Amanda M. Evans · Joseph C. Flatman
Nicholas C. Flemming *Editors*

Prehistoric Archaeology on the Continental Shelf

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To our families, especially to our children
Colin Keith, Zoe Flatman, Kirsten Flemming
and Peter Flemming

Preface

Seabed prehistoric archaeology has arrived during the last decade at what economists like to call 'escape velocity'. Archaeological sites ranging from 5,000 years old to around 1 million years old have been found offshore, mapped and sometimes excavated off all major continents, in both hemispheres, from the shore to depths of over 100 m, and from almost the pole to the equator. Research groups that have durability and funding are becoming established in many countries. The new data are being absorbed and interpreted.

Good ideas, good inventions, and new frontiers of research have a way of being discovered or invented many times before they are finally proven to work or to be intellectually useful. From flying machines to steam engines, from diving gear and safety razors even to the alteration of species through time, the story has been the same. Flood myths such as Deukalion, Noah and Gilgamesh go back thousands of years in written form, and probably 10,000 or more to their oral beginnings. Submerged cities in the Mediterranean were well known to the ancient geographers and historians, sometimes correctly and sometimes with embroidered details. Successive glaciations in the European Alps were deciphered during the mid-nineteenth century, and immediately led to the calculation that the ice volumes on the continents would lead to a global sea level drop of the order of 100 m.

By the early twentieth century, palaeontologists and archaeologists had noted shoreline caves in Algeria and southern France containing bones of extinct megafauna that could only have walked there when the sea level was much lower. Fossil bones, terrestrial peat, and occasional flint tools were trawled up by fishermen, and correctly explained as originating when the continental shelf was occupied by human ancestors. All finds occurred by chance, and there seemed no way of making research on the seabed proactive. The available technology was seriously inadequate. During the twentieth century, steady enhancement of acoustic survey of the seabed through single-beam echo sounding, side-scan sonar, and then multibeam swath bathymetry, resulted in a much fuller understanding of drowned river valleys, periglacial phenomena such as moraines and ice tunnels, fossil coral terraces, and many other terrestrial or fossil coastal features remaining intact on the continental shelf. After 1945, the exploitation of offshore hydrocarbons and dredging for aggregates and navigational channels produced still more data. Divers, both commercial and amateur, reported complex geomorphological features on the seabed, submerged caves that could only be Pleistocene low sea level shorelines, and sometimes found prehistoric remains in sedimentary areas. I started research for my PhD in 1960 when side-scan sonar was a new tool, and just before oil and gas were discovered in the North Sea. Anything seemed possible. However, I also knew that my plans to study submerged Pleistocene caves and tectonically submerged classical ports in the Mediterranean were based on more than a century of previous scholarship. My hero was A. C. Blanc whose work on the west coast of Italy in the 1930s and 1940s showed how it might be plausible to go beneath the surface of the sea and search for prehistoric remains as a deliberate plan with a chance of success. Since then, a host of discoveries by many researchers in the southern Baltic, off the coast of Israel, in the North Sea, off both the Atlantic and Pacific coasts of the Americas have shown how far-sighted Blanc's ideas were.

This book is not an exhaustive global catalogue, which would have to contain references to many thousands of known seabed prehistoric sites. Rather, it is a highly selective set of sites, projects, surveys, and excavations from a wide variety of oceanographic conditions, climates and prehistoric cultures. The cumulative significance of this amalgam of sites is synthesised at the end of the book in the concluding chapter by Geoff Bailey. There are still huge uncertainties about the early migrations of hominins and anatomically modern humans which will only be resolved when we have a much larger data set to study from the sea floor. Equally, the role of the continental shelf as a refugium on the periphery of glaciated areas is still not understood, nor is the effect of the accessibility generally of the continental shelf and its resources during glacial maxima.

This book originated at the Sixth World Archaeology Conference (WAC 6) held in Dublin in June 2008. There was a session on seabed prehistoric research organised by Amanda Evans and Joe Flatman, and Amanda took the initiative to plan a published volume based on the papers in that session. Less than a month later, in July 2008, the Third International Conference on Underwater Archaeology (IKUWA 3) was held in London, with Joe Flatman chairing that conference's organising committee. At IKUWA 3, I organised a session on prehistory, co-chaired by Dimitris Sakellariou. Again, there was discussion of publication, and Amanda and Joe invited me to co-edit the proposed book with them. Inevitably, we found that some speakers were not ready to write fully argued texts, and the ones that were provided resulted in an unbalanced global selection, so we invited further contributors to make a more representative picture of the situation.

I thank the authors and my fellow editors who did much more work than I did, and I hope that my long experience in this field provided some guidance and help when most needed. The subject is entering a new era when new sites will be discovered in critical areas such as the Sunda-Sahul shelf and Beringia, and when the more fully explored sectors of the shelf will provide so many sites with a rich variety of dates, modern interpretation of cultures, demographics, change through time, and social structure will be possible.

Governments are beginning to plan systematic topographic and bedform mapping of their continental shelves at high resolution with multibeam survey for commercial, military and management purposes. This will have the fringe benefit of providing the maps needed to reveal drowned terrestrial landscapes where they are not cloaked in a thick over-burden of marine sediments. Other sonar techniques can then provide maps through the sediments, while Remote Operated Vehicles and Autonomous Underwater Vehicles are opening up new possibilities for systematic photography and optical surveying of large areas. Ultimately, the great majority of prehistoric sites can only be examined in sufficient detail and excavated by divers, with the progress in diving systems, and training the archaeologists to dive, as an essential step. I hope that this book enthuses some of the younger generations to join this exciting research.

