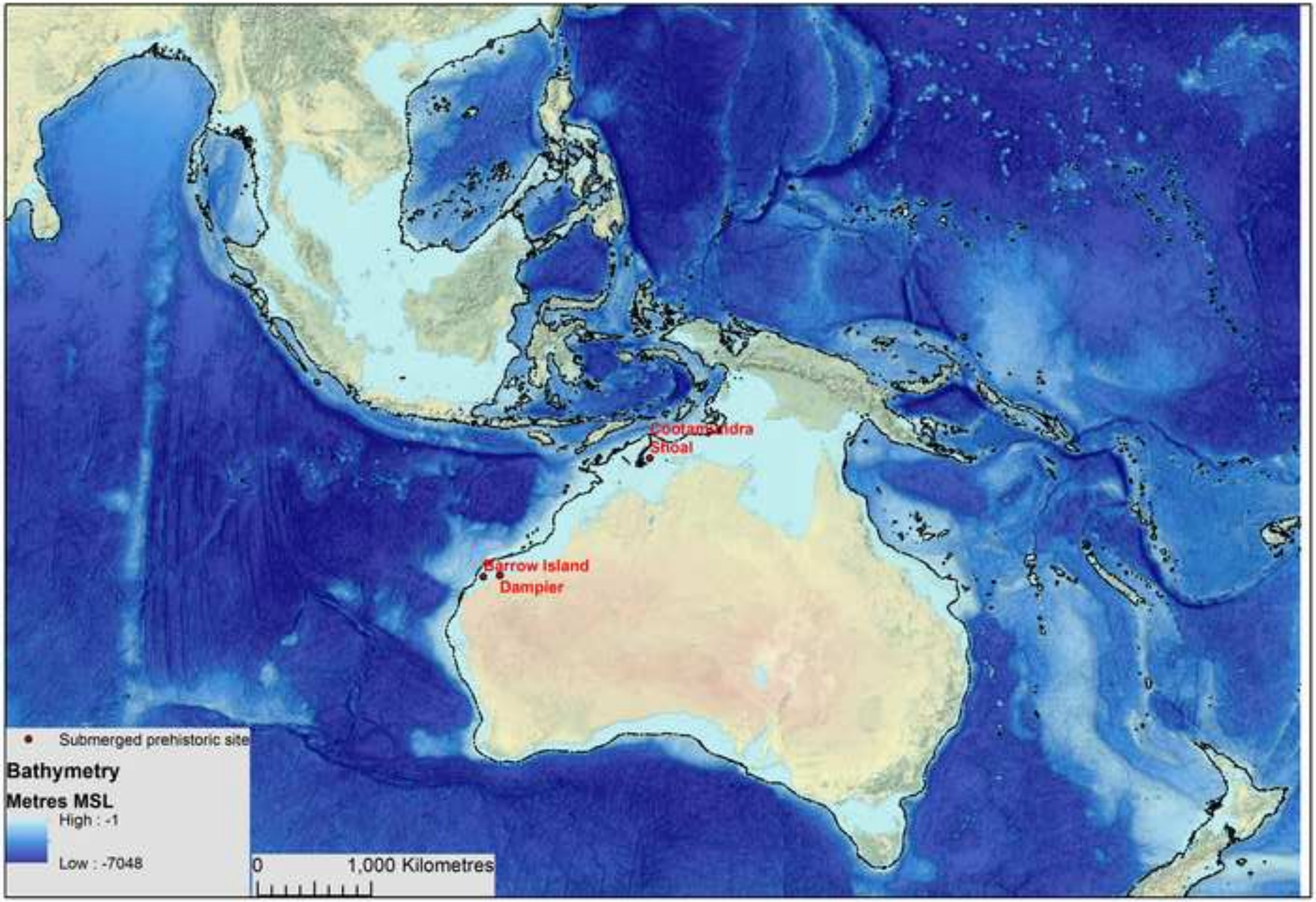

figure15.tif

Click here to download high resolution image

