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

Prehistoric Archaeology on the Continental Shelf

A Global Review

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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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The editors would like to collectively thank a number of individuals who were instrumental in the long process of bringing this book to fruition:

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- We would also like to thank and acknowledge all of the authors of this book—45 in number—for their hard work and good humour as we brought this book together. Their families should similarly be thanked for their forbearance over many years.

The following individual editors would then like to thank the mentioned individuals:

Amanda Evans: This book would not have been possible without the efforts of my co-editors Joe Flatman and Nic Flemming. I had the pleasure of organizing a symposium on this topic for the WAC 6 meetings with Joe, and am extremely grateful that he was willing to pursue this publication project. Joe was instrumental in bringing Nic Flemming on board and both Joe and I have benefitted greatly from Nic's experience and love of the subject matter. Nic's long involvement with submerged continental shelf research provided a critically important editorial perspective. I must also thank my husband and colleague Matt Keith for his unwavering support in this project and his interest in the subject matter. His contagious enthusiasm provided necessary encouragement to sit down and work on this project in my 'free time'. Finally, I would like to thank Michael Faught, Rob Floyd, Charlie Pearson, Rich Weinstein, and Melanie Stright for introducing me to submerged archaeology on the Gulf of Mexico's continental shelf.

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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 1
Prehistoric Archaeology on the Continental Shelf: The State of the Science in 2013

Joseph C. Flatman and Amanda M. Evans

Introduction

Prehistoric Archaeology on the Continental Shelf provides a review of data from submerged continental shelves around the world. In 14 chapters, data on sites, landscapes, analytical methodologies, and management tools from across the globe are discussed and debated. This is a snapshot of a scientific community in the throes of a dramatic phase of ongoing development. The data and analyses outlined in this book contribute to, influence, and, in many cases, drive the analytical agenda of prehistoric archaeology, underwater and terrestrial; the tools and techniques deployed are handled confidently; and the management of such sites is sophisticated and collaborative. Within this, however, it must be recognized that we still have a long way to go and a lot more to achieve; despite the heroic efforts of individuals and teams at work around the world over the past decades, seabed prehistoric research is still an evolving discipline, where, in particular, we have to find more sites. There are significant gaps in space and time where we have no data at all for thousands of years and millions of square kilometers, and we cannot do fully modern integrative and interpretive archaeology without more data and sites. In particular, there is a scalar mismatch between acoustics and signatures of prehistoric sites—that is, of identifying, from a distance, materials like worked lithics, fragments of bone or wood, charcoal, and arranged stones. Much research is at present being devoted to solving that problem. So far, visual inspection by divers or close-up remote sensing (ROV-based photography, etc.) are the only ways to detect lithics unless they have already been found by chance—as is so often still the case—be this the consequence of deliberate survey or industrial happenstance. Large-scale survey and analysis can

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show all sorts of probabilities, but few can afford to search hundreds or thousands of square kilometers visually. Just as still so often occurs on land, predictive modeling enhances probabilities, but not enough to give a reasonable chance of a survey finding lithics except in exceptional circumstances. In the marine zone even more than on land, we are still often in a rather humbling situation of constant iteration between chance finds, modeling, exploitation of known sites, interpolation, and guessing and hoping. Technology helps, but only so far, and technology improves all the time.

Being unafraid to recognize and admit to such methodological issues, and to dedicatedly search for advances on the current situation as the contributors to this book consistently do, is part of the present-day confidence in approach to this subject demonstrated by its practitioners. Such confidence is also the reason for the specific title of this book: It is about prehistoric archaeology that just happens to come from submerged environments on the continental shelf. In the past, such work labored under the niche title "submerged prehistoric archaeology," reflecting a lack of engagement with mainstream prehistoric archaeology. But this book's chapters demonstrate a community that has outgrown that niche to play the right and full place in global-level discussions of the prehistoric archaeology of the human race that the data from such contexts provide—including the unambiguous discussion of the pros and cons of the methodologies and approaches deployed. Prehistoric archaeology on the continental shelf is in the process of rewriting our understanding of key aspects of prehistoric civilization, from our earliest origins and first journeys, to our later exploitation, impact upon and exploration of the globe. The really exciting fact is that this data are merely the tip of the iceberg: as several chapters in this book indicate, the best is yet to come. In many parts of the world, the continental shelf represents an under-explored landscape that was available for exploitation throughout prehistory, but whose stories are missing from the archaeological record. Future discoveries and analyses of prehistoric archaeology from submerged contexts on the continental shelf look set to be genuinely earth-shattering, for example, new evidence, of the earliest arrival of humans in Australia, or of the extent of human activity in Beringia. Technology is also changing relatively faster offshore than on land (for example, the development of data storage in terabytes really changes the way one gathers data, the resolution that is usable, and removes the need for sampling data and plotting them as subsampled grids). Thus, in the twenty-first century the cutting edge of prehistoric archaeological research lies in submerged contexts, and that simply is not up for debate.

Prehistory on the Continental Shelf

Archaeologists have recognized the potential of continental shelves to contribute to our knowledge of the human past for over 50 years. Specifically, data from submerged sites contribute to both site-specific and landscape-level narratives, meaning that these analyses contribute to local, regional, and global-level debates.

Archaeologists study past human behavior, and build patterns by scaling-up data observed at the microscale, or site, to larger trends observed across regional, cultural, or temporal scales. An archaeological site is defined differently depending on the purpose, but generally is defined as a spatially delimited accumulation of cultural material that has sufficient quantity and quality to allow inferences to be made about behavior occurring at that location (after Butzer 1982, p. 259). Sites are critical to reconstructing past human behavior, but nonsites or data occurrences may still provide information needed to inform patterns of available resources (Butzer 1982, p. 260). As a science, archaeology is restricted to the data that have been found, but if archaeologists are ignoring entire landscapes it is undoubted that our current knowledge of prehistoric populations is flawed. This is a critical point to consider, since models are inherently biased by the information and variables used in their construction, and more importantly by the information that is omitted from the model.

Methodologies for the Continental Shelf

The methodology used in investigating sites on submerged portions of the continental shelf is intrinsically tied to technology and the specific environment under investigation. In some parts of the world, survey methodologies have been established for a long time—for example, in Denmark on the many submerged prehistoric sites analyzed there for many years (see Fischer 1995, 1997) or Italy on submerged cave-habitats, in particular (see Bard et al. 2002; Dutton et al. 2009)—but in all regions the methodology for investigating areas on the continental shelf has room for ongoing refinement. Like any aspect of archaeology, there is general agreement in some areas on the "baseline" analytical and methodological frameworks; such frameworks allow for more nuanced investigations that are not restricted to general "landscape survey" and which can consequently undertake higher-level analyses. Advances in methodology also encourage developments in technology. For example, advancements in mapping accuracy offshore (such as the change from Loran coordinates to DGPS or RTK positioning), allow for more precise control of context. Remote sensing data systems and the postprocessing capabilities for interpretation have increased exponentially, and will continue to evolve, and as noted above, such technologies are advancing relatively faster at sea than on land at the present time. These technological changes, however, complement a basic methodology used in many continental shelf contexts: it is not surprising—and nothing to be ashamed of—that a dredger, a bottom trawl net or a diver are more likely to find a flint tool, a bone, or charcoal deposit than a remote-sensing survey. For example, the Chilean site reported by Carabias et al. (this volume) was found by chance while undertaking a commercial contract survey on a jetty. Around the world, this is not an exception at sea any more than it is still on land, and is simply part and parcel of the complexities of how sites are found and how fieldwork is undertaken and paid for. It must be stated here, and repeated often, that no one methodology will work in all environments or for all types of sites. As the chapters of this book demonstrate, there is both the room and the need for an array of methodological approaches from the “low-tech” to the “high-tech, ” from the site specific to the landscape oriented.

As an example, one early attempt to establish a methodology for investigating prehistoric sites on the continental shelf focused explicitly on the northwestern Gulf of Mexico (CEI 1977; see also Pearson et al. this volume). The recommendations produced by this study stated that any investigation of prehistoric resources on the continental shelf take a three-step approach beginning with remote sensing of the area through either small-scale bathymetry or subbottom profiling to resolve the upper 9 m (30 feet) of sediment coupled with acquisition of a grab or drag sample of seafloor sediments (CEI 1977, p. 341). If a probable site was indicated by the data acquired in step 1, then subsequent data should be collected, either in the form of side-scan-sonar imagery of the area, bottom cores, and or additional grab or drag samples (CEI 1977, p. 341). The final step, if warranted, was recommended as underwater photography or videography, box core sampling, and/or diver investigation (CEI 1977, p. 341). The majority of the recommendations, such as bathymetric survey or diver photography, assumed that the feature of interest was exposed at the seafloor, which is not always the case. The basic investigative methodology developed in 1977 for the northwestern Gulf of Mexico assumed the use of a predictive model that correlated identifiable landforms with archaeological sites as observed in contemporary terrestrial settings. The cultural groups included within this specific geographical and chronological landscape were highly mobile hunter-gatherers with scant material culture (Aten 1983; Neuman 1984; Ricklis 2004). The predictive model included geological reconstruction and landscape change modeling, but recognized that a paucity of artifacts would likely exist at submerged sites associated with this specific region. Cultural signatures of human occupation were, therefore, identified that went beyond artifacts, such as potsherds and lithics, to include signatures more likely to be recovered in core samples, such as shells, faunal fragments, black earth, burned rock, charcoal, and pollen (CEI 1977, p. 172). Subsequent studies have been conducted worldwide that add to the theory and methodology of investigating submerged prehistoric sites. The basic methodology outlined by the 1977 study has benefitted from improvements in the technology, but is specifically intended to identify landscape features as opposed to sites, and assumes that large-scale survey will be conducted. This is appropriate for an area undergoing large-scale development by oil and gas industry, but is not appropriate for all environments, or for investigating other scenarios, such as chance finds.

In 1981, in recognition of advances in paleocoastline reconstruction, archaeologists, anthropologists, geologists, and oceanographers were invited to participate in a symposium addressing Quaternary coastlines and prehistoric archaeology; the resulting papers were published in one of the first edited volumes on the subject (Masters and Flemming 1983). The participants in this symposium noted that, at that time, the majority of prehistoric artifacts from the continental shelf were the result of chance finds by recreational SCUBA divers and fishermen, or activities related to offshore construction (Masters and Flemming 1983, p. 611). Intentional site discovery, they maintained, depended on both physical preservation of the site and ease of detection (Masters and Flemming 1983, p. 622). The participants presented diverse case studies ranging in location from Siberia to Australia, but concluded that a standard framework could be universally applied to site prediction and detection. At minimum, local geomorphology has to be modeled to identify areas of probable feature preservation, recognizable features (such as shell middens) must exist, and basic requirements such as access to fresh water, protection from environmental exposure, and/or availability of food must have existed within the area of interest (Masters and Flemming 1983, p. 623). Recommendations for survey and identification of prehistoric features were similar to those outlined for the Gulf of Mexico: chiefly, bathymetric or subseafloor survey conducted at tight intervals (no greater than 150 m). The authors stressed, however, that this type of survey cannot prove without doubt the existence of prehistoric sites, it can only identify the most probable areas in which sites could be preserved (Masters and Flemming 1983, p. 624). Again, the methodology outlined in the 1983 volume assumes that an investigation of the continental shelf is being driven by survey, and is not immediately applicable to site investigation due to the discovery of chance finds. For example, the Cinmar site off of the US Atlantic coast was discovered by the chance find of a commercial dredging operation (see Stanford et al., this volume)

Methodologies applied to the continental shelf are not restricted to large-scale survey: indeed, if anything the reverse is true, since much of the key work around Europe in particular over the last few decades has been site specific, often the result of chance discoveries of sites. Benjamin (2010) discusses a range of different such projects and gives a noteworthy evaluation of the evolution of attempts to create standard methodology; the SPLASHCOS European Commission COST program (Cooperation in Science and Technology) research network that ran between 2009 and 2013 (http://www.splashcos.org/) includes other such examples. To cite a rather different example, however, Gagliano et al. (1982) published the results of a study that analyzed terrestrial analogues for potential offshore deposits. The results, developed under contract for the United States' National Park Service, analyzed core samples from verified terrestrial prehistoric sites along the Gulf of Mexico coast. Lab analyses of sediment core data indicated that the following variables were credible indicators of modified environment: grain size, pollen content, geochemical composition, point-counts, foraminifera species identification, and radiocarbon dating of appropriate samples (Gagliano et al. 1982). Recognizing that site identification could not be dependent upon the presence of man-made artifacts, the terrestrial corollaries were developed so that landforms could be tested for indicators of prehistoric archaeological site occurrence without the presence of obvious anthropogenic artifacts such as projectile points (Gagliano et al. 1982, p. 115). Numerous studies have been conducted around the world that have employed variations of the continental-shelf methodologies outlined above (e.g., Pearson et al. 1986; Johnson and Stright 1992; Browne 1994; Faught and Donoghue 1997; Momber 2000; Dix et al. 2004; Gaffney and Kenneth 2007; Benjamin et al. 2011).

Some research projects have avoided the complications of working in submerged environments by using evidence from terrestrial contexts to address changes in human subsistence and coastal settlement patterns instigated by changing climate conditions (e.g., Bailey and Parkington 1988). Although the technologies and environments are different, there are some similarities across many of the chapters that follow, representing locations ranging from Beringia to Argentina. For example, we now know that anthropogenic sites with artifacts can survive stratigraphically in context through several glacial cycles and several marine transgressions and regressions, something that was unthinkable less than 30 years ago. The Fermanville site (again found by chance) shows that a deep Paleolithic site can preserve stratigraphy even though exposed to tidal currents on the seabed and several interstadial sea-level changes (Scuvée and Verague 1988).

The techniques outlined above do not represent a universal methodology to all continental shelf sites, but are well established and constitute different tools and options that the research planner can draw upon in order to obtain data. Critical to this volume is an acceptance that good data are good data, irrespective of where they come from. Good data are defined here as trustworthy data, data underlain by solid, reliable, and repeatable methodological tools and techniques. This is the type of data, and type of approach, now consistently being achieved by those working in submerged contexts. The confidence in the approaches deployed means that the archaeologists involved spend more time asking questions of that data and formulating new hypotheses, and less time worrying about how to collect that data and their potential (un)reliability.

Global Significance of Continental Shelf Prehistory

Beyond discussion of the reliability and significance of the data being recovered lies the reality of the untapped potential of prehistoric sites located on the continental shelf, which is huge in terms of the extent of the potential search area, likelihood of any discoveries being significant either because of their location of detailed content, and possibility of discovery due to the level of industrial activity currently being undertaken or planned on the continental shelves alongside the sophistication of the tools and techniques used to survey these areas. Put more simply:

$$W(\text{area}) + X(\text{potential}) + Y(\text{likelihood}) = Z(\text{significance})$$

Studies conducted in an area where there is a strong understanding of the physical environment (W), combined with a predictive model that identifies the landscape or physical features of archaeological interest (X), and that are conducted in an area with a high rate of preservation potential (Y) are likely to yield results of local, regional, and probably global significance (Z). A good starting point for these analyses is the map first produced by Geoff Bailey for Nic Flemming's (2004) *Submerged Prehistoric Archaeology of the North Sea.* As Flatman (2012) outlines, the untapped potential of the continental shelf of SE Asia is but one example of the conjunction outlined above. Bailey's 2004 map also highlights other locations with high potential for finds, the ultimate theme of this book—the continental shelves of

South and Central America, Africa, the Arabian Peninsula, and the Indian Subcontinent. These are areas with unbridled archaeological potential where discoveries are likely to rewrite our understanding of global prehistory, and crucially, they are all areas undergoing active exploration, primarily for industrial objectives, in ever greater detail (see also Bailey 2011). This exploration may not always be beneficial in terms of the survival of prehistoric remains (see Bicket et al. and Faught, this volume), but it is assuredly beneficial in the identification of such remains.