Nicholas C. Flemming

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Nic Flemming: It has been a privilege to work on this book with Amanda Evans and Joe Flatman. I thank them both. One of my roles was finding authors in those parts of the world where prehistoric research on the continental shelf is a very new subject, and I thank those contributors who agreed to take part in a publication which must have seemed remote to their interests and immediate concerns. Additionally, given my work in this field over many decades, my editorial comments tended to pick up inconsistencies or gaps which might have been missed if the subject had been treated as only "new". I thank the authors and my co-editors for responding positively to such criticisms which may at times have seemed pernickety. My wife, Professor Jay Kleinberg is a historian, and I am grateful to her for the opportunity to learn about the analytic processes of the social sciences, and for her tolerance of my working hours, and my habit of turning holidays into research projects.

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Chapter 11
Submerged Archaeology and Cultural Responses to Climatic Amelioration

Garry Momber

Introduction

Climatic oscillations throughout the Pleistocene meant there were times when the world was colder, the ice caps were larger and the oceans were smaller. During the coldest periods in the northern hemisphere, temperatures could be 25 °C below current averages, sea levels around the world were up to 130 m lower and large areas of the continental shelves were dry (Hubbard et al. 2009; Lambeck and Chappell 2001; Shennan et al. 2000; Lambeck 1995; Bailey 2011; Stringer 2006). At the warmest times between glaciations the climate was a degree or two hotter than at present and the sea level gained an additional 4–5 m.

There have been on the order of eight major glaciations in the last million years that have been mirrored by corresponding interglacials (Stringer 2006). The temperature swings that resulted saw the shifting of ecosystems, and the redistribution of favoured environments for megafauna and people. As a consequence, hunter-gatherers found themselves drawn to new locations in pursuit of their prey. When the climate warmed, European migrations would have been drawn northwards. The discovery of worked lithics in Happisburgh, Norfolk and Pakefield, Suffolk is evidence of the earliest incursion from Mainland Europe to Britain (Fig. 11.1). The lithics from Happisburgh that date to 814,000–970,000 BP represent the oldest site of hominin activity north of the Alps (Parfitt et al. 2010).

Since the first forays into Britain by Lower Palaeolithic pioneers, there have been repeated phases of occupation when the conditions were suitable. The most conducive periods were during the warming phase that allowed people to move out of refugia in the south. Initially vegetation remained sparse allowing passage for herds and their hunters to be relatively unhindered. The retreating permafrost left rich open grasslands but as the climate continued to ameliorate, plants and trees began to move north. This led to the advance of richer vegetation cover, fragmenting open spaces and interrupting or displacing movements of migrating herds. The time

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Fig. 11.1 Location map showing numbered sites mentioned in the text: (*1*) Happisburgh, England; (*2*) Pakefield, England; (*3*) La Cotte in Jersey; (*4*) La Mondrée, Cap Lévy, France; (*5*) Brown's Bank, North Sea; (*6*) Area 240, North Sea; (*7*) Worm's Head, Wales; (*8*) Potter's Cave, Caldey, Wales; (*9*) Gough's Cave, England; (*10*) Badger Hole, England; (*11*) Aveline's Hole, England; (*12*) Starr Car, England; (*13*) East Barns, Scotland; (*14*) Thatcham, England; (*15*) Abinger Common, England; (*16*) Hengistbury Head, England; (*17*) Howick, England; (*18*) Elgin, Scotland; (*19*) Broom Hill, England; (*20*) Oakhanger, England; (*21*) Bouldnor Cliff England; (*22*) Oransay, Scotland; (*23*) Oban, Scotland; (*24*) Forth Valley, Scotland; (*25*) Portland, England; (*26*) Westward Ho!, England; (*27*) Wooton Quarr, England; (*28*) Langstone Harbour, England; (*29*) Goldcliffe, Wales; (*30*) Prestatyn, Wales (Julian Whitewright after Garry Momber)

frame would have been many hundreds, if not thousands, of years before environments stabilised and matured but the greater long-term disruption was the melting of the ice caps. The run-off formed large rivers that dissected the landscape and caused a rise in sea level that in turn impinged on hunting territories. Fortuitously, transgressions were relatively slow which allowed habitats, and any humans that lived in them, time to adapt to the changing surroundings and to become well established before the sea arrived.

By the time sea level had reached its peak large stretches of open water were formed that carved islands from the original landmass and created barriers to movement. This proved particularly problematic when the climatic downturn came at the end of an interglacial as people and animals became isolated. The archaeological record shows incidences where Palaeolithic groups adapted to deteriorating climatic conditions and survived for a while but in due course evidence of their presence is lost (Stringer 2006). But the prehistoric archaeology found on the British Isles is only part of the story as many of the landscapes that played a crucial role in past human evolution, migration, and diffusion are now submerged.

Climate Change, Environmental Shifts and Human Dispersal

The time frame between the major glaciations and interglacial periods over the last million years was generally around 100,000–130,000 years (Hubbard et al. 2009; Lambeck and Chappell 2001; Stringer 2006). Intervening climatic events saw subsidiary fluctuations that would have resulted in smaller shifts of ecotonal zones. With each swing from cold to warm, people would respond by adjusting their ranges in pursuit of food. The extent to which people could move would have been restricted by the thresholds of human survival. During most of the Pleistocene, Britain was seldom habitable as it was on higher and colder ground to the north. Not far to the south, however, evidence from the Channel Islands and northern France showed that hunters and gatherers were surviving during periods when Britain remained unoccupied. The discoveries from La Cotte in Jersey included evidence of Middle Palaeolithic (c. 300,000–30,000 BP) people who hunted mammoth and rhino. It was a time when Jersey was connected to mainland Europe. The assemblage recovered from La Cotte is greater than the entire Mousterian collection in the whole of the British Isles (Patton 1987). A similar case exists in 20 m of water off La Mondrée, below the Cap Lévy peninsular Normandy, where thousands of lithics have been uncovered from stratified deposits. These were knapped when the land was dry (Cliquet et al. 2011). Further evidence of hominin activity on the submerged lands of the North Sea, as well as rich sources of macrofauna, is demonstrated by the finds from Area 240 (Tizzard et al. 2011), Brown's Bank and Dogger Bank amongst others (Gaffney et al. 2009; Glimmerveen et al. 2004; Fischer 2004; Flemming 2004; Coles 1998; Godwin and Godwin 1933). This should not be surprising as during the height of the largest glacial episodes the magnitude of land people could have occupied was vast (Bailey 2004; Flemming 2004). There were times when lower sea levels of over 120 m were responsible for exposing land for c. 600 km west of the Channel Islands and c. 1,000 km north of Calais.