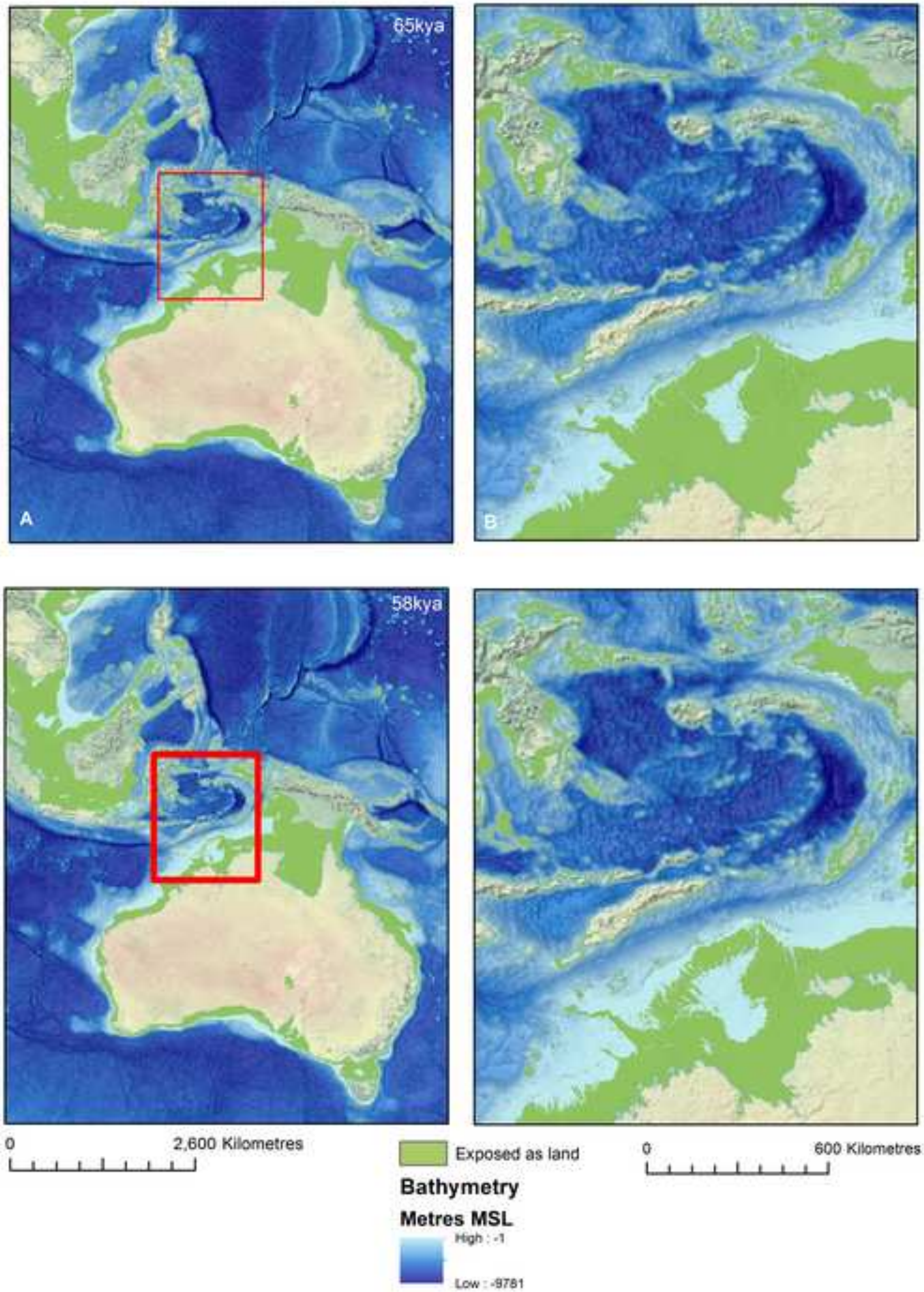

figure16.tif
Click here to download high resolution image