Continental shelf prehistory has the potential to contribute to fundamental questions in archaeology. For example, one of the most prevalent hypotheses, and for a time the only accepted theory, for the peopling of the New World argued that the first Americans walked across the Beringia land bridge during the last glacial maximum, and populated the New World at approximately 11,000 years BP (Bonnichsen and Lepper 2005; Meltzer 2009, p. 3). Consensus could not be reached in explaining how those early inhabitants spread from what is now mainland Alaska throughout the remainder of the western hemisphere (e.g., Wendorf 1966; Fladmark 1979; Dixon 1999). Further complicating the question of modern human's first arrival in the New World were the increasing numbers of archaeological sites that predated 11,000 BP. Early archaeological sites (older than 11,500 BP) were once considered to be anomalous. Absolute dates, stratigraphy, and site integrity were, and continue to be closely scrutinized. In the case of Monte Verde, Chile, one of the first sites to return anomalously early dates, the occupation dates were highly disputed, and subjected to intensive scrutiny by a multidisciplinary panel of over 40 specialists in 1997 (Bonnichsen 2005, p. 15). The findings of the panel, which included several staunch critics of the site, validated some of the dates for Monte Verde and were cited as evidence that the hypothesis of the Bering land bridge as the first and only migration route was inaccurate (Bonnichsen and Lepper 2005, p. 15). Archaeological sites such as the Meadowcroft rock-shelter (Pennsylvania, USA), Monte Verde (Chile), the Debra L. Friedkin site (Texas, USA), and the Channel Islands of California (USA) have produced absolute dates that indicate the presence of modern humans much earlier than 11,000 years BP (Bonnichsen 2005; Goebel et al. 2008; Erlandson et al. 2011; Waters et al. 2011). Evidence from these and other recently published sites continues to push back the date range for possible occupation of the western hemisphere before 12,000 years BP.

Future Directions, Opportunities and Challenges

The levels of collaboration and cooperation currently witnessed between the marine archaeological and industrial communities in many locations around the world are unprecedented, and would have been unimaginable even a decade ago. While such collaboration is by no means universal—one need only think of the lack of archaeological involvement in current continental shelf exploration and exploitation along the coast of Africa—there is in general a good precedent for both continued and expanding relationships in this regard. As outlined in Flatman and Doeser (2010) (see also Flemming 2011), there is a simple reason for this: mutual benefit. Successful marine-zone prehistoric heritage projects always involve some or all of the following characteristics, characteristics that are not always shared by ostensibly similar terrestrial projects:

- *Business facing:* Such projects are strategic, timely, and well managed, responding to currently pressing needs to identify, and help mitigate, shared risks. Many marine-zone heritage projects use the same data sets for archaeological site identification as are used in assessing the presence of shallow seafloor hazards, thereby making the archaeological assessment a cost-effective component of the overall project.
- *Proactive:* Such projects are good at showing immediate functionality and use to all partners, such as modeling the locations of sites or seabed and water column dynamics around particular locations. The efficiency of stakeholder partnership projects is often instrumental to this functionality and cost-effectiveness, such as through the use of legacy data or industry platforms, and frequently involves industry provision of in-kind support via the loan of equipment.
- *Communicative:* Such projects see effective local-level, long-term communication and collaboration between individual industry employees, researchers, and curators.
- *Partnership based:* Many projects are partnerships from the outset, with all partners being included in project development and design, data sharing and collection, and/or data processing.
- *Media friendly:* Such projects undertake outreach, including significant public outreach and media potential for all partners through internal industry media and conferences, and the provision of accessible, user-friendly resources.
- *Mutually beneficial:* Such projects assist industry and the planning sector in the acquisition of new data sets (allowing for better preplanning and risk avoidance); provide historic environment professionals with new investment (supporting management-based research into the historic environment as well as the development of analytical techniques); and provide all sectors with collaborative data acquisition, analysis, and management, together with the additional public relations benefit through media-friendly enterprises, data sharing, and sponsorship.
- *Cross-disciplinary:* Such projects have had at their heart cross-management of projects by both natural and historic environment professionals, intermeshing cultural and natural environment research specialisms and data.

The discussion of cultural resource management (CRM) archaeology and the wider management regimes of prehistoric archaeology from submerged contexts raises three additional points of discussion. The first of these points is with regard to the long-term durability of the marine CRM sector. This sector of the CRM community is currently one of the only parts of the wider CRM community that is currently booming in the midst of the sustained economic depression in place globally since 2007. The extent of industrial activities in the inshore and increasingly offshore zones around the world, stretched across the continental shelves, is staggering. Traditional industries and related infrastructures such as oil and gas exploration and recovery, marine mineral extraction, fishing (including increasingly fish farming), port and harbor development, pipe and cable laying are increasingly being joined by new industries such as wind and wave "renewable" energy development. All of these industries are forecast to grow at an exponential rate over the coming decades, both in traditional areas and also increasingly in new areas of discovery, such as South East Asia, Africa, and South America. But alongside this growth is an increasingly recognized—although not formally analyzed—lack of appropriately trained or experienced archaeologists within marine CRM firms. Anecdotal evidence, such as that discussed at the 2014 Society for Historical Archaeology (SHA) conference forum on capacity building in submerged precontact archaeology, demonstrates a sustained skills gap, with more jobs available than appropriately skilled people to fill them, the inverse of the normal hiring situation within the CRM community. In particular, there is a lack of practical survey data collection and analysis skills among potential new employees. Put simply, postgraduate university programs in archaeology must meet university curriculum standards that do not allow for practical sea time for students. Many students graduate from programs without the ability to run marine surveys and, more importantly, interpret the raw data that such surveys collect. This is a systemic problem, one that is increasingly recognized by the same academic institutions.

A different regulatory issue stems from the management of human remains from prehistoric submerged contexts. So far, such discoveries have been relatively few in number and crucially, have been made in areas with limited or no Indigenous communities involvement in the management of prehistoric sites above or below water. But given the range and intensity of industrial activity discussed in the following chapters, the likelihood is that significant future discoveries of human remains will be made in areas with Indigenous communities who are not afraid to exercise their existing legal rights to the control of ancestral landscapes and material culture. The legal battle over "Kennewick Man" in Washington State (USA) illustrates the potential for ancient remains from submerged contexts, and the complexity of determining legal "ownership" or cultural affiliation (see http://www.nps.gov/archeology/kennewick/). To date, no known legal cases have explicitly addressed archaeological human remains from continental shelf environments. However, in the USA, legal challenges to the proposed Cape Wind offshore wind turbine development illustrate the potential for conflict between indigenous rights and development (Evans et al. 2009). If the types of resource-conflict scenarios outlined in Flatman (2012) become a reality in the resource-hungry mid-twenty-first century, then such claims to legal control and/or ownership of submerged prehistoric sites may become serious issues in their own right, a crucial part of the "politics of the past" debate that has been being played out on land for generations.

A third regulatory issue then concerns the combined protection and crucially public recognition of the significance of prehistoric sites in such environments. At present, such sites are " protected" (when this occurs at all) through different forms of domestic environmental regulation, primarily marine planning regulations in force in many nations' territorial waters, as for example enforced by the Marine Management Organization (MMO) in the territorial waters of the UK, or the Bureau of Ocean Energy Management (BOEM) in the territorial waters of the USA. While this is no different from countless thousands of comparable prehistoric sites on land similarly managed through similar regulatory frameworks, the “higher level” specifically heritage-related regulatory systems that exist and that are used to protect, acknowledge, and celebrate such sites on land and in the intertidal zone are currently absent in relation to such prehistoric continental shelf sites in the marine zone. For example, in the UK, the 1979 Ancient Monuments and Archaeological Areas Act that formally “Schedules” archaeological sites of the highest national importance could be used to protect such sites underwater, as the Act does for many thousands of prehistoric sites of equivalent significance on land (although the terms of the Act restricts it, both on land and underwater, to sites with identifiable structures, a provision that can limit its protection of prehistoric artefact sites of the type in question here). The Act contains provisions for the protection of marine sites; it is purely a matter of the right sites being nominated for such protection, either as a result of one-off recognition on the basis of significance or threat, or, more usefully, as a consequence of sustained, strategic programs of survey and exploration of the type described elsewhere in this book, and already underway in some locations, for example under the auspices of the National Heritage Protection Plan (NHPP) in England, where an ongoing strategic program of work (with its origins in the Aggregates Levy Sustainability Fund that ran between 2002 and 2011) is currently in the process of identifying and proposing submerged prehistoric sites on the English continental shelf for such statutory designation (NHPP Measure 3A1, *Unknown Marine Assets and Landscapes,* see http://www.english-heritage.org.uk/professional/protection/national-heritage-protection-plan/plan/activities/3a1). The success of books such as Gaffney, Fitch and Smith’s (2009) *Europe’s Lost World: the Rediscovery of Doggerland* (and related TV shows about such sites), demonstrates that there is a public appreciation of an appetite for such prehistoric archaeology; one next step is thus its more formal recognition in the regulatory system, alongside other such nationally—indeed, internationally—important sites. Advances in international regulatory and celebratory systems might also have a role here in due course, for example, thorough the network of World Heritage Sites, potentially under the auspices of the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage.

Epilogue

It is crucial that the challenges outlined here are not seen as insurmountable for exploration of the world’s continental shelves. Offshore development presents opportunities for investigation and research, but requires that archaeologists undertake training appropriate to investigating formerly exposed landscapes that are now submerged on the continental shelf. As demonstrated by the chapters that follow, as well as elsewhere (see for example Fischer et al. 2011), methodological elements already exist that negate the question of whether continental shelf site investigation is even feasible. There is time and room enough for multiple approaches to prehistoric archaeology of continental shelves; what is required now is that more archaeologists engage in this type of research, refining and improving the methodology, thereby expanding the archaeological record. Only in this way will archaeologists uncover data specific to prehistoric coastal zones, which can in turn lead to new insights about past human migrations, exploration, and adaptations, and ultimately to our understanding of human prehistory.

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Chapter 2
Submerged Archaeological Landscapes and the Recording of Precontact History: Examples from Atlantic Canada

Dominic Lacroix, Trevor Bell, John Shaw and Kieran Westley

Introduction

Atlantic Canada is a vast region of northeastern North America comprised of the Maritime Provinces of New Brunswick, Nova Scotia, and Prince Edward Island (PEI), the Island of Newfoundland, Labrador, and eastern Quebec, including the Magdalen Islands. (see Fig. 2.1). Undisputed human presence in North America is currently limited to the late Pleistocene and early Holocene (Waters et al. 2011). The presence of glaciers over most northern regions during the Last Glacial Maximum (LGM) postponed human settlement until these areas became ice-free. As a result, the earliest evidence of human presence in Atlantic Canada follows the northward disappearance of glacial ice (e.g., Fitzhugh 1978; MacDonald 1968; McGhee and Tuck 1975). The patterns of ice retreat and associated relative sea-level (RSL) changes are therefore intricately linked to the evolution of the paleolandscapes that Northeastern indigenous populations would have inhabited across Atlantic Canada during its precontact history.

Atlantic Canada was almost completely covered by Late Wisconsinan glacial ice, which at the height of the LGM, reached the edge of the continental shelf, now hundreds of kilometers offshore (Shaw et al. 2006). As ice began to retreat, multiple local ice dispersal centers became independent from the main Laurentide Ice Sheet.

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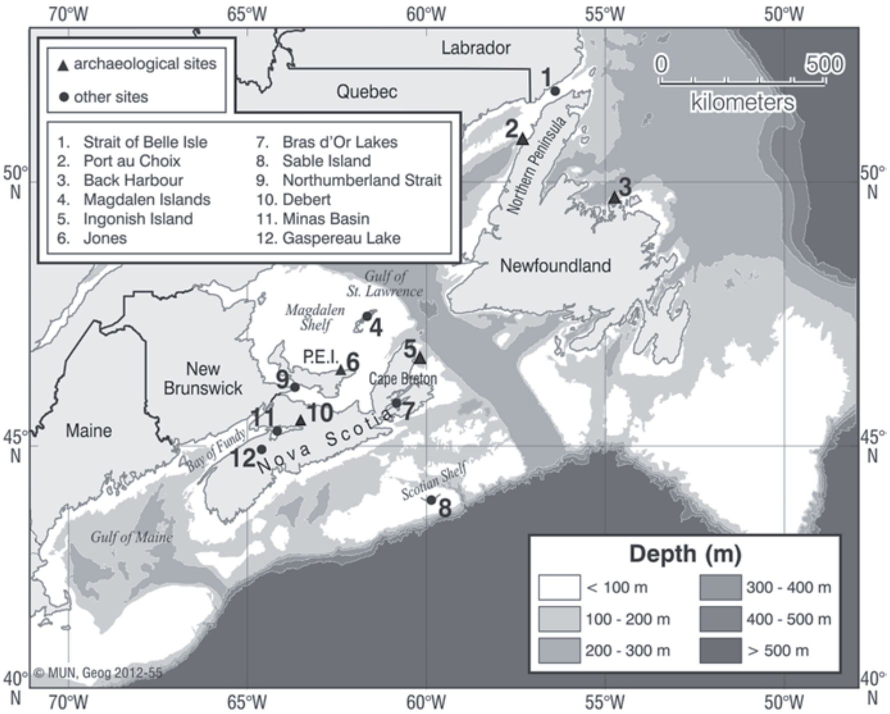

Fig. 2.1 Map of Atlantic Canada including the Maritime Provinces of New Brunswick, Nova Scotia, and Prince Edward Island (PEI), Newfoundland and Labrador, and eastern Quebec and its simplified offshore bathymetry

This resulted in variable local responses to ice unloading and a complex history of crustal readjustment across Atlantic Canada (Quinlan and Beaumont 1981). Therefore, the diverse interplay between isostatic responses and eustatic sea-level rise, at a local scale, has produced highly variable temporal and spatial patterns in local RSL histories (Shaw et al. 2002).

The following sections provide a broad overview of the major changes that have occurred to the paleolandscapes of Atlantic Canada, highlighting the areas that appear to offer the most potential for submerged landscape archaeology. Current evidence of human presence on these submerged landforms is reviewed and the factors influencing the preservation potential of a variety of submerged geomorphic features is examined. It is suggested here that submerged landscapes of Atlantic Canada are well-positioned to address a number of important research questions that can greatly advance our understanding of the precontact history of the region. Two case studies are presented: in one, the investigation of submerged archaeological landscapes helps archaeologists reinterpret portions of the region's precontact history, whereas in the other a similar focus reveals manners in which indigenous groups who witnessed the result of a catastrophic submergence-induced event have incorporated its memory into their oral histories.

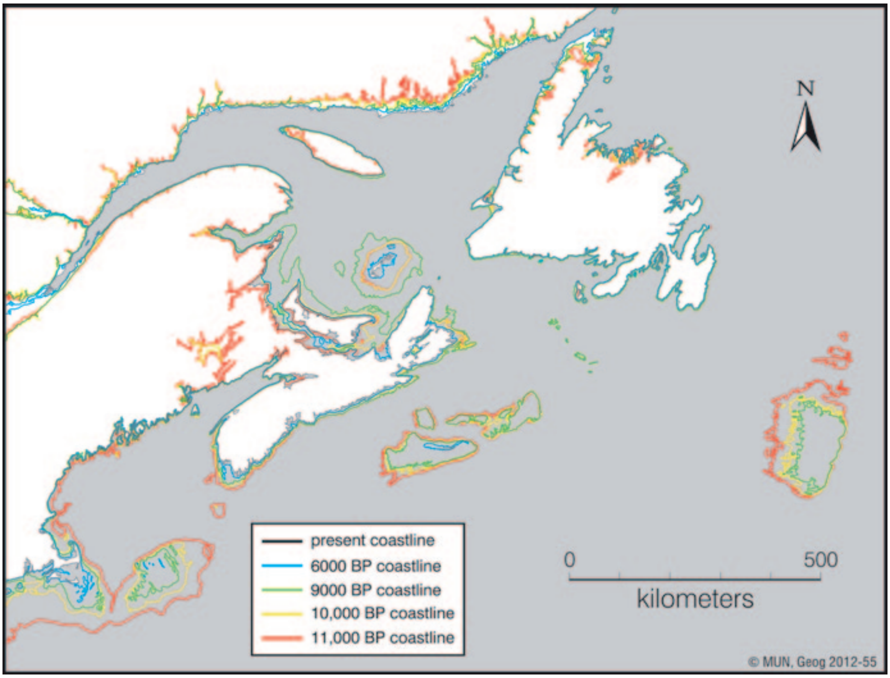

Fig. 2.2 Paleolandscape evolution of Atlantic Canada at various periods (simplified from Shaw 2005: Fig. 5; see Shaw et al. 2006 for the extent of glacial ice cover that would have prevented access to certain landscapes prior to 10,000 BP)

Early Holocene Paleolandscape Evolution

Atlantic Canada's complex response to deglaciation has resulted in three principal RSL patterns (Quinlan and Beaumont 1981). Coastal regions of the southern Labrador-Quebec Peninsula and Newfoundland's Northern Peninsula have been emerging since they became ice-free, and all former shoreline positions are found above the current sea level. The southernmost regions of Atlantic Canada, those formerly located at the very edge of the LGM ice cover, such as the main offshore banks, have been submerging throughout the postglacial period and all former shoreline positions are now located below current sea level. In the remaining regions, sea levels dropped to a local lowstand before rising to their modern position, although in certain areas postglacial shorelines were never above current sea level (see Figs. 2.2 and 2.3).