Accepting that there was exploitation of the continental shelf, it is fair to ask if data from submerged landscapes would tell us anything new that cannot be learned from terrestrial sites. To address this, the following sections review some of the cultural traits that developed across Europe following the last stadial at the end of the Pleistocene. The review focuses on the different archaeological signatures left by the influx of people into Northwest Europe during the Holocene. This period has been selected because there are sizable amounts of remaining data that help distinguish cultural variations between locations, particularly between Britain and Mainland Europe. In some cases cultural as well as technological trends can be tracked spatially and temporally to help inform an understanding of human dispersal and development.

The impact of the severance of the Britain Isles is considered with reference to new discoveries at Bouldnor Cliff in the Solent, England. The formation and preservation of this site is addressed to review the potential for similar sites further offshore. Finally, the survival of the submerged Middle Palaeolithic site La Mondrée, Normandy, France is presented as an example of stratified archaeology in a deposit that has survived for 60,000–90,000 years while enduring exposure to severe glacial conditions and subsequent submergence. It now lies in 20 m of water.

Holocene Occupation Opportunities

The Northwest European continental shelf was a significant facilitator of human expansion in the early stages of the Holocene. At the end of the Younger Dryas the sea levels were 30–40 m below those seen today. This meant the North Sea and eastern English Channel were largely terrestrial (Coles 1998; Lambeck 1995). This has been clearly demonstrated by the Vista Centre of the University of Birmingham who interpreted the first returns from seismic records to identify and annotate the Pleistocene land surface covering an area of 23,000 km^2 in the southern North Sea. The results revealed the survival of geological and palaeo-geomorphological structures buried below the current seabed morphology. Features included plains, hills, rivers, basins and wetlands (Gaffney et al. 2007).

Evidence from Greenland ice cores showed that the Dryas glacial event finished suddenly due to a rise in the order of 5–10 degrees within a couple of decades c. 11,500 BP (Alley 2000). The increase in temperature would have resulted in a relatively rapid melting of the ice cover releasing abundant sources of meltwater and encouraging a wide expansion of vegetation (Scaife 2000; Scaife 2011). Landscapes that would have been the first to profit from the warming of the climate were the lowlands. If these areas were not already occupied, they were soon exploited by humans, as archaeological evidence is quick to appear on the British mainland (Reynier 2000; Clark 1932; Clark 1954; Rankine 1952; Leakey 1951).

It took another 5,000–6,000 years for the sea to complete the transgression and cover the lowlands. This was a long period over which Mesolithic hunter-gatherers could adapt and diversify. When the sea came in, living space was lost and the separation between Britain and mainland Europe formed a major obstruction. This discontinuity between the landmasses is reflected in the archaeological record.

Human Adaptation in the Mesolithic

The beginning of the Mesolithic saw Maglemosian (c. 11,500–8,500 BP) tool technologies spread across northern Europe from the fringes of Russia to Scotland. A common material culture remained prevalent for around 3,000 years and demonstrated wide-ranging movements of hunters who would have been following herds that included red deer, elk and reindeer (Bang-Anderson 2003; Carter 2009; David 2009; Casati and Sørensen 2009). In Britain, large scatters of worked flint tools plus occasional organic assemblages from this same time period indicate extensive activity in substantial and well-defined sites. These include Starr Car, Yorkshire occupied around 9,000 BC (Clark 1954; Chattertton 2003; Conneller 2003), East Barns, East Lothian in c. 8,280–7,970 cal BC (Godder 2007), Thatcham, Berkshire in c. 9,150–8,600 cal BC (Reynier 2000), as well as Abinger Common Surrey (Leakey 1951), Oakhanger, Hampshire (Rankine 1952) Hengistbury Head, Dorset (Barton 1992), Worm's Head, Gower and Potter's Cave, Caldey, Wales (Schulting 2009) plus Gough's Cave, Badger Hole and Aveline's Hole, Somerset, England (Conneller 2009a). The end of the initial Early Mesolithic and the beginning of the British Later Mesolithic is signified by new technologies with the introduction of a diverse range of microliths, in particular, scalene triangles and the narrow, straight-backed 'rod' type. Sites include Howick, Northumberland c. 7,800–7,600 cal BC (Waddington 2007) and at a similar time at Silvercrest, Elgin c. 7,520–7,340 cal BC (Suddaby 2007), for a protracted period at Broom Hill, Hampshire c. 7,600–6,450 cal BC (O'Malley and Jacobi 1978; Jacobi 1981), with numerous flint assemblages found on the Pennines (Chatterton 2007:73). The construction of large houses was another attribute of the early phase of the Later Mesolithic, Later Mesolithic, with a significant grouping dating between c. 7,500 and 8,000 cal BC. These are robust constructions of around 6 m across. One of the most important discovered to date was that at Howick in Northumberland. It was a multi-phase, sub-circular Mesolithic hut measuring c. 6 m and containing more than 13,000 lithics. Its earliest phase of construction was dated to c. 7,800 cal BC, and was occupied for 150–200 years, providing strong evidence for sedentism. Waddington argues that the settlement at Howick was a response to the ingress of the sea, forcing people to move further inland (Waddington 2007:106). Similar arguments can be made for East Barnes, 60 km to the north which contained another substantial structure dated to c. 8,000 BC with an internal living space that measured 5.8 m by 5 m. Around 30,000 lithics have been recovered from this site (Gooder 2007). Further north again in Elgin, two hut circles have been identified with around 900 lithics (Suddaby 2007). The oldest structure measures 6.5 m in diameter and dates to c. 7,430 cal BC. To the south at Broom Hill, a hut with a diameter of almost 6 m has been found associated with a palimpsest of flint implements including 100 woodworking adzes with a date range from c. 8,000 cal BC to the late seventh century cal BC (O'Malley and Jacobi 1978; Chatterton 2009, p. 110). This is a site that would have been closer to dense forest than the sites to the north. Numerous other post-hole features of later date have been investigated but for the most part they are associated with less substantial structures (Wymer 1977; Wickham-Jones 2004; Bell 2007). The large huts found on the British mainland during the early Late Mesolithic are not dissimilar to contemporary sites in continental Europe where, unlike in Britain, they continue to be prolific and develop throughout the Later Mesolithic (Grøn 2003; Skaarup and Grøn 2004; Jenson 2009). In the British Isles as a whole, notwithstanding occasional exceptions towards the end of the Mesolithic epoch, large shelters recede from the archaeological record. This is a pattern that compares favourably with a trend towards smaller lithic scatters as the British Mesolithic runs its course.