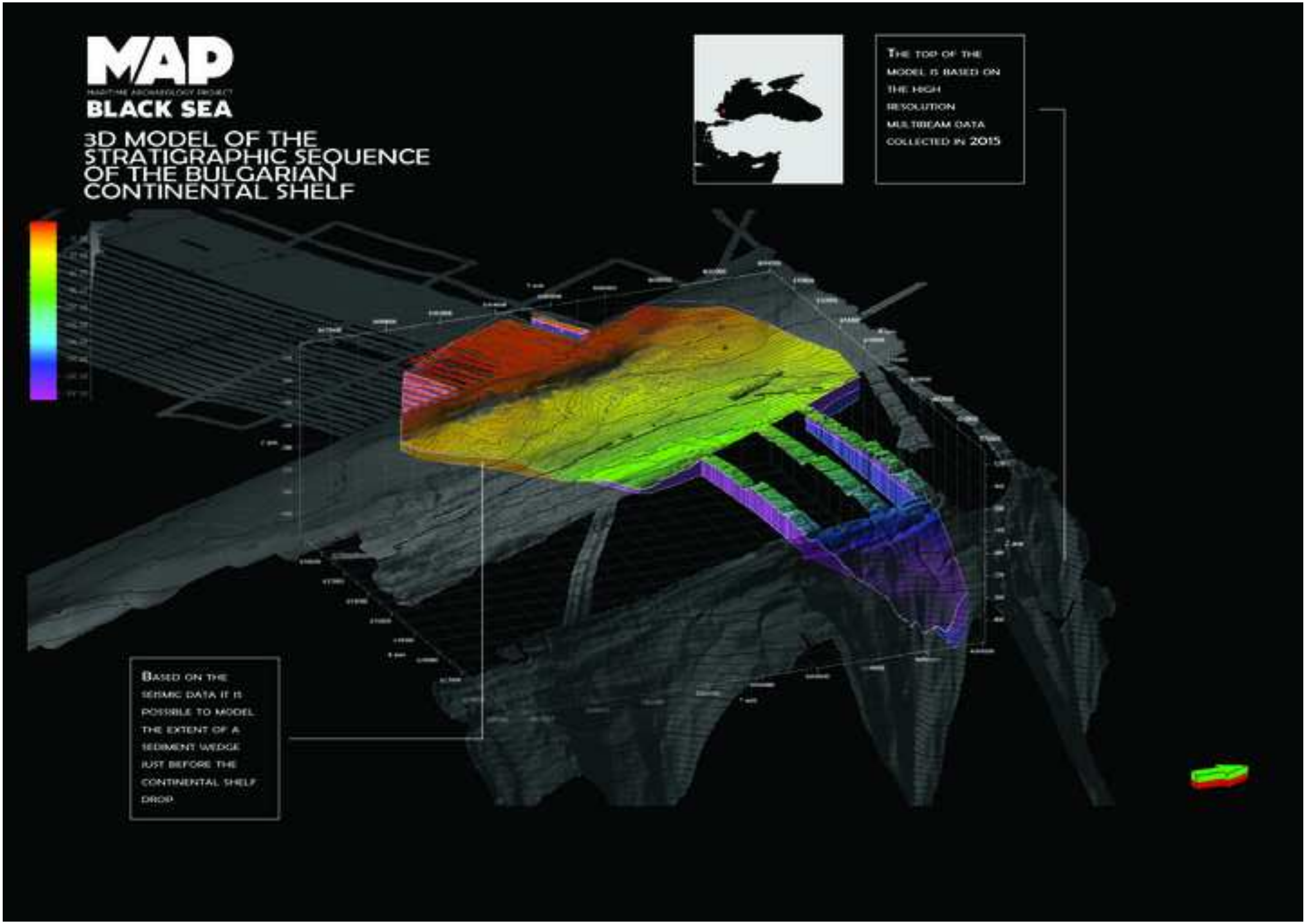

figure17.jpg
Click here to download high resolution image