The paleogeography of Atlantic Canada has been discussed in detail elsewhere (Shaw et al. 2002; Shaw et al. 2006). The general outline of contemporaneous shorelines at selected time slices are presented in Fig. 2.2 and maps of the regional pattern of RSL values for the same time steps are presented in Fig. 2.3 (all dates provided in the text and figures are in uncalibrated radiocarbon years BP). The most dramatic changes to Atlantic Canada's paleolandscapes occurred in the first few thousand

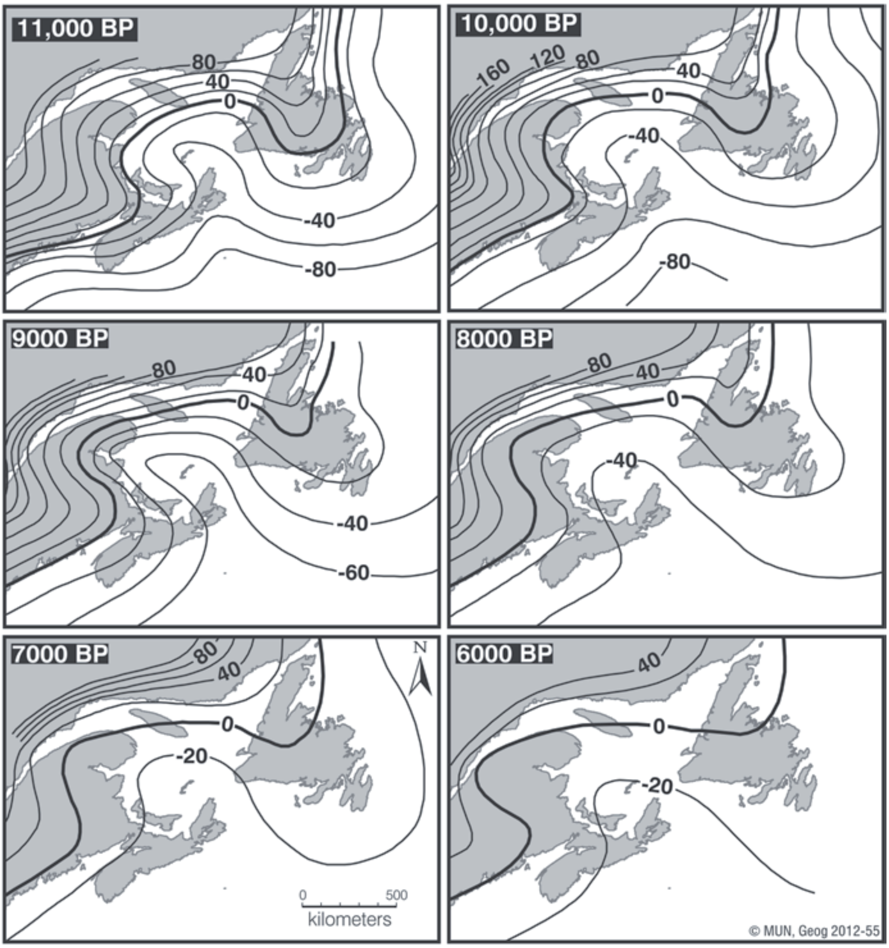

Fig. 2.3 Isobase maps for 11,000–6,000 BP, where lines [isobases] join points of equal emergence or submergence (negative) for each specified time period. (After Shaw et al. 2002: Figs. 5 and 6)

years that followed glacial retreat. At this time, large offshore islands existed along the edge of the continental shelf, although transgression almost immediately began in this area, greatly reducing their size until they completely disappeared, with the exception of Sable Island. The Magdalen Plateau was also occupied by a massive island extending off today's Magdalen Islands and reached its peak size ca. 9,000 BP. Another dramatic transformation created a land bridge between PEI and the mainland by 10,000 BP, which was maintained over the next 4,000 years. Important expanded coastal areas were also present at one time or another along the southern shores of New Brunswick, Nova Scotia, the perimeter of Cape Breton Island, and the central and southern regions of Newfoundland. The paleoenvironmental evolution of all regions, except those found at the northernmost extent of the study area, took the form of a more-or-less rapid succession from herbaceous tundra through shrub tundra and open woodlands to closed forests (Anderson 1980; Lamb 1984; Macpherson 1995; Mott 2011; Richard 1985).

Assessing Archaeological Potential

There are three simple criteria for a submerged archaeological landscape to exist: the sea level must have been lower at some point in the past, prehistoric humans must have been present and occupied the exposed land, and sedimentary processes during transgression must have preserved rather than eroded the landscape (Westley et al. 2011b). As the broad-scale paleolandscape evolution presented earlier indicates, large areas of Atlantic Canada were emergent at some point during the post-glacial period. At this scale, the regions that appear to offer the most potential are the shelf-edge archipelago, the expanded southwestern tip of Nova Scotia, the enlarged Magdalen Islands, and the Northumberland Strait. Currently, there is no evidence of human presence on many of these former landscapes. Because of ongoing high-energy marine processes, many submerged landscapes have been reworked to a point where, if any archaeological material had been deposited, they would no longer be preserved in their original context. The following sections highlight which areas offer the best archaeological potential to advance an understanding of Atlantic Canada's precontact history.

Evidence of Precontact Human Presence on Submerged Landscapes

In Atlantic Canada, the earliest evidence of a coastal adaptation dates to ca. 8,500 BP, appearing with the earliest human presence in coastal areas found along the southern shores of the Quebec-Labrador peninsula (McGhee and Tuck 1975; Pintal 1998, 2006). South of the St. Lawrence Estuary, however, the first evidence of a truly coastal adaptation appears much later, ca. 5,000 BP, as sea-level rise brought contemporaneous coastlines near their current position (Bourque 1995; Sanger 2005; Tuck 1975). It is probable that the earliest inhabitants of the southern regions of Atlantic Canada made use of coastal resources due to the high productivity of coastal environments (Price 1995; Perlman 1980). Coastal settings offer numerous advantages, including access to a diversity of food and raw material resources, a high water table, and ease of transportation and communication along waterways (Benjamin 2010, p. 255; Andersen 1995). It is at the coast that the greatest population densities are found in all periods for which data are available (Maarleveld and Peeters 2004, p. 112).

The evidence for a precontact human presence on the now-submerged landscape is currently limited. In Atlantic Canada, archaeological research targeting precontact submerged heritage has been, at best, minimal (e.g., Davis 1991; Westley 2008) as most underwater efforts have focused on the historic period (e.g., Barber 1981; Bernier et al. 2007; Dagneau and Moore 2009, 2010; Fitzhugh and Phaneuf 2008; Roman and Mather 2010; Skanes and Deichmann 1985). The locations where precontact artifacts have been recovered from underwater contexts mainly reflect chance finds resulting from modern fishing and recreational diving activities. Therefore, in Atlantic Canada and adjacent regions of New England, the evidence of human presence on submerged landscapes is limited to the Gulf of Maine (e.g., Crock et al. 1993; Stright 1990; Price and Spiess 2007; Rice 1979; Spiess et al. 1983; Turnbull and Black 1988), the Bay of Fundy (e.g., Black 1997; Davis 1991), the greater Northumberland Strait (e.g., Deal et al. 2006, p. 263; Keenlyside 1983, 1984), and nearshore and intertidal areas of Newfoundland (e.g., Carignan 1975; Rast 1999; Westley 2008). The exception to the lack of research is the formulation of a seven-stage landscape research strategy that integrates computer modeling, geophysical surveys, paleolandscape interpretations, paleoenvironmental analyses, and archaeological prospection in order to pinpoint locations with the greatest chance of finding archaeological sites (Westley et al. 2011a). Until this strategy is applied at a much larger scale, the record of human presence on the now-submerged landforms will remain scant and rely mostly on anecdotal finds.

Preservation

The prime objective of submerged archaeological surveys is the identification of archaeological deposits in their primary context since this offers the most value to archaeological research. For a submerged site to be found in situ, however, it must first survive terrestrial burial, then one or multiple transgression episodes (Bailey and Flemming 2008). After inundation, numerous factors may affect the sediments holding archaeological remains. In Atlantic Canada, wave, current, and ice erosion are the principal destructive forces affecting submerged archaeological deposits (Flemming 1983). The greatest impact on archaeological deposits occur when the site is located either in the surf zone, where it is exposed to the direct impact of breaking waves, or in water only a few meters deep, where wave impacts at the seabed can still be violent (Bailey and Flemming 2008; Will and Clark 1996). Although constant exposure to these forces results in deposit disturbance, rare conditions may, in fact, cause the most damage to archaeological sites undergoing transgression (Flemming 2004, p. 13). These include tsunamis, extreme storms, iceberg grounding, and peak conditions such as highest tide, highest wave, and strongest current events.

Site preservation issues are illustrated along the emergent portions of the Sable Island Bank, which were once part of a large archipelago located at the edge of the continental shelf (see Fig. 2.2). As the sea level rose, these large islands progressively shrank in size and, today, Sable Island constitutes the only emergent portion of this former archipelago. Seismic stratigraphy of the deposits that form this and the majority of the other offshore banks, show that geological units associated with the postglacial period are made of reworked and unconsolidated sands due to high wave-energy conditions during transgression, followed by millennia of constant reworking by extra-tropical storms, hurricanes, and other marine processes (Amos and Miller 1990; Fader 1989; King and Fader 1986). Therefore, despite the occasional recovery of buried peat, providing pollen data and datable organic material (Mott 2011), there is only a very low likelihood that archaeological material, if ever present, has survived the early Holocene transgression.

Given the potential for site destruction, large-scale landscape survival is unlikely to be common in Atlantic Canada. Constant exposure to high-energy conditions, however, does not necessarily rule out site preservation. In British Columbia, multiple intertidal sites have been identified with undisturbed stratified deposits that have survived in the active beach zone on highly exposed locations, suggesting this may be the case elsewhere as well (Fedje et al. 2009). In fact, small pockets of in situ deposits have been identified by a number of researchers, often in association with favorable topographic settings, either lodged in peat layers, which are more resistant to erosion than marine deposits, or in sediments stabilized by sea grasses (e.g., Galili and Rosen 2011; Malm 1995; Momber 2000; Neumann et al. 2000; Wessex Archaeology 2008). Archaeological material recovered from reworked contexts can still provide valuable information to archaeologists (Grøn 1995; Hosfield 2007; Wessex Archaeology 2008; Westley et al. 2004). When medium-energy conditions dominate, affecting mostly fine-grained sediments, larger objects are likely to remain in position or in the vicinity of their original location (e.g., Brunning 2007; Faught 2004; Fischer 1995; Will and Clark 1996; Malm 1995).

Low-energy settings, however, are the most likely locations where in situ archaeological deposits can be identified; these include fossil estuaries and river valleys; the flanks of submerged banks and ridges likely to have peat layers; valleys, depressions, basins with wetland marsh deposits; nearshore creeks, mudflats, and peat deposits; low-gradient beaches with constructive onshore wave action; fossil archipelagos; erosional features protected by islands or found within an archipelago; submerged caves and rockshelters in re-entrant bays; fossil erosional shorelines; submerged rocky shores; and deposits of sediments formed within or washed into rocky gullies or depressions (Flemming 1983, 2004). Low-energy conditions can occur at a very local scale in the midst of high-energy environments, as a result of the particular geomorphology surrounding a given location. For example, during transgression in the Gulf of Maine, rocky islands sheltered basins from erosive wave action, protecting lakes and wetlands associated with evidence of human presence (Kelley et al. 2010). Here these environments were able to develop due to a slowstand period during which RSL rise was greatly reduced, underscoring the importance of relying on a well-constructed and locally specific chronology.

In Atlantic Canada, lowstands were generally of insufficient duration to develop large coastal landforms that could survive transgression and, therefore, there is only rare evidence of submerged shorelines (Shaw et al. 2009; Shaw 2005). However, few areas have a sufficiently detailed chronology to permit definite statements (Kelley et al. 2010). The most favorable setting encountered thus far is in freshwater lakes that once bordered coastal regions during the early Holocene and were rapidly submerged during the Holocene transgression. One of the best examples is found in the southern regions of the Bras d'Or Lakes, an inland sea on Cape Breton Island, Nova Scotia. The coastal regions of these freshwater lakes developed over more than 5,000 years, before being suddenly inundated as sea level rose above their rocky sill ca. 5,500 BP (Shaw 2005; Shaw et al. 2009). As seen in Fig. 2.4, multibeam imagery of the lake bottom reveals the presence of spits, barrier beaches, and lagoons in at least two different areas of the Lakes. Here, it is the rapid onset of transgression and the relatively restricted fetch within the lake that have helped preserve these coastal features.

Evidence of fluvial systems has also been identified near the modern coast, although the evidence is often minimal. Some of the best preserved fluvial systems have been found within the Bras d'Or Lakes, and also off the coasts of modern PEI (Forbes et al. 2004; Shaw 2005; Shaw et al. 2009). Multibeam bathymetry of the nearshore zone along the coasts of PEI indicates that relict fluvial features are still present on this open shoreline of the central North Shore (Fig. 2.5a), and provides clear evidence that a former lake and river system occupied the Northumberland Strait in the early Holocene when the Island was connected to the mainland (Fig. 2.5b). Deltaic systems have also been preserved in locations sheltered from wave action, although they appear to occur most frequently around Newfoundland, where early postglacial streams incised glacial deltas and outwash deposits at fjord heads, thus providing an ample sediment supply as the sea level dropped to local lowstands (Shaw 2005).

In summary, although large landforms were exposed at some point during the early Holocene, the most favorable settings for the preservation of submerged archaeological landscapes are found at the local scale, where a variety of factors combine to preserve these landscapes. A number of relict coastal, fluvial, and deltaic landforms are known to exist in Atlantic Canada, and through the targeted use of multibeam bathymetry, seismic profiling, and field sampling, areas with a fairly high archaeological potential can and have been identified in a variety of settings across the region.