Burials and Artistic Expression

The evidence for burials across mainland Europe is relatively extensive throughout the Mesolithic, but evidence for burial practice in the UK is generally restricted to the early period. In England and Wales, human bones have been found in 12 different caves (Conneller 2009a). Most of these bones are individual pieces, however, caves at Worm's Head, Gower and Ogof-yr-Ychen, Cadley, Wales (Schulting 2009), and Gough's Cave, Badger Hole and Aveline's Hole, Somerset, England, contain assemblages that could be attributed to intentional deposition (Conneller 2009b). All the bones and burials were dated to the Early Mesolithic or the transition with the Late Mesolithic after which the practice fades. By comparison, burials are found in Mesolithic sites on the continent (Skarrup and Grøn 2004; Uldun 2011) while disarticulated skeletal remains are not uncommon. Almost forty percent of Scandinavian Mesolithic sites within which faunal remains survived also contained individual human bones (Meiklejohn et al. 2009). A similar pattern is apparent when considering artistic representations. Abstract depictions, carved implements and ritual apparel are more prevalent during the Maglamosian period than they are in the Later Mesolithic of Britain (Clark 1936; Chatterton 2009; Conneller 2003; Terberger 2003).

A Tendency Towards Regionalism and Resource Diversification

The arrival of the Later Mesolithic in the west coast of Scotland saw it become a focal point for marine exploitation. Substantial midden sites at Oronsay, Oban and the Forth Valley amongst others indicate specialized lifestyles where tools evolved that were without parallel on mainland Europe (Wickham-Jones 2009; Mithen 2004). The range and magnitude of the deposits suggest an element of regionalisation and possible sedentism (Richards and Schulting 2003, p. 123). Nonetheless, an assessment of the 23 known shelters in Scotland, including caves and rock shelters, by

Caroline Wickham-Jones concluded that a generalised pattern in the Later Mesolithic could not be reached with any certainty (Wickham Jones 2004, p. 241). The findings augment the case for growing variation and adaptation as would be expected when subsistence strategies diversify. Other sizeable Later Mesolithic sites exploiting coastal resources are known in England at Portland (Palmer 1977; Mannimo and Thomas 2009) and Westward Ho! (Churchill 1965). At Wooton Quarr, Isle of Wight (Loader et al. 1997; Tomalin et al. forthcoming) and Langstone Harbour (Allen and Gardiner 2000), a multitude of worked flint tools have come to light. Despite these major discoveries, English coastal sites are relatively few; however, this may be attributed to geological and eustatic change rather than landscape preferences. Down warping of the continental shelf caused by isostatic rebound coupled with rises in sea level would mean that all but the latest Mesolithic sites would be underwater. Work by Martin Bell and his team in Wales, recorded activity in association with a range of coastal and intertidal sites, notably at Goldcliffe on the Severn Estuary and Prestatyn, North Wales, (Bell 2007). Here, as with other English sites, the remains indicate temporary seasonal encampments rather than a permanent presence (Bell 2007; Palmer 1977). The record of British Later Mesolithic coastal exploitation contrasts markedly with European practices. In Northwest Europe there is increased coastal settlement which results in technological advancement and social development (Ǻstveit 2009; Fischer 2004; Skaarup and Grøn 2004; Grøn 2003). This is particularly true of the Knogemose and the proceeding Ertebolle cultures of the Baltic, as it was with the Mesolithic of southern Brittany whose hunter-gathering and fishing lifestyle continued for around 1,000 years after the arrival of farming (Andersen 2011; Lübke 2009; Fischer et al. 2007; Pedersen 1997; Cunliffe 2001; Cassen et al. 2011).

The Late Mesolithic in continental northern Europe occurred during the mid-seventh millennium BC. Unlike the lithic forms found in Britain at that time, the period is characterised by the introduction of trapeze-type microliths. These appeared in the southern reaches of the European Plain by c. 7,000–6,800 cal BC (Terberger 2003). In Denmark, at c. 6,400 cal BC, the change is signified by the different and arguably more sophisticated Kongemose tool technology (Fischer 1997, p. 70). Investigations of submerged sites off the Storbaelt and Funen in the Danish Archipelago over the last few decades have produced thousands of finely crafted Kongemose lithics (Pederson et al. 1997; Skaarup and Grøn 2004), many associated with earlier coastal sites (Fischer 1997). The exploitation of coastal resources came at a time when coastlines were extending inland rapidly, forcing seas into the Baltic region and across the lower European plains (Lübke 2011). Within 1,000 years, the sea level in Denmark was only a couple of metres lower than today, and the Kongemose had been superseded by the Ertebølle. Further south, in Belgium and the Netherlands a comparable pattern is witnessed where the transition from the early to later periods saw technological change and movement away from a more terrestrial to a marine-based diet (Sergant et al. 2009; De Bie and Van Gils 2009; Crombé et al. 2003). The close interactions with the sea that grew and developed along the North Sea and Channel coastlines are not as evident in Britain. Neither are the technological advancements that appear to have taken place. However, as much of the Mesolithic landscape is now underwater the picture is far from complete, and it has been difficult to draw conclusions with certainty. The discovery of the archaeological deposits within the submerged landscape off Bouldnor Cliff on the Isle of Wight is helping to fill gaps in our understanding.

Bouldnor Cliff Submerged Mesolithic Landscape

Investigations of the 11 m deep submerged forests off the north shores of the Isle of Wight at Bouldnor Cliff have been ongoing intermittently since the 1980s. It was in 1999 that the first archaeological discovery was made by the Hampshire and Wight Trust for Maritime Archaeology (Momber 2000). The archaeology was found on an 8,000–8,200 year old peat terrace that runs parallel with the coast for more than 1 km. The peat protrudes from beneath a 7 m high section of protective sediments that were deposited above it as sea level rose. Research and fieldwork supported by English Heritage in 2003 and the Leverhulme Trust in 2007 has built a picture of the palaeo-environment, the palaeo-landscape, the process of inundation and the subsequent erosion resulting in the formation of this site (Tomalin 2000a; Momber 2004; Momber 2009; Momber 2011; Momber et al. 2011).

The archaeological and palaeo-environmental evaluation demonstrated that the Mesolithic environment was associated with fen, a freshwater wetland, and possibly a lake or river floodplain before it became brackish (Scaife 2000; Scaife 2011). The site was fed by the Lymington River from the north and drained by the River Yar to the south (Fig. 11.2). The landscape would have been ideal for fishing, wild-fowling and hunting while interpretation of the geomorphological evolution has identified it as a natural amphitheatre with watercourses that allowed opportunities for movement in all directions. The sea, with its marine resources, was approximately 8 km away and could be reached by foot or small watercraft. Passage to it along the River Yar was through flint rich chalk downs that would have been covered by rich forest. The variety of geographical and ecological systems found within a day's walking distance in any direction from the western Solent basin could have potentially provided resources including flint, timber and food needed for year-round survival.

Between 2007 and 2011 excavations at loci BC-V unearthed charcoal, a reused pit full of burnt flint, widespread evidence of burning, the foot of a wooden post in the seabed, wood chippings, roasted hazelnuts, prepared string, and more than 20 pieces of worked interrelated timber (Figs. 11.3 and 11.4). Organic material from the pit full of burnt flint provided a secure radiocarbon date of 6,370–6,060 cal BC. (BETA number to be provided).

Assessment of timbers by Dr Maisie Taylor has revealed sophisticated woodworking. One piece has been tangentially split from a tall, straight oak tree in the order of 2 m in diameter. This method employs wedges to cut a plank towards the edge of a tree so the grain runs parallel, or close to parallel along its width. The technique can be used to create a flat plank. This plank would have been of large proportions, possibly in the order of 8 m–12 m long. Prehistoric timbers made using these

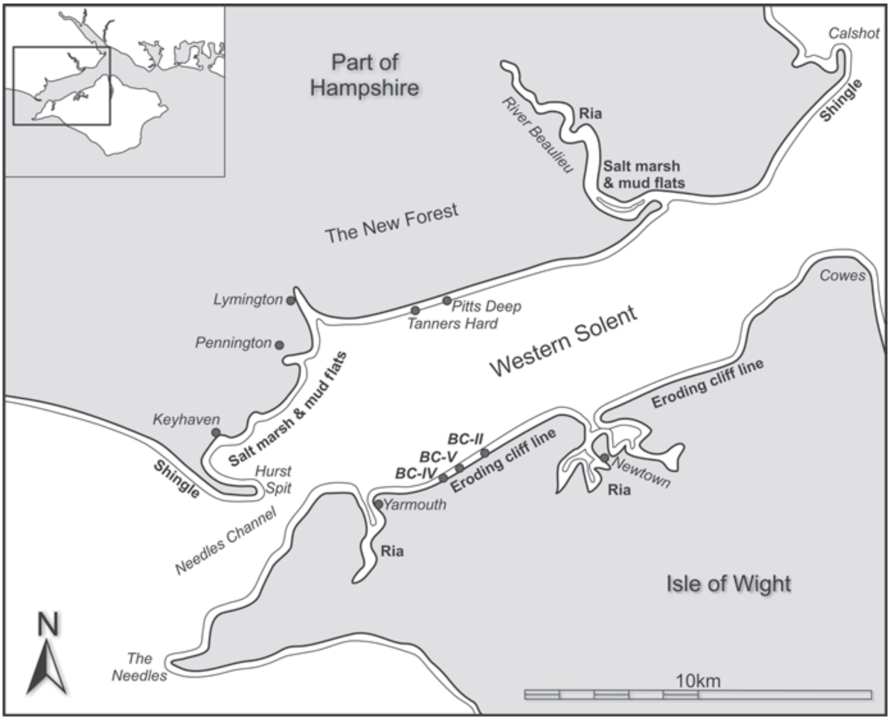

Fig. 11.2 Map of local Bouldnor Cliff area with geomorphological, archaeological and palaeo-landscape features highlighted. Bouldnor Cliff sites are represented by *BC-II*, *BC-IV* and *BC-V*. Submerged landscapes have also been recorded at Pitt's Deep and Tanner's Hard (Julian Whitewright after Garry Momber)

conversion techniques have been found in burial chambers on mainland Britain, although they post-date this specimen by 2,000 years; the earliest known example is from the burial chamber in the Neolithic Haddenham Long Barrow dating to c. 4,000 BC (Evans and Hodder 2006). This method of timber working was also used during the construction of log boats such as the Appleby boat of c. 1,100 BC or the Brigg Boat c. 834 BC in the Bronze Age (McGrail 1978).