People, Their Landscape, Their History, and Submergence

Despite the aforementioned evidence suggesting the existence of submerged archaeological landscapes in Atlantic Canada, there are no submerged precontact archaeological sites currently known beyond the intertidal zone. Dealing with submerged precontact landscapes in the absence of direct archaeological evidence from the seafloor necessitates a different approach to archaeological investigation. Forced to rely on patterns spanning wider regions, the human-landscape interactions then become the focus of attention. The following examines two study areas where the investigation of submerged landscapes offers insight into a variety of human-landscape interactions that were integral to the lives of the region's early

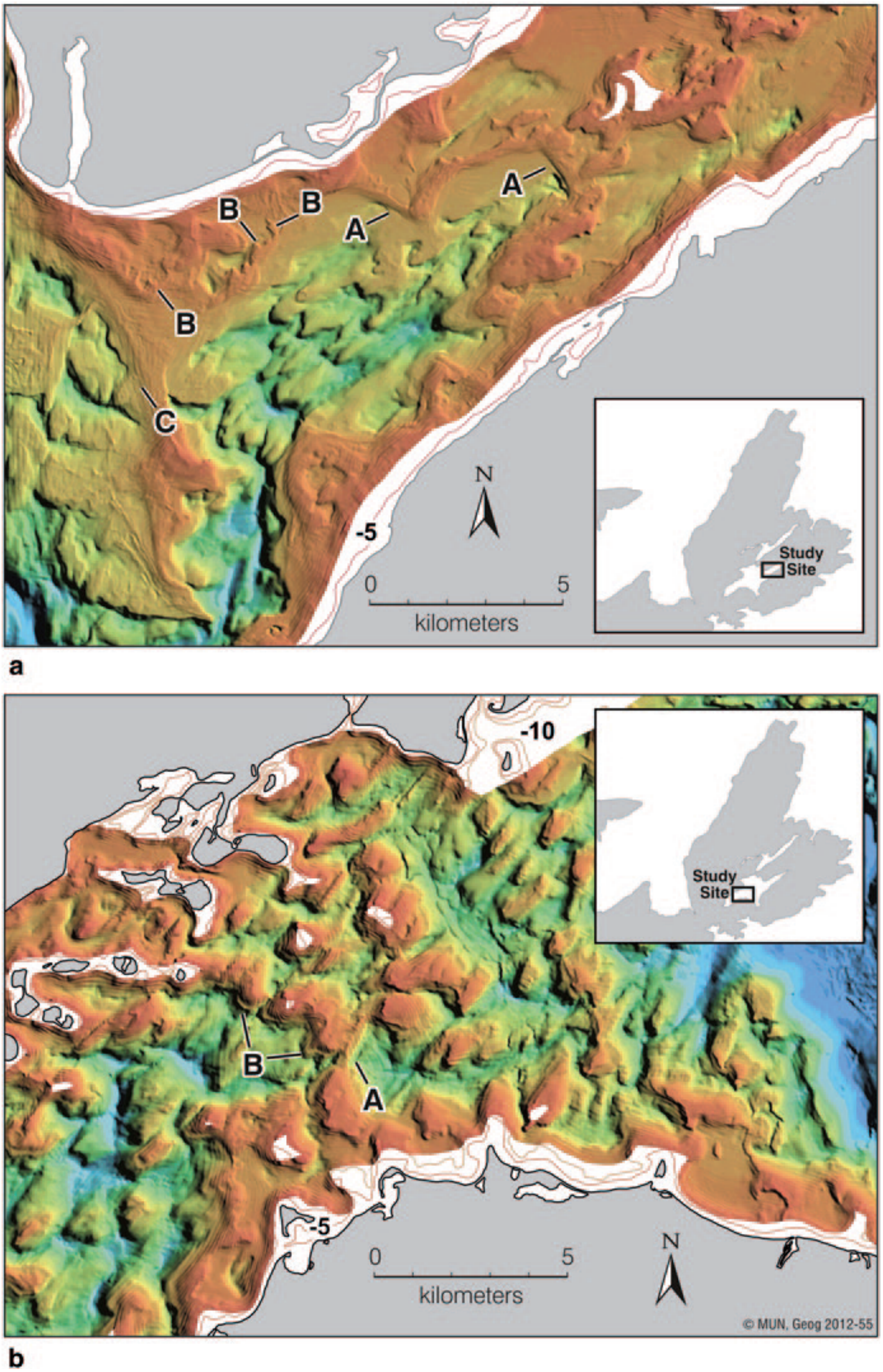

Fig. 2.4 Multibeam bathymetry of selected areas of the Bras d'Or Lakes showing evidence of preserved coastal features: **a** barrier beaches (*A*), spits (*B*), and tombola (*C*) in East Bay, and **b** submerged barrier beach (*A*) and erosional terraces (*B*) in West Bay. Shallow waters are represented by reds up to 25 m depth where yellows begin, and blues represent waters of 50 m depth or more (After Shaw et al. 2009: Figs. 8 and 9)

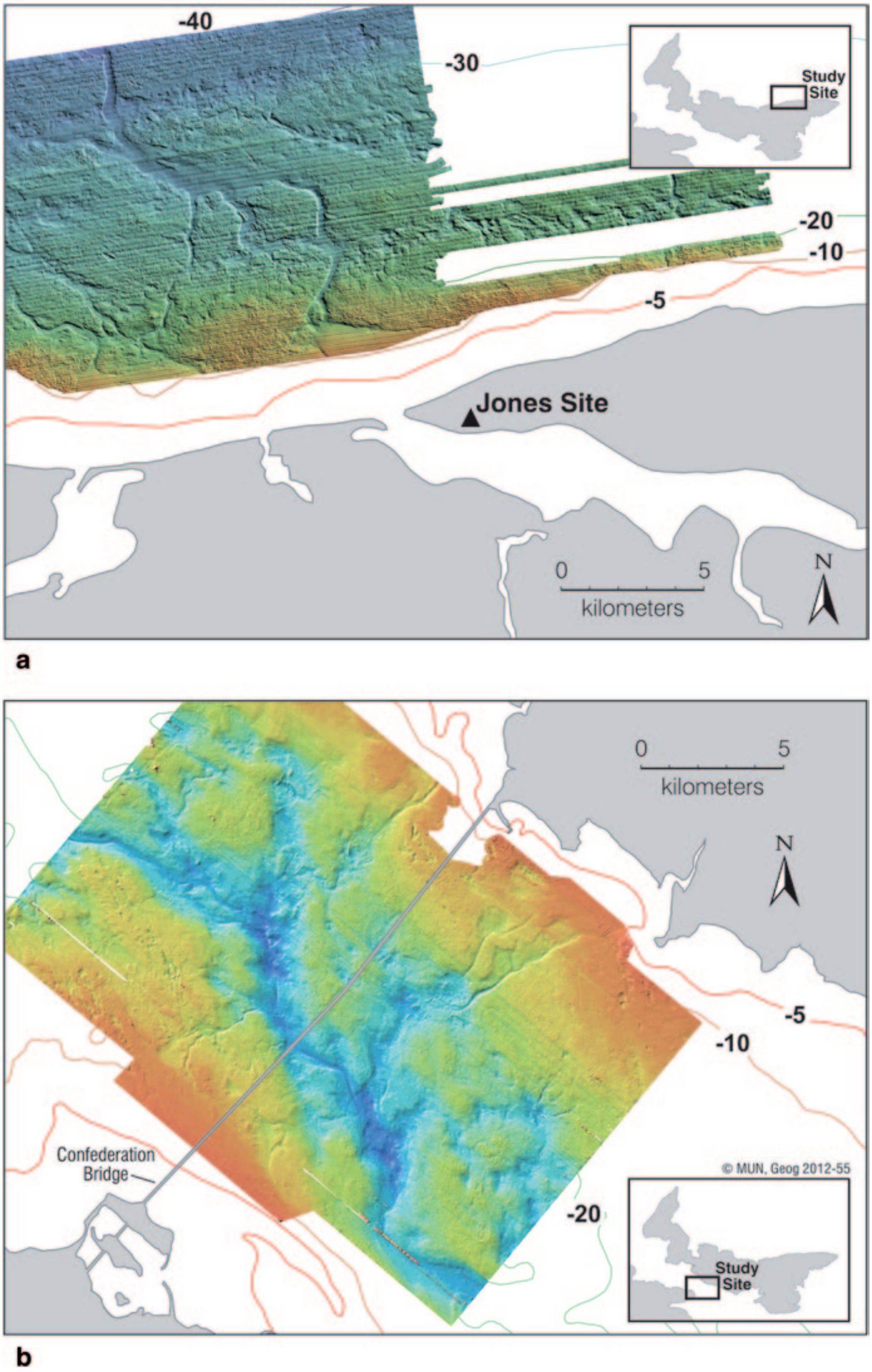

Fig. 2.5 Multibeam bathymetry off the coast of Prince Edward Island (PEI) showing preserved fluvial systems: **a** central North Shore and **b** Northumberland Strait. Note the definite inland location of the Jones site for any period where local sea-levels where more than 10 m below their current level. (After Forbes et al. 2004; Shaw et al. 2009)

inhabitants and which would not be evident otherwise. This demonstrates that researching human-landscape interactions that occurred on, or were influenced by, submerging landforms can help reinterpret the region's precontact history, and better understand how indigenous people developed their own histories. The now-submerged early Holocene coastal regions off PEI and the Magdalen Islands are especially well-positioned to inform archaeologists about the early development of seal hunting in the Northeast and re-evaluate current understandings of undated assemblages from the Magdalen Plateau. In contrast, the Minas Basin offers an interesting example in which rapid landscape submergence has led its indigenous inhabitants to develop their interpretation of a particular event, incorporating the social memory of the catastrophic event into their oral histories.

The Magdalen Plateau Hunting Ground

The Magdalen Plateau occupies the central area of the Gulf of St. Lawrence and this central location likely made this region an important hub in the development of local marine resource exploitation by postglacial pioneering groups. Early human presence on the Plateau is attested by finds of Debert-form Paleo-Indian points along the Northumberland Strait (Davis and Christianson 1988; Keenlyside 1985b, 1991). Over time, the descendants of these original families likely intermingled with other populations, such as the Plano-like Late Paleo-Indian population occupying the southern shores of the St. Lawrence Estuary (Dumais 2000), and the various Archaic groups inhabiting other coastal regions of Atlantic Canada.

An aspect of the developing coastal adaptation would have been the harvest of the large harp seal herd returning to the Magdalen Plateau every winter. This migratory species' summer range is found in Greenland, but two main breeding herds return to Atlantic Canada every winter, moving with the advancing sea ice front, and arriving between November and January via the tip of the Northern Peninsula (Sergeant 1991). The "Gulf" herd passes through the Strait of Belle Isle and into the Gulf of St. Lawrence, while the "Front" herd breeds off northeast Newfoundland. In early winter, harp seals must be intercepted in open water, necessitating a specialized technology. Harp seals reach their highest level of fat content and buoyancy in early winter, facilitating their capture with harpoons and providing an indispensable source of winter fat to their human captors (Spiess 1993). The seals remain in open water until the females are ready to calve, by early March, when they move onto the ice and can be hunted with simple clubs. The presence of sea ice is therefore an important factor influencing seal presence. Reconstructed sea-ice cover (SIC) conditions, inferred from fossil dinoflagellate assemblages preserved in marine sediments, suggest that during the early and mid Holocene, the Gulf of St. Lawrence was characterized by SIC conditions similar to the present (de Vernal et al. 1993). Therefore, just as today, the expanded regions of PEI and the Magdalen Islands during the early Holocene would have been ideally suited for a harp seal harvest.

New technology developed for the open water hunt would have revolved around harpoon design. These technological developments would not have occurred in a vacuum and would have been influenced by the people's own cultural traditions, as well as by ideas exchanged with other groups also developing their marine mammal hunting toolkit. Therefore, a certain level of similarity between assemblages in the region is to be expected. Small triangular and basally thinned points, with sharp barbs and a deeply indented base, have been identified from undated contexts on the Magdalen Islands and the northeastern coast of PEI and appear to predate the Woodland period (ca. 2,500–500 BP). These points are almost exclusively made of Ingonish Island rhyolite from Cape Breton and bear an important morphological resemblance to the Early Paleo-Indian Debert form of fluted projectile points seen in the Maritimes (Keenlyside 1991). A very general resemblance between the Magdalen–PEI point style and those from Early Archaic contexts north of the Gulf of St. Lawrence has also long been noted (Keenlyside 1985a, b, 1991, 2011), and this superficial resemblance probably attests to ongoing exchanges between the various groups inhabiting the shores of the Gulf of St. Lawrence.

Given their size (width: 2–5 cm, length: 3–9 cm; Keenlyside 1991: Table 2.2), these points were clearly intended for large animals, and very few large animals would have frequented the Magdalen Islands except for marine mammals (Cameron 1962; Dumais and Rousseau 1986). Within Atlantic Canada, the most striking morphological similarities between these points and other assemblages occur with Dorset Paleo-Eskimo endblades. While the workmanship, choice of raw material, and size standardization differ greatly between the two traditions, the two-point styles share a very similar shape outline. Although they are the result of independent development histories, we suggest this similarity may be, in part, functionally driven by the adoption of similar techniques to secure endblades to removable harpoon heads. This type of composite technology first appears in North America as a part of the Paleo-Indian big-game hunting toolkit (Boldurian and Cotter 1999). The Magdalen–PEI point style would then represent a local reinterpretation of the composite lance technology brought by Paleo-Indian pioneers to hunt caribou in Atlantic Canada, reimagined into harpoons for the in-water harvest of marine mammals. Although Keenlyside (1991, 2011) has suggested that these points tipped spear-thrower darts, it is more likely that they were used as harpoon endblades (Rousseau 1986, p. 26).

All known Magdalen–PEI endblades have been recovered from undated contexts, but were tentatively assigned to the Late Paleo-Indian period, ca. 10,000–9,000 BP, based on the stylistic considerations discussed above and a single undated stratigraphic context at the Jones site (Fig. 2.5a; Keenlyside 1985a, b, 1991, 2011). Recent work at the Jones site, however, has shown this context to be disturbed down to its basal stratum (MacCarthy 2003), leaving only stylistic similarities to support Keenlyside's original assessment. The patterned location of the finds further casts doubt on the Late Paleo-Indian assignation. The endblades were all recovered along the modern shorelines of the islands (Keenlyside 1991; McCaffrey 1992), far inland from the contemporaneous shoreline present during the Late Paleo-Indian period. As seen in Figs. 2.2 and 2.5, the northern shores of PEI and the shorelines of the Magdalen Islands extended far beyond their current limit until ca. 6,000 BP. This is especially true of the Magdalen Islands, which were already very large, long before PEI was fully deglaciated. The earliest traces of the marine-oriented technological development then had to occur some distance away from the current coastlines. Therefore, the current endblade assemblage is unlikely to date to the Late Paleo-Indian period, unless one is willing to extend its coverage to ca. 6,000 BP as McCaffrey (1992) has suggested. Instead, they likely represent an Archaic-period assemblage quite unlike those present either north or south of the Magdalen Plateau. This does not, however, negate that these points may represent a reinterpretation of an ancestral Early Paleo-Indian pattern by a descendant population. Any transitional material, likely similar to the finds already recovered, would now be in submerged contexts.

Archaeological evidence of the earliest developments, therefore, lies offshore from the current islands. Multibeam bathymetry coverage off the central north shores of PEI show relict valleys extending from the inner shelf (see Fig. 2.5a; Forbes et al. 2004). Furthermore, the smooth surface and low relief of the Magdalen Plateau, visible in the paleolandscape reconstructions, is due to reworked sediments that have been filled, and now mask, a complex system of buried channels and basins of various ages (Josenhans and Lehman 1999). Some of these relict systems may still preserve buried traces of the seal hunting development. A single offshore artifact find has been reported for this area. It consists of a Late Archaic ground slate semilunar knife, estimated to date to 5,000–4,000 BP, recovered from the nets of a scallop dragger (Keenlyside 1984). By this time, however, the contemporaneous shoreline would have been in close proximity to the modern coastline and the artifact was likely lost from either a boat or land-fast ice and, thus, is not a good indicator of human presence for the period of interest.

A number of precontact sealing stations are known in Atlantic Canada and provide information on the nature of the archaeological record expected on the now-submerged landforms. In Newfoundland, at least two sites were likely the focus of intense sealing activities. The first is Back Harbour, on the northeast coast, where the intensity of occupation was such that the entire modern community is considered one large archaeological site (Temple 2007; Wells and Renouf 2008). There are more than 20 sites recorded within this small community, with a peak presence during the Archaic which included a significant burial ground, a large habitation area, and a large activity area where heavy woodworking ground-stone tools dominate. The second is Phillip's Garden, found near the modern community of Port au Choix on the Northern Peninsula. Here, seal skeletal elements are abundant, and the site is pockmarked by the remains of at least 68 dwellings (Renouf 2011). These sites clearly were significant places to the families living in these regions, and their presence has made an important impact on the local landscapes. Therefore, precontact human presence targeting the mass exploitation of harp seal on the extended regions of PEI and the Magdalen Islands can be expected to have left significant traces of their presence, and a targeted search strategy would likely be successful in identifying a true Late Paleo-Indian-Early Archaic presence on the Magdalen Plateau.

In summary, submerged landscape research focusing on the Magdalen Islands allows archaeologists to begin to address issues related to the antiquity of coastal adaptations in this region. The local development of harpoon endblades can be seen as a reinterpretation and reinvention of the ancestral Paleo-Indian big-game hunting pattern, which was repackaged for large sea mammals. The similarity between the assemblages recovered from the Magdalen Islands and PEI, which cluster at the point of shortest crossing, strongly suggests a close relationship existed between the two areas by the Late Archaic. The presence of groups on the Magdalen Islands also suggests precontact seafaring abilities, as large open-water crossings were always necessary to reach this area. Finally, in the process of reevaluating the impacts submergence has had on the archaeological record it becomes evident that an assemblage assigned to the Late Paleo-Indian, is in fact more likely to date to the Late Archaic or possibly even later.

The Storied Minas Basin

Changes linked to submergence were not always gradual. These sometimes dramatic changes would have had a direct impact on the lives of the people inhabiting areas experiencing sea-level transgression. Popular and anecdotal evidence for large-scale floods that swallowed land and impacted human life are prevalent among many cultures. Among Western cultures, two stories are particularly well-known. The first involves the legendary Atlantis that was swallowed up by the sea and vanished in a day, and the second, the Biblical flood that wiped the world clean of the wickedness of man. In Europe, fossils and drowned forests (Noah's Woods, see Gaffney et al. 2009, p. 2) were attributed to the great deluge. Flood myths are also present among indigenous cultures in Canada. The Haida of northwestern British Columbia have oral histories that remember a world of mostly water and catastrophic flooding events (Kii7iljuus and Harris 2005). Within the framework of the archaeology of submerged landscapes, these myths can become an important interpretive tool and provide insight into the responses humans have had to sea-level change.

One example of a dramatic change that has occurred in Atlantic Canada, and left an important mark in the psyche of the culture that witnessed it, is the catastrophic tidal expansion that occurred when the megatidal regime of the Bay of Fundy finally reached the Minas Basin. This basin is found at the southeastern end of the Bay of Fundy where the basin and the bay are connected by a narrow channel (Fig. 2.6). Human presence in this area has a great time depth. The oldest dated site in Atlantic Canada, the Debert Paleo-Indian site, is located only 10 km from the shores of the Minas Basin, although at the time of its occupation, it would have been at least 25 km away from the contemporaneous coastline (Borns 2011). This basin has long been an important hub of human movement, being at the head of a number of important interior travel routes, including the Gaspereau Lake and River system which itself exhibits evidence of a continuous human presence dating back to the Paleo-Indian period (Laybolt 1999). As a result, the Minas Basin has clearly been an important place for the communities that inhabited this landscape.

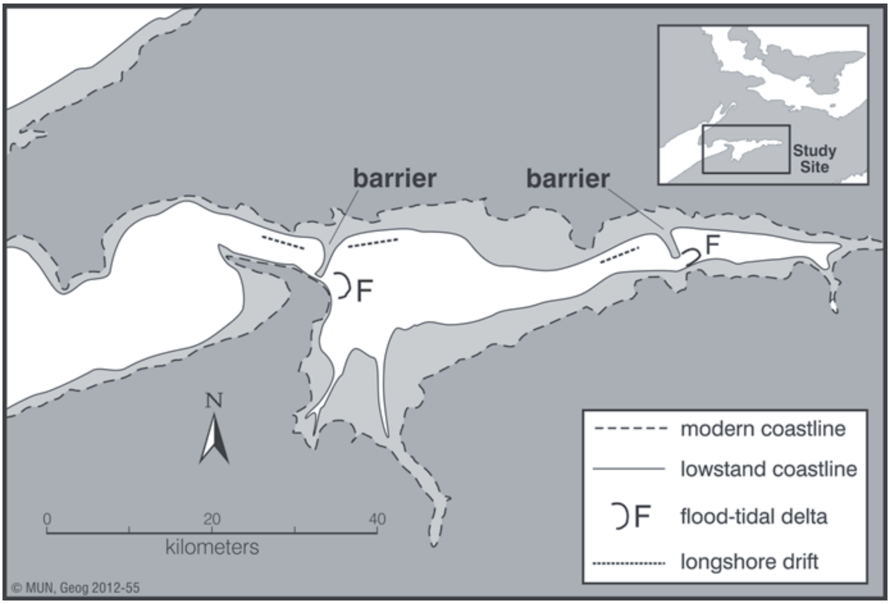

Fig. 2.6 Early Holocene configuration of the Minas Basin, including the sand and gravel barrier that restricted water exchange between the Basin and the Bay of Fundy. (After Shaw et al. 2010: Fig. 7)

Over the course of precontact history, the Minas Basin has seen important changes in its topography due to sea-level rise. A submerged forest of pine and hemlock dated to 4,400 BP has been documented along its southwestern shores (e.g., Goldthwait 1924; Grant 1970; Harrison and Lyon 1963; Lyon and Goldthwait 1934). This forest was eventually capped by an immense salt marsh as sedimentation kept pace with rising high tide. By 3,800 BP, an outlet of the Gaspereau River became subtidal and an extensive oyster bed developed off Boot Island. Relatively young oyster shells measuring up to 25 cm in length have been recovered, suggesting optimal growing conditions, and three specimens have produced radiocarbon dates near 3,800 BP (Bleakney and Davis 1983).

At the time these beds developed, the Minas Basin was likely lagoonal to mesotidal, protected from the megatidal cycles of the Bay of Fundy by a sand and gravel barrier at the Minas Passage (Shaw et al. 2010). With the rapid breakdown of this barrier ca. 3,400 BP and near-instantaneous tidal expansion into the basin, water temperature dropped, tidal currents and turbidity increased, and the environment of the inner estuary became macrotidal. This rapid change is reflected in the undisturbed context of the buried oyster bed, indicating they died in situ due to high turbidity and heavy sediment loads (Bleakney and Davis 1983). According to Shaw et al. (2010), the impact this catastrophic change had on the people of the area appears to have been remembered for over three millennia in the form of a Mi’kmaq legend in which Glooscap, their culture hero, had Beaver build a large dam in order to form a bath in the Minas Basin, reducing water flow and angering Whale in the process, which eventually resulted in Whale rupturing the dam with its tail with such force that water still flows back and forth to this day.

Places are not just points on a map, they are remembered locations where action transpired and memories linger. They are the materialization of memory within the landscape, a memoryscape (Nuttall 1992; Kahn 1996; Knapp and Ashmore 1999; Van Dyke 2008). In an illiterate world, memories are transmitted through storytelling. Narratives associated with particular places are often linked to important social information (Cruikshank 1990). They provide mythical accounts for the creation of a landform; describe important historical events for the group; delineate codes of ethical conduct; provide important messages for travelers; define the relationship of people to the land and its resources; describe particular harvesting or processing activities; and bring songs, friends, or encounters back to mind. Narratives are of prime importance and place names help locate narrated events in the physical setting where they occurred. As stories and myths repeatedly unfold against a geographical backdrop, they become an integral part of those places. Places themselves become mnemonic pegs that help recall their associated narratives. Story and place dialectically help construct each other. Events are given meaning through retelling and re-enactment, establishing bonds between people and features of the landscape that can endure for millennia.

In the Minas Basin, ongoing submergence led to a catastrophic event that greatly impacted the lives of the people inhabiting the region. While travelling across the Minas Basin, generations of people inhabiting the region came into direct contact with evidence of the catastrophic transformation that occurred thousands of years before, further reinforcing elements of the familiar story. As the ancestors of today’s indigenous nations journeyed along the now-submerged forest, they would have recalled the story associated with its dramatic creation, transmitting its memory across many new generations. Over the last 3,400 years, the repeated retelling of this particular story, with its association to the local culture hero and the visible evidence of his actions all intermingled to transform the submerged landscape of the Minas Basin into a memoryscape, a process reflecting the active role precontact indigenous groups took in the recording of their own history.

Conclusion

Local patterns of sea-level change have greatly impacted the evolution of the paleolandscapes of Atlantic Canada. During the Holocene, large tracts of land became exposed by ice retreat and vegetated, before disappearing as a result of sea level rise. The most dramatic examples include the creation of a chain of large offshore islands at the edge of the continental shelf, the remarkable expansion of the Magdalen Islands, the creation of a large interior landscape replete with lakes and river systems around PEI, and the seaward migration of tens of thousands of kilometers of coastlines as sea levels dropped to their local lowstand. Only a few regions, however, have concrete evidence of a human presence on now-submerged landscapes. These include the coastal regions of Newfoundland, the Northumberland Strait, the Bay of Fundy, and adjacent regions of the Gulf of Maine. As discussed above, many inundated regions revealed through a broad-scale paleolandscape reconstruction have been impacted by marine processes to such an extent as to greatly limit their potential for archaeological research. The highest potential resides at the local scale, where the interplay between a variety of factors can result in the preservation of submerged archaeological landscapes.

The evolution of Atlantic Canada's paleolandscapes after the LGM has greatly impacted both the colonization of the area by human populations and the archaeological visibility of their presence. Throughout the Holocene, sea-level change has allowed people to explore and settle new regions, also forcing them to rescind their use of ancestral landscapes as sea level rose. These changes are still ongoing today. As once-emergent landscapes disappear through transgression and once-inhabited worlds are lost, they become part of the social memory of the groups who formerly inhabited these regions as they are actively involved in the recording of their own histories. Submerged landscape research can also help write and revise our interpretations of the precontact history of Atlantic Canada, providing insights into the antiquity of coastal adaptation in the Northeast, human mobility, interaction networks, precontact seafaring abilities, and human responses to changing coastal environments. The study cases presented attest to the importance of continued archaeological research targeting the submerged landscapes of Atlantic Canada.

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Chapter 3
Remote Sensing, Target Identification and Testing for Submerged Prehistoric Sites in Florida: Process and Protocol in Underwater CRM Projects

Michael K. Faught

Introduction

At the time this chapter was written, only 3 states out of 22 in the USA with coastlines, Maine, Maryland, and Florida, required background research, predictive modeling, and remote sensing surveys pertinent to locating and protecting submerged prehistoric sites[1]. The goal here is to provide examples from the state of Florida that demonstrate how these methods work, and to encourage administrators, resource managers, and other researchers to incorporate these protocols in future underwater work in order to protect submerged prehistoric sites.

Why focus on Cultural Resource Management (CRM) as a venue for practicing submerged prehistoric geoarchaeology? Because more and more of these kinds of projects are being required and more are going to be required in the future, because they are adequately funded, and because they demand appropriate technologies like side-scan sonar, sub-bottom seismic profiling, swath bathymetry remote sensing, and sometimes sediment sampling by various coring devices (Faught and Flemming 2008). It can be argued, in addition, that large industrial strength hydraulic dredging and sand resource mining equipment, which normally are considered destructive to archaeological resources, can be adapted to conduct controlled underwater exposures, by increasing the size, or depth of the potential sample areas, or both, thereby enabling development, managing resources, and learning more about the past.

As Senior Maritime Archaeologist at Panamerican Consultants, Inc., the author has been involved in several maritime CRM projects in Florida with foci on historic

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[1] The states with coastal margins include thirteen states and Florida along the eastern seaboard, four and Florida in the Gulf of Mexico, and four with Pacific Ocean coastlines. Pacific states rarely require *any* submerged resource evaluations, shipwreck or prehistoric, itself a cause for concern, but coastal states along the Atlantic seaboard and around the Gulf of Mexico do require remote sensing surveys for historic shipwrecks with some regularity.

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and prehistoric resources, including both survey and testing phases. These projects, discussed and cited in the following sections, include private sector pipeline trench exposures, dredging for berthing facilities in Tampa Bay, and navigation widening projects conducted for the US Army Corps of Engineers (USACE). These USACE projects have been in Tampa Bay, the St. Johns and Indian rivers, Naples and Sarasota bays, and in two offshore locations on the east and west coasts of the state. These projects have served as examples for revising and refining methods of searching for prehistoric sites. While the results are not spectacular, the projects have produced data used in developing protocols for identifying and testing submerged prehistoric "targets" that may be useful to others.

The Floridian peninsula—and its now-submerged continental shelf—has been occupied for as long as people have been in North America and it has produced more recorded submerged prehistoric sites, artifacts, and burials than any other state in the USA (Faught 1988, 2004; Flemming 1983; Clausen et al. 1975, 1979; Dunbar 1991; Goodyear and Warren 1972; Ruppe 1980; Stright 1990, 1995). Florida has also been at the forefront of legislation and management of submerged cultural resources for decades, first with shipwrecks, and now with requirements for research and protection specific to submerged prehistoric sites.

There are three primary aspects of the projects that demonstrate how concern for prehistoric sites can be incorporated in CRM projects. These are: (1) modeling for sites by the identification of relevant antecedent landforms, culture groups and sea-level history; (2) remote sensing using different kinds of underwater acoustic devices and identification target genres; and (3) coring, or dredging, and (4) geologic analysis of sediments to test for the presence or absence of evidence for human activities.

Modeling for Sites: Cultural Histories, Local Geologic Details, Sea-Level Rise History

An excellent example of the method of compiling and synthesizing details of culture history, geology, and sea-level rise in order to identify potential zones for prehistoric sites is Coastal Environment's (1977) "Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf, Volume I: Prehistoric Cultural Resource Potential"[2] (CEI 1977). This work showed that predictive models for prehistoric sites can be developed by summarizing local upland Pleistocene-Holocene archaeological data, local geologic information, and local sea-level rise history to reconstruct when and where different paleolandscapes would have been dry, and what local culture groups would have been in the project area at that time. This allows the researcher to model site locations, types of sites, and kinds of artifacts to be expected. This approach is qualitative, but statistical modeling is also possible where Geographic Information System (GIS) layers are available, such as archaeo-

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[2] See Pearson et al. this volume for more on this project.

logical site distributions, reconstructed drainage patterns, paleovegetation and paleofaunal distributions, and paleolandscape extents.

Other data sets also can be useful, such as geo-referenced historic maps (discussed below) or the distributions of previously remotely sensed features of interest. Knowing the distributions of archaeological sites is best accomplished with regulatory agency-based data compilations such as state site file data in the USA. The Florida Master Site File (FMSF) has sophisticated GIS layered data, available to professionals and vetted researchers with more than 31,000 sites statewide that have been recorded and digitized. In Florida, these data include cultural affiliation, site type information (including multiple categories for submerged sites), and citations to reports.

Georeferencing Historic Charts to Understand Past Coastline and Channel Configurations

Georeferenced historic navigation charts are useful tools to reconstruct coastal and channel configurations that existed before modern impacts to bays and inlets. Many charts made in the nineteenth and early twentieth centuries can be georeferenced and used with precision in GIS analysis and in combination with remote sensing information. Two examples are presented here. Fig. 3.1 shows significant made-land cloaking the original bay bottom where dredging for new berths was planned in Hillsborough Bay (the northeast arm of Tampa Bay). The modern fill concealed a near-channel paleolandscape, likely the channel of the Paleo-Hillsborough River, which had the potential for prehistoric sites. The channel was identified with sub-bottom profiler and plotted on the historic map of the GIS project. Because of diverse modern impacts to the bay and the restricted area of dredging, monitoring of dredge spoil was recommended in order to record any cultural materials dredged up from the original Bay bottom (Faught and James 2007). Based on chert artifacts, cut-marked bone, and a diagnostic Middle Archaic projectile point recovered during monitoring (Faught and Ambrosino 2007), the location was designated as a new "site" (8 HI 393, Port Sutton Dredge Site) in the Florida Master Site File (FMSF).

Figure 3.2 was made by georeferencing charts made from 1859 to 1879 and overlaying them on a modern orthophoto quad with Florida Master Site File (FMSF) sites indicated. The figure illustrates the complex morphology of the St. Johns River bottom, and revealed meander-like channel segments that had not been previously recognized by local geologists. Some of the paleochannel segments were confirmed with seismic remote sensing revealing diverse preserved strata (Faught and James 2011). The chronology of this record remains to be worked out.