The rich archaeological material from this settlement on the edge of the basin contrasts with the scarcity of Mesolithic-occupation sites in the wider region, suggesting that the lowland basin below Bouldnor Cliff was a focal point offering attractive settlement opportunities. Five loci of archaeological material have been identified eroding from the cliff so far. Two of these are known to cover areas that extend at least 20 m wide. Work at the Bouldnor Cliff site is still in its evaluation stage, yet it has already uncovered artefacts the like of which are seldom seen in British Mesolithic sites. The physical environment around a wetland or lacustrine feature, the available resources at hand, the concentration of Mesolithic material, the string and the size of the worked timber suggest a site of industrial activity, technical sophistication and settlement.

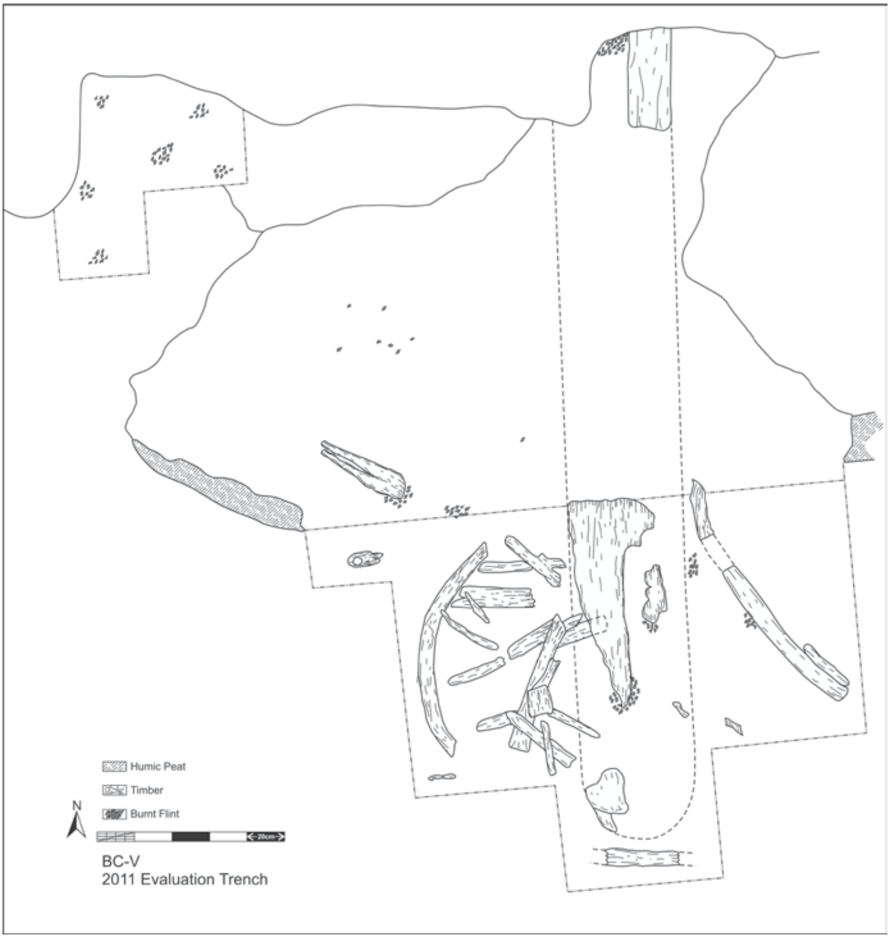

Fig. 11.3 Plan of trench excavated at BC-V showing the assemblage of worked timbers with interpretation suggesting the construction of a log boat/dug-out canoe. (Julian Whitewright after Garry Momber)

Fig. 11.4 A selection of the worked timbers from the excavation trench at BC-V. (Photo by Garry Momber)

Geomorphological Evolution and Site Formation Processes

The Solent was long believed to be formed by the passage of the Solent River that tracked across Christchurch Bay when sea levels were lower (Fox 1862; Everard 1954; Allen and Gibbard 1993; Bridgland and D'Olier 2001). This was discounted by Velegrakis (Velegrakis 2000) at the end of the twentieth century and questioned by Tomalin (Tomalin 2000b) but questions regarding formation of the Solent remained unresolved until deposits along the fringes of the waterway were scrutinised. Analysis took the form of bathymetric data in conjunction with sedimentary, diatom and foraminifera evidence from select sediment archives at Bouldnor Cliff. The interpreted evidence revealed a sequence of events that saw final inundation by the sea around c. 6,000 cal BC (Momber et al. 2011). This was followed by the deposition of brackish, estuarine sediments depositing metres of silt that protected the palaeo-land-surface. The sea entered the system via the River Yar (Fig. 11.2). By c. 4,000 cal BC rising sea-level eroded the barrier to the east of the basin and a couple of thousand years later the western barrier was also breached. It was at this time that the Solent formed and what was a sedimentary sink in the estuary became open to erosion (Ke and Collins 2002; Momber et al. 2011; Scaife 2011). The new Solent channel has cut across the infill deposits and in doing so has removed most of them. The deposits that remain are found in sheltered areas to the north and south of the Solent. They are still subject to ongoing erosion. Bouldnor Cliff lies in a bay on the south.