Use of these maps is important because Middle and Late Archaic—that is, middle and late Holocene prehistoric sites—are the most frequent kinds of submerged prehistoric sites identified in the USA, and they are found in shallower water situations (less than 30 ft (10 m)), such as in bay and inlet settings as found in most coastal states (e.g., Blanton 1996). Submerged prehistoric sites known elsewhere in

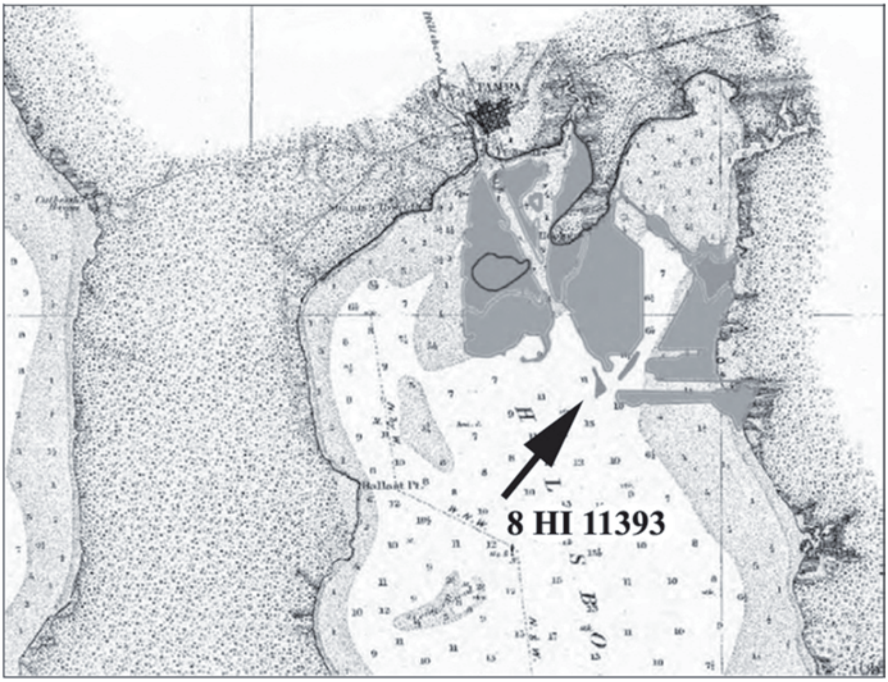

Fig. 3.1 A portion of Hillsborough Bay, in the northeast arm of Tampa Bay, Florida, with the 1879 configuration in *black* and *white*, and made-land portions of the modern configuration in *darker gray; arrow* points at berth excavation sites in *black* along the probable margins of Paleo-Hillsborough River identified with sub-bottom profiling

the world are dominated by similar middle and later Holocene examples in similar shallower water settings (Benjamin et al. 2011; Masters and Flemming 1983). Some submerged prehistoric sites could have been relatively recently submerged depending on the local geology. In Louisiana, for instance, 2000-year-old Woodland period sites have been completely or partially drowned due to sediment loading and recent subsidence (Charles Pearson personal communication, Richard Weinstein personal communication).

Geoarchaeological Uses of Acoustic Data—Target Identification

Strictly speaking, submerged prehistoric sites cannot be remotely sensed because no equipment is presently available that can directly identify artifacts or other physical evidence that a prehistoric site is present. Thus, searching for submerged prehistoric sites is really an exercise in remote sensing for paleolandforms, sedimentary deposits, or other geomorphic features that have known potential for archaeological

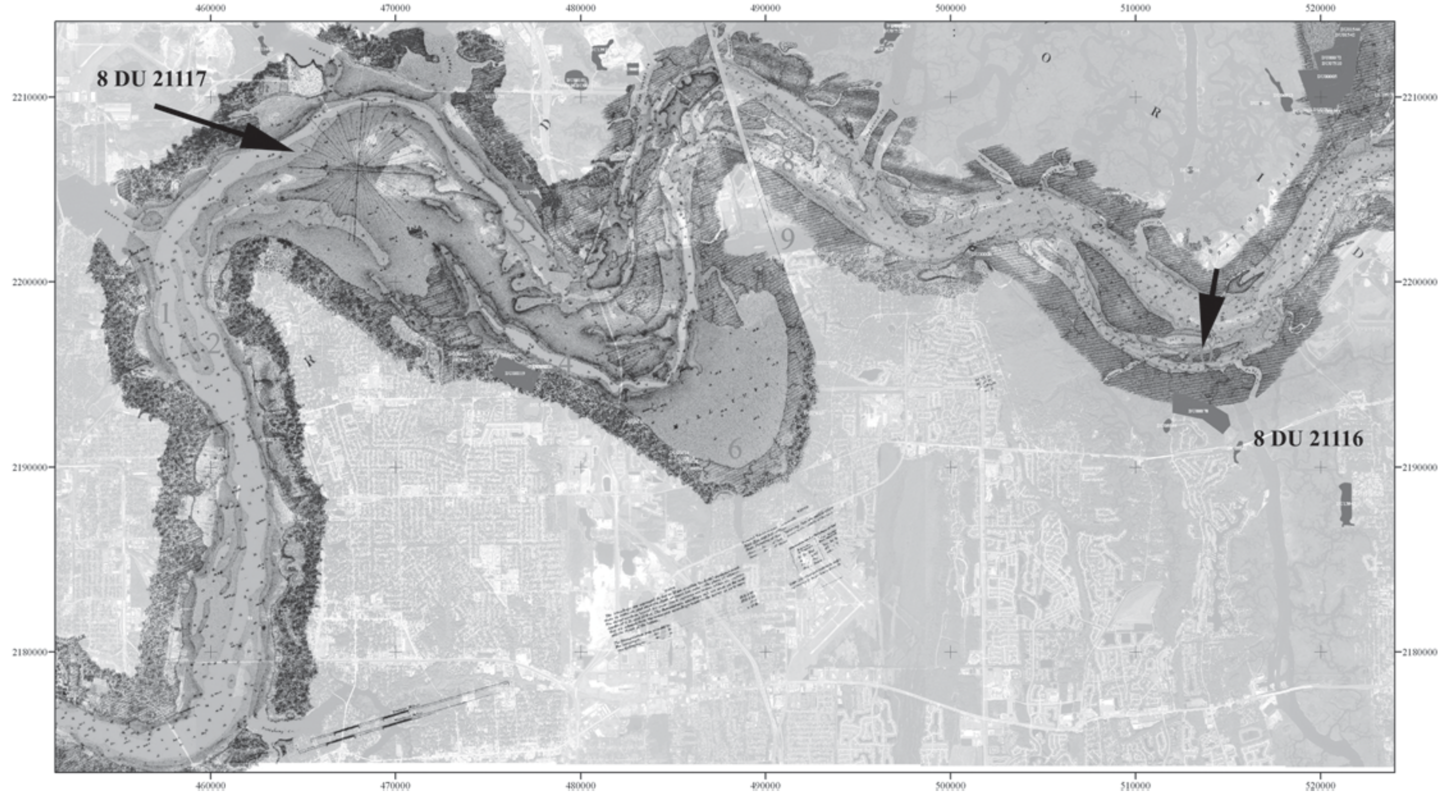

Fig. 3.2 A projection of the 1856 and 1879 charts of the St. Johns River (NOAA Historic Maps online), georeferenced, showing the locations of two archaeological sites added to the FMSF and the local orthophoto quad from USGS and LABINS

site presence and preservation. The key to success is using local terrestrial archaeology to predict the location of submerged sites locally.

There are more and more examples of models using terrestrial analogs and reconstructions of bottom morphology and seismic data to identify site potentials (Benjamin 2010; Benjamin et al. 2011; Coleman and McBride 2008; O'Shea and Meadows 2009). Likewise, models of the presence and preservation of submerged coastal archaeological sites impacted by the sea-level transgression have been discussed in several previous publications (Blanton 1996; Gagliano et al. 1982; Hoyt et al. 1990; Kraft 1986; Kraft and Chacko 1978; Kraft et al. 1983; Lewis 2000; Waters 1992).

Where paleolandscape areas are exposed or shallowly buried, side-scan sonar and multibeam bathymetry are useful tools to make what are known as "sound underwater images," or acoustic images, for understanding antecedent landscape configurations, like paleochannel patterns, or exposed shell middens or rock outcrops, features that should produce high backscatter arrays (Faught 2002–2004; Fish and Carr 1991; Gusick and Faught 2011). However, most of the sea floor is covered by silt, mud, and sand sediments and only seismic remote sensing can penetrate these beds. Seismic remote sensing with sub-bottom profilers is most useful for identifying marine sediment cover, paleodrainage patterns, and buried features, like shell middens (Gusick and Faught 2011; Leach and Belknap 2007).

Seismic remote sensing is not a panacea, however. Seismic data are reflection coefficients, basically dark and light (higher and lower amplitude) reflections, due to changes of sediment characteristics. These characteristics can be due to beds of differential hardness, as well as to constituents like organic or fine-grained deposits that create highly reflective (dark) returns (Plets et al. 2007; Stevenson et al. 2002)[3]. Thus, the analytical challenge is distinguishing reflectors that have archaeological significance, i.e., subsurface layers that may contain archaeological material or indicate proximity to such. Because some littoral processes generate organic rich deposits, they can be identified in sediment profiles with sub-bottom profilers, and allow estimation of past coastline presence, and human behaviors nearby.

Inset terraces (horizontal surfaces) near paleochannel features and shell midden accumulations, especially those attaining substantial positive relief, are common target items or features in the predictive models in Florida presented here. Other terrestrial analogs also can be used, especially locally unique features (such as sinkholes, or tool-stone rock outcrops), but horizontal surfaces near drainages and shell midden deposits are the most easily identifiable features in Florida using remote sensing.

This "channel adjacency" model of prehistoric land use proved useful in the St. Johns River (Fig. 3.2) where a flat terrace-like surface adjacent to a vestige of a paleochannel feature at a depth of 10 m (30 ft, Fig. 3.3) was recommended for avoidance and later tested during diving operations with 4 in. air lift excavation

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[3] One caveat of remote sensing with subbottom profilers is that lower frequency devices are needed in sandy/shelly environments, whereas higher frequency devices can be used with finer grained and higher organic content deposits.

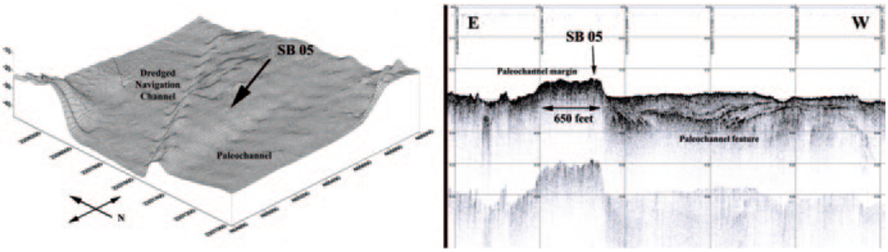

Fig. 3.3 *Left*: bathymetric mesh reconstruction of the bottom morphology of the St. Johns River; *right*: a sub-bottom profile in the St. Johns River, *horizontal lines* at 10 ft intervals. *Arrows* point at Paleochannel margin where artifacts were located with radiocarbon age consistent with the depth

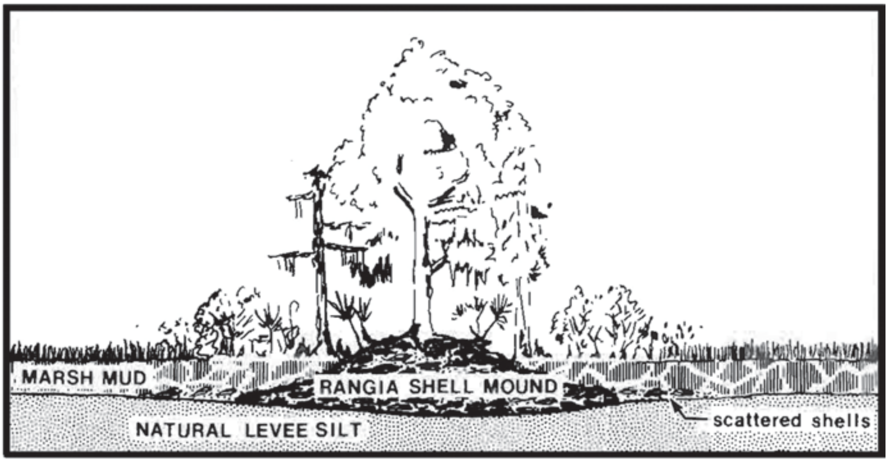

Fig. 3.4 Conceptual image of how a shell midden can become submerged as the sea levels rise (after Gagliano et al. 1982, p. 4). Root systems and the interlacing of disarticulated shells will tend to hold the archaeological deposits in place

sampling. Point count analysis of the samples, described in more detail in the following section, produced fossil bone, small debitage flakes, and a radiocarbon age on charcoal of 6010 ± 40 BP (Beta 285863). Sea-level reconstructions demonstrate the feature would have been exposed as dry land at that time. The find has been designated as a new site in the Florida Master Site File (8 DU 21117).

Shell middens may be the most likely, most frequent, and most accessible target in inundated settings in many places. Fig. 3.4 is a schematic of a midden in the process of being submerged (Gagliano et al. 1982, p. 4). Pioneer plants, shrubs, and eventually trees can grow on the raised feature after abandonment. These plant assemblages can also be the potential for identifying manuported plant species that may have grown on the feature after being brought in by humans. The theoretical benefit of these processes is that the hardness of the shells, and their interlocked matrix, and the root systems involved will hold the feature in place, and keep it relatively cohesive during transgression. Shell middens can have potential for large size, differential density, thickness, and relief for identification by remote sensing (Twitchell et al. 2010; Leach and Belknap 2007).

At 8 DU 21118 in the St. Johns River (Fig. 3.2), several "positive relief" features were identified from the seismic data, one of which was confirmed as a probable midden feature after testing on the basis of dominant frequency and disarticulated character of the oyster shells (*Crassostrea*), the presence of avian bone, and reconstruction of pre-inland waterway dredging configurations (Faught and James 2011). Leach and Belknap (2007) published on their comparison of a known culturally accumulated shell midden and cores and seismic data taken from natural submerged bioherms and a possible submerged midden feature in another set of seismic data from Maine. However, not all positive relief features have turned out to be cultural, or even possibly cultural. In the St. Johns River, two positive relief features were domed outcrops of limestone bedrock (Faught and James 2011) and in Tampa Bay, one positive relief reflector proposed as a midden feature turned out to be a bed of fossil marine shell of probable Sangamon age (e.g., the last interglacial high stand of the sea level).

Fishing weirs, causeways, dugouts, or other prehistoric features are also potential targets of interest but they are difficult to predict or identify with remote sensing. Connaway (2007) demonstrates that fish weirs are usually built in particular (predicable) settings in drainage ways that may be identified through predictive modeling. Other features can be locally specific targets. For example, several mid-Holocene cemeteries have been found in peat beds in ponds, and may also be present offshore Doran 2002.

Testing: Coring, Dredging, and Sediment Analysis

It is arguable that more work has gone into creating models for determining submerged archaeological site's potential occurrence and preservation potentials than on actual in-field testing of submerged landforms by diving, coring, or dredging. On the other hand, the logistics and conditions for working underwater are significant, but not insurmountable, obstacles for advancement.

Coring has been used effectively to sample the sea floor bottom, because it probes sediments efficiently and effectively from the water surface, from boats, or underwater by divers (Gifford 1983; Leach and Belknap 2007; Pearson et al. 1986). In 1982 and 1986, archaeologists at Coastal Environments Inc., demonstrated the benefits of close order seismic remote sensing, followed by robust coring probes to sample targets identified as high probability landforms for the occurrence and preservation of prehistoric features. This research resulted in the identification of a probable shell midden of 8,000 BP age (Pearson et al. (this volume)). Another example of coring, conducted for offshore wind farm construction permits, in massachusetts identified preserved soil horizons that could have been potential areas for human occupation sites, but no direct evidence was acquired that indicated evidence for a site (Robinson and Brett 2006). Vibracores were used in Tampa Bay to investigate sediment beds on the paleomargins of Pleistocene-aged Lake Edgar that were within a pipeline corridor. The northern paleo-lake margin was identified as highly probable for human occupation, and the pipeline trench was recommended for diver post excavation monitoring, described below.

Of benefit to the CRM consultant is the fact that many industrial projects in underwater settings use cores for engineering data about the substrate (texture, consolidation, etc.), potentially amortizing the cost for samples with good planning. However, the submerged prehistoric geoarchaeologist will, more than likely, need more cores and control on their placement than are typically collected for engineering purposes. Data descriptions collected for engineering, including data on contacts, color, texture, and hardness, are useful for the geoarchaeologist, assuming additional data are gathered to determine environments of deposition and chronology.

Cores, however, cannot be used in every situation, such as rocky substrates (Faught 2002–2004), and sites discovered by coring may need additional study or mitigation. Sampling strategies using various dredging options increase the amount of sediment that can be excavated and sampled, increasing the likelihood of site discovery.

Panamerican Consultants, Inc., a US-based archaeology consulting firm, has conducted several “testing phase” operations using different sampling strategies—some in lieu of coring—that were organized to probe and sample submerged prehistoric “targets.” These projects include diver-controlled induction dredge and airlift excavations in Tampa Bay (Faught and James 2010), the St. Johns River (Faught and James 2011), and the Indian River (James et al. 2010).

Diver-controlled hydraulic and airlift dredges can be very effective in moving sediments underwater. In general, hydraulic dredges (i.e., induction or water dredges) are effective in shallow water (less than 20 ft), but airlift dredges less so (Faught 2002–2004; Latvis and Quitmeyer 2006). Both kinds of dredges work in deeper water, but the airlift can be more powerful and easier to manipulate at deeper depths. Dredge sizes range from 7.62 to 15.24 cm (3–6 in.) diameter hoses, with 10.16 cm (4 in.) dredges being the most common; anything larger is difficult for a diver to handle safely[4].

Both kinds of dredges have the potential to expose and screen large amounts of sediment in relatively quick time once on site. Diver-assisted dredge excavations can be analogous to shovel test probe, test pit, or trenching approaches on land. Loose deposits, particularly sand beds, limit the size and depth of any exposure, because the sides tend to slump faster than can be removed after sitting open for a period of time, such as overnight. In those cases, coffer structures are necessary for deeper excavations.

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[4] Industry diving is regulated by the Occupational Safety and Health Administration (OSHA), and the US Army Corps of Engineers (USACE) diving is particularly stringent. For the Academic or agency diver, AAUS is adequate standard. Appropriate regulations must be followed in each case.

In addition to diver-controlled dredging in CRM projects, Panamerican has recommended and conducted two projects that monitored industrial scale exposures into Tampa Bay. The first project monitored the effluent from an 18 in. swinging ladder dredge for the construction of additional berthing area in Tampa Bay (Faught and Ambrosino 2007). The 18 in. "swinging ladder" dredge operations were conducted by sampling at the effluent site "boil" (the location of the dredge area is shown in Fig. 3.1). Provenience was controlled by DGPS location and depth of the dredge head kept in digital logs by the dredgers plus the estimated time in the dredge pipe. Time of discovery was recorded for items of interest, and dredge head location could thus be calculated. Monitoring included backhoe scoops of spoil and inspection of residual after work stoppages. This particular experience was somewhat effective; a diagnostic Middle Archaic (middle Holocene age) projectile point, other chipped stone, and bone indicated a site (designated in the FMSF as 8 HI 11393), but construction of a sluice or other, more controlled screening apparatus was recommended for similar projects in the future.

The second project included inspecting a trench for a gas pipeline dug by clam bucket dredge devices. Archaeological divers inspected a trench dug by clam bucket over a particular 500 m, high probability portion of Tampa Bay that was 15 ft wide, 6 ft deep, as well as the associated spoil piles from the bucket drops. The trench was excavated into fine sandy sediments that slumped to their angle of repose after exposure, concealing stratigraphic details. Divers swam the exposure seeking stratigraphic information, and possible exposed sites in situ, with limited effectiveness. Archaeological excavation of high probability sections of trenches for Industry was recommended for similar projects in the future.

Site Preservation Potentials and Signatures: How to Know That You Have a Site After You Have Been Digging Around and Have Seemingly Meaningless Samples?

In the Big Bend of Florida, artifact arrays representing submerged prehistoric sites remain cohesive but reworked after the sea-level rise and submergence (Faught 2002–2004). This was also noted at the Cato and Douglas Beach sites on the west coast of Florida (Bullen et al. 1968; Murphy 1990). In fact, virtually all known examples of submerged prehistoric sites are partially or wholly reworked by the process of the sea-level transgression and sediment reworking in ways analogous to terrestrial site deflation and matrix replacement (Masters and Flemming 1983; Fischer 1995; Benjamin et al. 2011). Submerged site "deflation" results from fluidization and removal of sediment matrix at times of inundation, leaving "lags" of larger clasts (particles), such as chipped stone artifacts or shell.

Even though sites can remain cohesive, and discovery of artifact arrays certainly indicate places where people used to be, culturally derived deposits are not always apparent from core samples, or to the diver, or at first glance of the collected samples after screening and bagging dredged deposits in the field. Artifacts are certainly important, but artifacts are rarely encountered when sampling some sites, as Gagliano et al. determined systematically (1982, p. 2). They noted then:

> In instances where submerged landforms likely to contain evidence of human occupation have been identified, some surveys have included … small-diameter gravity cores. The retrieved core samples have been studied in the laboratory by archaeologists to determine if any indications of human activity are present. This has proved to be a challenging and, with few exceptions, an unrewarding exercise, primarily because there is presently little framework of reference with which to compare the core data.

This remains true even today. Little research has been done to identify the sedimentary signatures of the deposits that make up submerged archaeological sites ("anthropomorphic" sediments or soils). Gagliano et al.'s (1982) "Sedimentary Studies of Prehistoric Archaeological Sites: Criteria for the identification of submerged archaeological Sites of the Northern Gulf of Mexico Continental Shelf" is a rare exception and of high value, but it has limited distribution for those investigating submerged prehistoric sites.

Gagliano et al. chose 15 terrestrial sites in Louisiana and Texas that occur on eight identifiable and mapable landforms to study in detail. Their landforms included a major natural levee, a minor natural levee, chenier and accretion ridges, a barrier Island, salt dome margins, estuarine margins, Pleistocene terrace on a channel margin, and sites by lake margins. They sampled sediments by test excavations at known sites and box core sampling of sediment profiles; recording color, bedding, and contact descriptions. Analytically, they sorted the sediments to particle size; they conducted point counts[5] and grain size analysis, multiple geochemical analyses, and radiocarbon dating. They demonstrated that sites were recognized by increased diversity of constituents, including high frequencies of bone, charred wood, and shell. Some micro fragments of ceramic and lithic artifacts were identified, but they were rare.

Shell midden deposits in Florida are notorious for having very few artifacts. Therefore characteristics of shell midden sites that might act as criteria for "declaration" of a site are needed, and these include such evidence as disarticulated specimens of mollusk species that dominate the collection of (most often *Crassostrea* in Florida, but also *Donax*, and *Mercenaria*) faunal bone, specifically shark and alligator teeth in the Indian River project area, charcoal, and manuports (i.e., nonartifactual items out of place) (Faught and James 2011).

By close examination of sediment samples, known as "point counting," first sorting size categories and then sorting out and identifying the particle types in each size category (Fig. 3.5), Panamerican has declared two remotely sensed targets as archaeological sites, and has cleared other targets as not being sites. In the example described earlier, in the St. Johns River (Figs. 3.2 and 3.3) a 30 ft deep terrace feature adjacent to a paleochannel vestige produced evidence for a probable occupation area in the form of small chert flakes, fossil bone, and diversity of other particle types (Fig. 3.5; Faught and James 2011). The feature has been designated

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[5] "Point counting" is the sorting of sediment matrices into particles of constituent groups, and recording and graphing frequency distributions of them for comparison and description.

Fig. 3.5 Point count results for one unit in the St. Johns that produced evidence for an archaeological site. *Tweezers* in far right frame point at debitage flakes

as a site in the FMSF (8 DU 21117). A radiocarbon age estimate of 6010 ± 40 BP (Beta 285863) on charcoal associated with the flakes and fossil bone is consistent with paleolandscape modeling, the sea-level estimates, and the depth of the terrace.

Conclusion

Experience in Florida has demonstrated that effective strategies can be developed to conduct submerged prehistoric archaeology in CRM projects that include remote sensing, target identification, sediment sampling, and site identification protocols. It is the author's opinion that the surveys and the testing for these sites should and will become more frequent, because even reworked sites found in continental shelf or other submerged circumstances are significant (and, therefore, in need of protection) by their rarity and importance in understanding past human settlement patterns and environmental conditions.

These projects, however, will only be accomplished with regulatory agency's insistence and more consultants with expertise. To date, the 22 coastal United States other than Maine, Florida, and Maryland virtually ignore these resources. This situation has evolved from a number of factors, including lack of awareness of local zones of potential for submerged prehistoric sites, the inexperience of local academics and resource managers with recent developments in underwater archaeological method and theory, and the complexities of working on and under the water, especially with increasing depth and distance from shore. Of course, cost is always expressed as an inhibitor.

Of potential benefit are those industrial projects that regularly remotely sense and core for ocean bottom data such as bottom type, sediment beds, and bathymetry. These same datasets are also necessary for the geoarchaeologist researching submerged prehistoric sites. This overlap of information can result in economies of scale that reduce information costs, resulting in more resources for testing models, even in lower probability areas, to confirm model validity (Faught and Flemming 2008). The value of this kind of cooperative approach has been demonstrated by the use of industry data that has been used to reconstruct drainage patterns on the Doggerland paleolandscape in the North Sea (Finch et al. 2008).

In fact, identification of high probability landforms is the easy part of submerged prehistoric sites' archaeology; sampling is the hard part. There is a real need to excavate, rather than just avoid high probability places in order to test the accuracy of the models. Coring is a useful strategy, especially with intensive pattern and with geoarchaeological analyses, but controlled dredging allows for much more sediment sampling with a goal to approximate sampling coverage as if the project were terrestrial.

It is argued here that dredge monitoring with effluent screening is a viable method of resource management, given the difficulties of this kind of archaeology and the restricted impacts of many projects. To go even further, it is suggested that today's industrial strength dredges are eminently adaptable to underwater archaeological excavations because of modern and precise DGPS positioning and dredge digging head depth control. Coupled with screening facilities of appropriate nesting sizes for local conditions, trenching or sediment removal projects become geoarchaeological sampling units, analogous to trenching with backhoes in terrestrial archaeological projects. Whether this kind of sampling happens in CRM projects, or a funded research operation, remains to be seen, but it is not outrageous to suggest that continued discoveries will result from CRM-based projects because, as noted in the introduction, those projects are required and funded.

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Chapter 4
Prehistoric Site Discovery on the Outer Continental Shelf, Gulf of Mexico, United States of America

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Introduction

For the past three decades, there has been an increasing interest in the archaeological potential of the continental shelves of the world. There is no doubt that, given certain conditions, some prehistoric sites established on the continental shelf during periods of lower sea stand have withstood the effects of rising seas and remain preserved on the now-submerged portions of the shelf. One of the settings that can provide the conditions leading to site preservation on the continental shelf is a filled-stream valley. This is particularly true of the larger valleys that, with sea-level rise, develop into estuaries and slowly fill with sediments before being completely inundated. In this setting, archaeological deposits located in topographic lows within the stream valley, or on landforms that become buried by, and encapsulated within, estuarine sediments, can remain intact beneath the erosive impacts associated with marine transgression.

Developing statements concerning the potential occurrence and distribution of preserved archaeological deposits in these offshore settings requires the projection of a culture history for the area with its attendant settlement patterns, best drawn from onshore analogues. It also requires an assessment of the geological and ecological history of the area, as well as the identification of the geomorphological

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processes that affect archaeological site preservation on continental shelves. Several studies relying on these types of data have produced what appear to be reasonable models of site occurrence and preservation in large stream valleys on the North American continental shelf (Belknap and Kraft 1981; Coastal Environments, Inc. 1977; Kraft et al. 1983; Masters and Fleming 1983). Testing these models requires a technology that permits the identification of submerged and buried landforms that have a likelihood of containing cultural remains, and it also requires a method for collecting samples from these landforms, which not only are submerged but are frequently buried. Fortunately, this technology is available today in the form of a variety of seismic instruments that enable refined mapping of ancient landforms in the subsurface geology of the continental shelf and in a range of coring devices that can collect a physical sample suitable for analysis from a submerged targeted landform.

Despite the availability of these geophysical and coring technologies, a relatively small number of submerged archaeological sites have been discovered on the world's continental shelves from buried contexts. Sites from buried contexts have been largely accidental finds due to dredging. Few buried early sites have been located through purposeful, directed research. Most prehistoric sites on continental shelves have been destroyed, scattered, or reworked by transgressive events (Waters 1992), and the discovery of preserved sites often requires a considerable effort to identify preserved, presubmergent landforms. The seemingly prohibitive expense involved in conducting geophysical surveys to identify potential high-probability areas for site occurrence, plus the extensive funds needed to undertake a coring program to sample selected landforms in these areas, has curtailed research efforts. Nevertheless, in 1984, Coastal Environments, Inc., initiated a study with the specific objective of locating buried prehistoric archaeological deposits in a filled stream-valley setting in the Sabine-High Island area on the outer continental shelf (OCS) of the Gulf of Mexico (GOM) in the USA (Pearson et al. 1986). That study, sponsored and funded by the Minerals Management Service (MMS) (now the Bureau of Ocean Energy Management (BOEM) of the US Department of the Interior, was designed to test a model of site occurrence and preservation developed in two earlier studies of the cultural resources potential of the GOM OCS (Coastal Environments, Inc. 1977; Gagliano et al. 1982). To date, the Pearson et al. 1986 report is the only completed study to ground truth and test targeted landforms identified from seismic data on the GOM OCS. (A second study, funded by BOEM, is underway to test areas to the south and southwest, and the final report is forthcoming.) The project was conducted in two phases. The first phase involved the synthesis and evaluation of previously collected archaeological, geological, seismic, and borehole data from the study area. The second phase involved the collection and analysis of additional seismic data and core samples from several offshore target areas that had been identified as potential archaeological site locales. This successful effort utilized research concepts, methods, and techniques that continue to have promise in the directed search for submerged archaeological sites on continental shelves.

The region selected for this study was a 90 km^2 area in the GOM offshore of the Sabine River, the waterway that forms the boundary between the states of Texas and Louisiana. Specifically, the area of interest was in the offshore portion of the old Sabine River Valley that extends across the continental shelf (Fig. 4.1). This valley

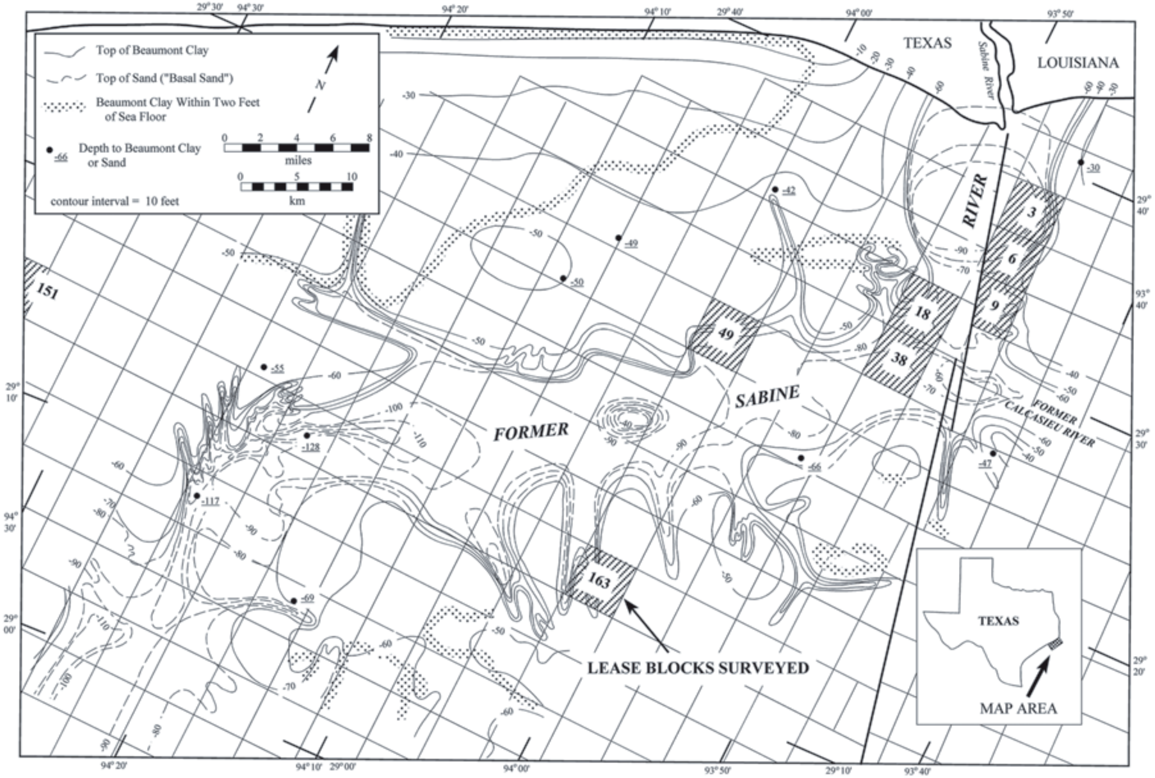

Fig. 4.1 The study area showing the filled and submerged Late Pleistocene/Early Holocene Sabine River Valley extending across the older Prairie/Beaumont formation on the outer continental shelf in the Gulf of Mexico (modified from Nelson and Bray 1970). The *grid* of federally established "lease blocks" for mineral exploration is shown, as are the *lease blocks* that were intensively surveyed for the 1984 study. *Contours* are in feet below mean sea level

was incised into old land surfaces of the Prairie/Beaumont formation during periods of lower sea level during the Late Pleistocene. Subsequently, over the past 18,000 years or so, this valley became filled with sediment and, finally, submerged as sea level rose. This Late Pleistocene/Early Holocene River system was selected specifically for this study for several reasons. First, this river system was active and the region was exposed as dry land from at least 18,000 years ago to about 6,000 years ago, a period when prehistoric populations occupied the area. Second, the river system was active for at least 12,000 years, sufficient time to permit the accumulation of an extensive archaeological record. Third, a large body of published and unpublished data on the present setting and geologic history of the offshore river system was already available; much of it derived from offshore oil- and gas-exploration activities (Bernard 1950; Bernard and LeBlanc 1965; Bernard et al. 1962; Berryhill 1980; Curray 1960; Nelson 1968; Nelson and Bray 1970). This past research revealed that relict features with high probabilities for both site occurrence and preservation existed within the now-filled and submerged valley system.