The formation of the Solent dramatically remodelled the seabed by reshaping and transforming the submerged palaeolandscape. First, estuarine deposits covered and protected earlier surfaces and secondly, sea-level rise overtopped hills to the east and west allowing a new channel to be formed perpendicular to the original drainage pattern. This masked the previous north-south flowing river, a fact that was overlooked by geologists and geomorphologists for 140 years. Modern technology and analytical procedures has proven that the palaeo-landscape was something other than it first appeared and shows that the seabed morphology did not reflect the earlier land surface.

The archaeological material from Bouldnor cliff not only demonstrates that a rich resource of organic archaeological artifacts has survived in immaculate condition underwater for more than 8,000 years but it has shown how sea-level rise can protect archaeological material. Preservation was possible while the remains were encapsulated within a stable oxygen-free environment afforded by fine fluvial and marine silt. This has wider implications for comparable areas submerged during the Holocene around the North European Continental shelf.

La Mondrée

The site located below the granite outcrop of La Mondrée, on the north coast of the Contentin Peninsula off Fermanville, France has proved the potential for much older sites (Cliquet et al. 2011). Submerged peat deposits at the location were first discovered in 1968, after which, divers in 1970 identified prehistoric tools scattered at the base of a cliff in an eroded depression measuring 180 by 50 m (Scuvée and

Veragué 1988). Closer inspection revealed hundreds of worked flint objects while follow-up excavations and survey in the 1970s and 1980s resulted in the recovery of 2,500 objects of worked flint, of which the great majority were tools. Lithic analysis confirmed the tools to be from the Mousterian Tradition, typologically placing the occupation in the Middle Palaeolithic. The site has been dated using palaeo-environmental evidence from cores to around MIS 5a–5c, around 60,000–90,000 years ago, during the Devensian glaciation (Cliquet et al. 2011).

Survey and sampling in 2003 and 2010 recorded a variable covering of seabed sediments ranging from sand to cobble to boulder with outcrops of hard clay and rock. Worked flints and flakes remained in abundance across the site on the surface of the seabed. Evaluation trenches excavated in 2003 revealed relatively deep intercalated and unconsolidated sedimentary deposits suggesting a hollow or channel within which sediments have accrued. Flints were recorded in close association within the trench and a number of them could be refit to reconstruct part of the original flint nodule. Cohesive pollen sequences from within the trenches suggest a stratified primary deposit (Clet et al. 2003). Many of the lithics recorded looked like they had been freshly uncovered with minimal signs of degradation. The insertion of the hand held core into the sediments during the 2010 fieldwork demonstrated that the sediments extend for more than 1 m in depth. This work was conducted in conjunction with the Association pour le Développement de la Recherche en Archéologie Maritime (Adramar), the Département des Recherches Archéologiques Subaquatiques et Sous-Marines (DRASSM), and the Centre National de la Recherche Scientifique (CNRS). A grid was established across the site to provide a survey framework. A survey extended 100 m north to south and 50 m to the east of the granite cliff. Lithics were found across the area with a concentration to the south where the sand deposits were deepest. The fresh nature of artefacts indicates relatively recent exposure. It is evident that the seabed archaeology originated from protected layers below the surface and that deflation of seabed material has resulted in their exposure (Clet et al. 2003). It is anticipated that the palaeo-channel or hollow would be bordered by a substrate that has been sufficiently robust to withstand the environmental changes and sea-level fluctuation. Exposures of clay recorded on the eastern edge of the survey area may denote the edges of this palaeo-feature.

The Significance of Middle Palaeolithic Submerged Archaeology

Research into the Middle Paleolithic deals with a time when population movements from the continent to Britain are little understood. Sites in close proximity to the southern side of the Channel/Manche can potentially have a high impact on explanations of how Neanderthals were living within their landscapes at this time and how they were interacting with the changing environments. Insights into their population dynamics, social organisation and favoured conditions can show how they adapted to the changes and may help us to understand their final demise.

The archaeological review presented above shows how ecological regimes brought about by climate change would have presented strong drivers for human dispersal. The warming of temperatures at the onset of the Holocene provides a proxy for many other similar warming episodes that went before. The early Holocene was a time of low sea level when rivers and plains would have provided access for exploitation of a wide-ranging continual landmass. Large herds traversed the plains before the grasslands were colonised by forests and land was lost due to ingress by the sea. While this process unfolded following the opening of the Holocene, it was the Maglemosian hunters whose lifestyle prevailed for the first few thousand years. Changes in environmental circumstances were reflected by the introduction of new tool types and large 'permanent' structures. These adaptations were indicative of alterations that heralded the new living strategies of the Later Mesolithic in Britain.

Around 8,000 cal BC sedentism and regionalism were becoming evident. As the routes used by migrating mega fauna were lost, subsistence patterns would have shifted. If people did not move with the herds, they needed to find ways to exploit local resources. The ability to survive, as the sea overran terrestrial living space, would have been dependant on a capacity to extract resources more from a smaller area. Fortunately, for the Mesolithic occupants, estuarine conditions were growing as the sea advanced up established fluvial systems. These supported ecosystems that could be much richer in sources of protein (Rowley-Conwy 1983; Westley and Dix 2006). Where people were able to stay in the same area for relatively long periods of time, the rationale for the construction of large houses became more justifiable. This would have been part of the process of 'adaptive capacity and resilience' (Leary 2011, p. 80). Therefore, it is probably no coincidence that evidence for the building of large habitable structures in Britain occurs during this period of environmental change. The final separation from mainland Europe occurred about 8,000–7,500 years ago, a time when large house building shrunk from the archaeological record in Great Britain.

By c. 5,500–6,000 cal BC Britain had become an island. Later Mesolithic technologies continued to evolve and diversify, but the large artefact-rich sites of the earlier periods were generally replaced by more diffuse and smaller flint scatters indicating less permanent dwelling places. Marine travel was demonstrably possible, as indicated by occupations on Ireland, the islands around the UK, and the discovery of substantial Mesolithic log boats in mainland Europe (Andersen 2011; Mithen 2004; Richards and Schulting 2003; Skaarup and Grøn 2004; Woodman 2003). Nevertheless, while the initial partition between Britain and Europe might not have severed all transportation routes, travelling across the open water invariably became more risky as the seas grew. It is probable that the increasing separation caused by the growth of the North Sea, along with escalating forestation, facilitated expression of local idiosyncratic traits as people specialised in selected ecosystems. These differences suggest elements of growing isolation between groups in the British Mesolithic record.

Along the coasts of mainland Europe the story was different. Social and technological advances continued as Mesolithic communities forged relationships with the sea. From the Baltic to Brittany the continued development of large structures and

Table 11. 1 Dates of the Danish Mesolithic periods

Period Danish Culture Date BP	
Early Mesolithic Maglemose	c. 11,500–c. 8,500
Middle Mesolithic Kongemose	c. 8,500–c. 7,500
Late Mesolithic Ertebølle	c. 7,500–c. 5,900

permanent shelters paid testimony to technological advances (Cassen et al. 2011; Fischer 2007; Gron 2003), and the story of the marine transgression in the Baltic is particularly informative. Here, early Kongemosen sites were located on the edges of fresh water lakes but as the sea rose the fresh water systems flooded to form estuaries. The occupants responded by adapting their tool kits to make the coastal zone a major part of their subsistence pattern while taking on a more sedentary lifestyle (Gron 2003; Fischer 1997). The Kongemosen technologies dominated for about 1,000 years from the mid-seventh century BC (Table 11.1). Their archaeological sites can now be found in c. 5–12 m of water around the southern Baltic coast. Similar environmental transformations from fresh water to brackish would have been unfolding in the North Sea basin as the sea encroached. This process would have created many areas with conditions similar to the Baltic, albeit for more limited periods of time. Were there other cultures adjusting to the changing circumstances in comparable ways to the Kongemosen? The circumstantial evidence for such sites suggests they are more likely to have existed than not. Indeed, the technologically advanced site at Bouldnor Cliff suggests it could fall into this category, as it was a fresh water basin whose process of flooding compares with sites around the Baltic. As with the Kongemosen, its archaeology demonstrates a high degree of sophistication. It is not implausible that similar settlements existed between the Baltic and the Solent.

While the sea became a prominent influence on the Mesolithic of mainland Europe, the British record is in marked contrast. Here, advances in lifestyles were less apparent and the importance of marine resources seems to have been relatively limited (Churchill 1965; Palmer 1977; Edwards and Mithen 1995; Loader et al. 1997; Allen and Gardiner 2000; Richards and Schulting 2003; Mithen 2004; Bell 2007; Mannino and Thomas 2009; Wickham-Jones 2009). This presents an interesting enigma: were the technical skills expressed in the finds from Bouldnor Cliff lost or did the people who employed them relocate away before the sea crossings restricted movement? If the finds from Bouldnor Cliff represent a culture with a distinct skill set, were they an isolated group, or were they comparable to groupings in similar environments that have since been submerged? If so, evidence of these groupings may remain buried and preserved underwater.

The importance of the submerged landscapes across the Northwest European continental shelf are not, as already asserted, limited to the Mesolithic. The evidence from the British Channel Islands, such as surface recoveries by fishermen and aggregate dredgers and the discoveries at La Mondrée, make it clear that earlier humans lived on the lands now submerged. The stratified archaeological site below La Mondrée provides an outstanding example of a refugium on the doorstep of an inhospitable Britain that is now submerged. The prolific archaeological resource indicates the occupants were attracted to favoured locations. The many thousands of worked flints suggest a presence at the site for some time by a Neanderthal group or repeated visits by one or many groups. The site also proves that stratified material could survive climatic downturns, the glacial maxima and the marine transgression that followed. In addition it infers that there could be many more sites where conditions are comparable and it is these sites that have the greatest potential to inform our understanding of early human subsistence patterns and dispersal.

The presence of people in low-lying lands that surrounded Britain provides a direct example of an archaeological resource that has become divorced from prehistoric studies. If researchers are to extract the information needed to fill gaps in prehistory, then the challenge is to locate, recover, and analyze archaeological evidence from submerged sites on the continental shelf. To do this, there is a need to understand the geomorphological and palaeo-environmental processes that reshaped the landscape. When these are interpreted, it will be possible to target locations where human activity might originally have been focused and where archaeological material is likely to be preserved. Historically, this challenge has been a difficult one to overcome but the technology available today is enabling us to look into these drowned lands with increasing levels of resolution. Once it is possible to identify submerged landforms that would have been attractive for human occupation, recovery of stratified, georeferenced samples will permit studies of the taphonomy to enable interpretation of the changes while analysis of palaeo-environmental samples can rebuild the living landscape. The final and most important step is to place the people in their palaeolandscape. For that, excavation and recovery of artefacts using marine archaeological divers with modern tools and modern methodologies will be necessary.

Conclusion

The archaeological record indicates cultural divergence and human dispersal during periods of climate change and sea level rise. The driver for localised cultural and technical adaptations appears to be in response to changes in the physical and natural environment. These were most acute following glacial events when increases in vegetation and sea level were impacting negatively on established subsistence patterns while, at the same time, offering new and alternative opportunities. Some of the most significant changes would have been forced on those who saw the coastline encroach into their territories. Evidence of human adaptations in these areas is now most likely to be located underwater. This makes archaeological sites within submerged landscapes key to an accurate understanding of Pleistocene and Holocene human dispersal, and in many cases, cultural change. The task now is to find them and learn from them.

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