Developing statements concerning the occurrence and distribution of preserved archaeological deposits in offshore settings such as the Sabine River Valley requires knowledge of the presubmerged natural landscape, as well as an understanding of the settlement systems of the prehistoric populations residing there. The former came from a detailed reconstruction of the geological history of the offshore Sabine River Valley, the latter from prehistoric settlement systems and site distributions, as they are currently known along the onshore portion of the Sabine River, as well as other coastal-plain rivers in the region. Present knowledge of prehistoric sites, their content, their distribution, and their locations relative to specific natural landforms within and adjacent to the onshore Sabine River Valley provided a model that was extended out onto that portion of the valley that now lies submerged on the OCS.

Field Techniques

As noted, Fig. 4.1 depicts the estimated configuration of the offshore Sabine River Valley as defined by Nelson and Bray (1970). Although the source material is more than 50 years old, it is still considered an accurate geologic reconstruction. This figure shows several areas (“lease blocks”) that received intensive geophysical survey coverage during the 1984 study. Lease blocks are the 3-mile-square units used by the US Government in its offshore mineral-extraction leasing program. In the GOM, oil and gas companies have subjected a very large number of these lease blocks to geophysical survey, as part of their exploration activities.[1] As a background to the study, the authors examined data from previously conducted seismic surveys of over 100 lease blocks and 23 pipeline rights-of-way in the offshore Sabine River area. These surveys included interpretations of landform features identified in the shallow, subsurface zone extending to about 30 m below the sea floor. In addition, records of 35

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[1] For discussion of development-related archaeological surveys in the UK, see Bicket et al. Chapter 12.

geological borings made in the area were reviewed. These data were used to select eight lease blocks containing landforms thought to have a potential for the presence of preserved prehistoric archaeological sites. The identification of these "high-probability" landforms relied on the model of site-landform relationships derived from the archaeology of the lower Sabine River mentioned earlier. The degree of preservation of identified high-probability landforms relied on an assessment of the inundation history of each location as derived from the previously collected seismic data. An extensive amount of additional seismic data was collected in these eight lease blocks to more accurately map ancient, preinundation landforms. The seismic survey used an ORE sub-bottom profiler operated at a frequency of 3.5 kHz. Subsequently, 77 vibracores were taken at selected high-probability landforms identified in 5 of these lease blocks (Sabine Pass Blocks 3, 6, 9, 18, and High Island Block 49, lying from 6 to 32 km offshore as shown in Fig. 4.1). Water depths in these lease blocks ranged from 9 to 12 m. The vibracores were taken with a tripod-mounted device lowered to the sea floor from a jack-up barge. This vibracore rig could extract a 40-ft (approximately 12 m) core.

Sediment samples from the cores were analyzed in order to further refine the site-specific geology and to test for the presence of cultural remains. The analytical procedures followed those presented in the study by Gagliano et al. (1982) to distinguish between natural and cultural sediments. These techniques included grain-size, point-count, geochemical, pollen, and foraminifera analyses. In addition, a series of radiocarbon dates were run on materials collected in vibracores to date identified landforms and possible cultural features, as well as to refine the sea-level curve for the region.

Findings

Geologic Setting

The analysis of all of the collected seismic and core data provided an extensive amount of information on the geological history of the offshore Sabine River area and its archaeological potential. In most respects, the findings correspond closely to those developed earlier by Nelson and Bray (1970) relative to the configuration and age of the offshore Sabine River Valley. A major departure from Nelson and Bray is the identification of extensive areas of a relict late Pleistocene floodplain within the offshore Sabine Valley. This floodplain, known as the Deweyville complex, is recognized by fluvial terrace features along many large streams on the Gulf and Atlantic Coastal plains, including the Sabine River, and is characterized by "giant" meander scars three to six times larger than modern channels (Bernard 1950; Gagliano and Thom 1967; Saucier 1994).

The Deweyville channels identified along the offshore Sabine River are 275–330 m across, comparable in size to relict Deweyville channels found today along the on-shore Sabine River. Although it is recognized that Deweyville channels reflect much higher discharges than at present, there is no consensus over the nature and conditions responsible for the increased discharge (Alford and Holmes 1985; Saucier 1994; Blum et al. 1995). There has been disagreement over the age of Deweyville channels; however, recent evidence suggests they correlate with full-glacial conditions and date between 25,000 and 18,000 years BP, with the possibility that some maintained a higher-than-normal discharge for a slightly longer period, but no later than about 14,000 years BP (Saucier 1994; Weinstein and Kelley 1984). Within the study area, several radiocarbon dates were obtained from preserved swamp deposits capping Deweyville channel features. The earliest of these is 10,145 ± 285 BP (UGa-5402), indicating that Deweyville channels in the study area are somewhat older than that date.

In the study area, Deweyville deposits fringe both sides of the Sabine River Valley and exist as a topographically level surface 3–5 m lower than the older Pleistocene Prairie/Beaumont surface. These fringing Deweyville surfaces can be identified in seismic records for a distance of about 50 km down the river valley where they lie at a depth of about 18 m below sea level. Given their presumed age, it is likely that Deweyville complex features along the Sabine River extend farther offshore, possibly to near the edge of the continental shelf. Critical to the present study is the fact that along the lower Sabine River Valley, as well as along other major streams in the Gulf Coastal Plain, prehistoric archaeological sites are commonly found in association with relict Deweyville channels. Deweyville landforms offered a range of conditions conducive to human use and settlement. The terrace surfaces provided elevated landforms overlooking an adjacent river valley; the natural levees of relict Deweyville channels represented well-drained landforms suitable for settlement; and the filled former river channels contained swamp and open-water environments that would have supported a range of exploitable species. It is suspected that early human populations occupying that portion of the Sabine River Valley now extending across the continental shelf also took advantage of Deweyville landforms because of this advantageous combination of natural conditions.

The interior portions of the offshore Sabine Valley, identified as Holocene (modern) floodplain, were only minimally examined during the study. This is mainly because all of this area appeared on seismic records as a flat-to-very-uneven, dark, often "blurry" or "adumbrate" surface that absorbed and attenuated the seismic signal, thus obscuring any underlying floodplain features. This feature is often identified as a "biogenic gas front" in the seismic reports examined, and most agree that it represents methane gas derived from organic floodplain and estuarine deposits (Whelan et al. 1977). While upward migration and accumulation of methane gas does occur, vibracores collected in this study indicate this supposed "gas front" typically marks the presence of extensive swamp and marsh or estuary organic deposits laid down before rising seas inundated the area. This finding supports the observations of Roemer and Bryant (1977, p. 57) that "gas has been used too often in describing many naturally occurring phenomena that represent stratigraphic deposits." Relict floodplain landforms such as levees, channels, swamps, and the like certainly exist beneath this "gas front," but they cannot be identified in seismic records.

During the period between 25,000 and 6,000 BP, the Sabine River in the study area was a complex and dynamic riverine and, subsequently with sea-level rise, coastal estuarine ecosystem. One must assume that at any one time the area within the boundaries of the offshore Sabine Valley exhibited the range and variety of natural settings found in present-day riverine and estuarine settings. The onshore Sabine River Valley served as an analog with which to model the settings of the study area prior to marine inundation. As expected, close correlation is seen in the configuration and distribution of many of the geological features found along the lower sections of the modern Sabine River Valley, and in those interpreted for the buried and submerged river system in the offshore study area. Onshore, the Sabine River has incised an alluvial valley, ranging from 5 to 11 km in width, into Pleistocene-age Prairie/Beaumont deposits. Deweyville terrace features fringe both sides of the valley and the characteristic “giant” meander and channel scars of the Deweyville are quite evident. The Holocene floodplain of the Sabine River is confined to the central portion of the valley and is characterized by the present Sabine River course as well as relict meander belts and channel segments of earlier courses of the modern-size river. This is substantially the same setting reconstructed for the offshore study area on the basis of seismic and borehole records.

The geological setting, geomorphological history, and archaeology of the modern Sabine River Valley, therefore, provide a usable and presently essential model for identifying and dating features observed on seismic records in the offshore study area and in assessing the probability of archaeological site occurrence. The data collected offshore demonstrated that extensive areas of buried, late Pleistocene landforms are preserved in the offshore study area. Many of the offshore settings identified on these landforms are known, on the basis of onshore archaeological data, to be locales commonly associated with prehistoric remains. This primarily geological exercise served as a necessary prelude to the effort to locate cultural resources within the offshore study area.

In developing background geological information, the authors relied extensively on data contained in lease-block survey reports. The information presented in the lease-block surveys conducted in the GOM may represent the most extensive set of seismic data available for any continental shelf area in the world. While they are certainly valuable as a set of raw data, and were of some importance in the reconstruction of the geological setting of the offshore Sabine River Valley, the often widely varying geological interpretations found in these reports mean they must be used with caution. Lease-block surveys are required by federal regulations to identify natural and cultural hazards to mineral exploration that exist in the shallow subsurface zone (BOEM 2005, 2008). Therefore, the identification of features that might represent hazards is of greater concern than accurate geological interpretation; however, almost all of these survey reports attempt some level of interpretation. A review of these reports in the mid-1980s found that many failed to place the interpretation of seismic data within the context of regional geology. It was not uncommon to find widely varying, and often inaccurate, interpretations of the same feature or features occurring in adjacent lease blocks. For example, one lease-block survey report might identify a “large channel” extending into an adjacent block, while the survey for that adjacent block may record the same feature and identify it as a relict bay or lagoon or may not record it at all. Additionally, the same geological feature was often assigned radically different ages in different reports, such as Holocene, late Pleistocene, or even earlier. In most cases, reports prepared to meet federal guidelines are based solely on geophysical data, and do not have the benefit of correlating seismic data with near-surface sediment stratigraphy observed from cores sampled within the survey area. Lacking physical corollaries, geophysical reports often identified features observed on seismic records descriptively as "Horizon A" or "Lineament X" with little or no geological interpretation. Such terminology may be accurate from a geophysical point of view, but the geological explanations for such features are often not provided. This can be critical since these reports are used by the federal government as the basis for identifying potential high-probability locales for archaeological sites and the designation of archaeologically sensitive areas that must be avoided during mineral extraction activities. Obviously, if the geological interpretation is inaccurate, then the avoidance zones will be inaccurate as well (Ruppe n.d.).

Since the study in the early 1980s, the geological interpretations presented in lease-block surveys have become more comprehensive and rigorous and, thus, more valuable in regional geological syntheses. A principal reason for this increased scientific rigor is found in the reporting requirements now placed on lease-block surveys in federal waters of the GOM. As of 2005, the guidelines for cultural resources reports required: "a review of current literature on late Pleistocene and Holocene geology, paleogeography, and sea level change in the area [of the survey]…. A discussion of relict geomorphic features and their archaeological potential that includes the type, age, and association of the mapped features; the acoustic characteristics of channels and their fill material; evidence for preservation or erosion of channel margins…[and] the sea level curves you used in the assessment" (BOEM 2005). These requirements have enhanced the usefulness of these reports as it relates to geological interpretation and synthesis.

Archaeological Deposits

Vibracores were taken at five offshore locations selected as high-probability locales relative to archaeological site occurrence and preservation. The vibracores provided data enhancing interpretation of the geologic settings of these five areas and, also, provided "ground truthing" relative to identification of features on seismic records. Of particular importance is that the vibracores provided evidence of extensive areas of preserved, preinundation natural features and allowed the authors to correlate the ravinement surface marking the boundary between marine conditions (above) and preinundation conditions (below) with signatures in seismic records.

Of the five lease blocks examined in depth, only one produced data that is interpreted as evidence of archaeological remains. This was in the Sabine Pass 6 lease block, located about 16 km offshore (see Fig. 4.1). This area is situated on the

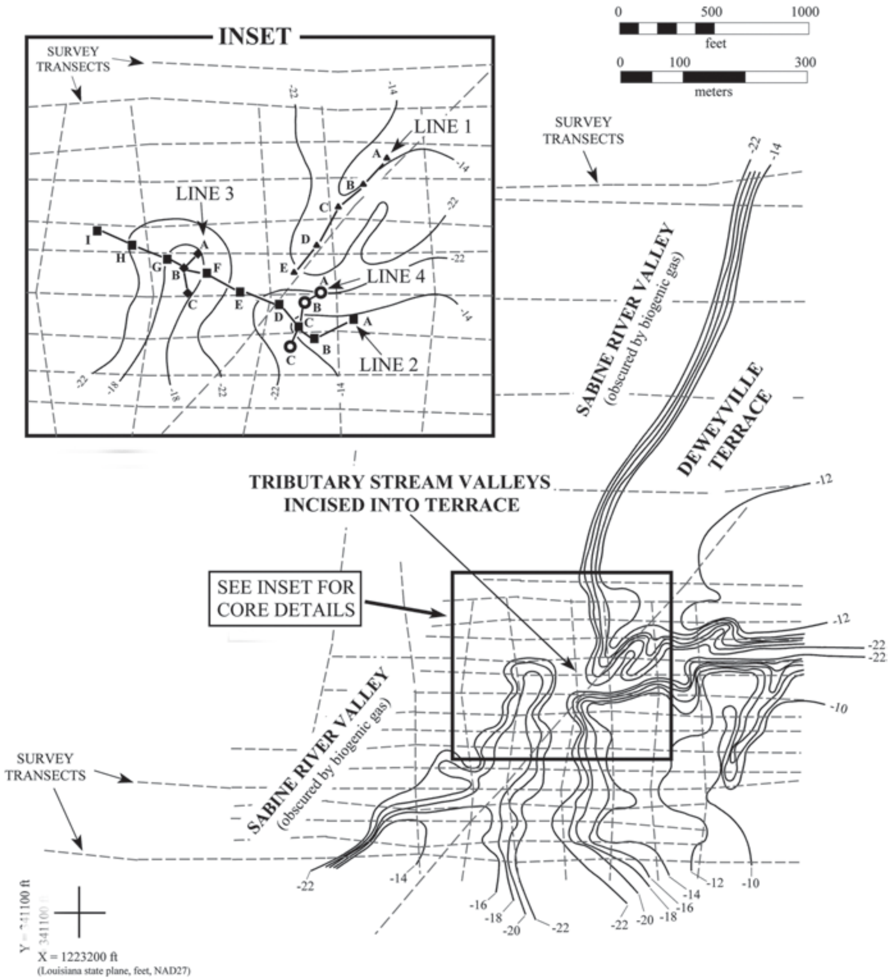

Fig. 4.2 Plan view of features identified from seismic records and vibracores in Sabine Pass Block 6 (after Pearson et al. 1986, Figs. 5–15). The locations of vibracores are shown in the *inset*. *Contours* are in feet below the present seafloor. (See Fig. 4.3 for a detailed stratigraphic interpretation of the vibracores in Line 2.)

eastern side of the former Sabine River Valley and includes a portion of Deweyville floodplain and two relict Deweyville channels, both filled with organic freshwater deposits. Figure 4.2 presents a plan view of the area derived from seismic records. Contour lines measure feet below the present seafloor to the identified Deweyville surface. The track of the seismic survey vessel and the vibracore locations also are shown.

Figure 4.3 presents the geological interpretation of an east-west line of vibracores taken at this location. This section extends across the southern tributary stream into the main Sabine River Valley to the northwest. Basal deposits consist

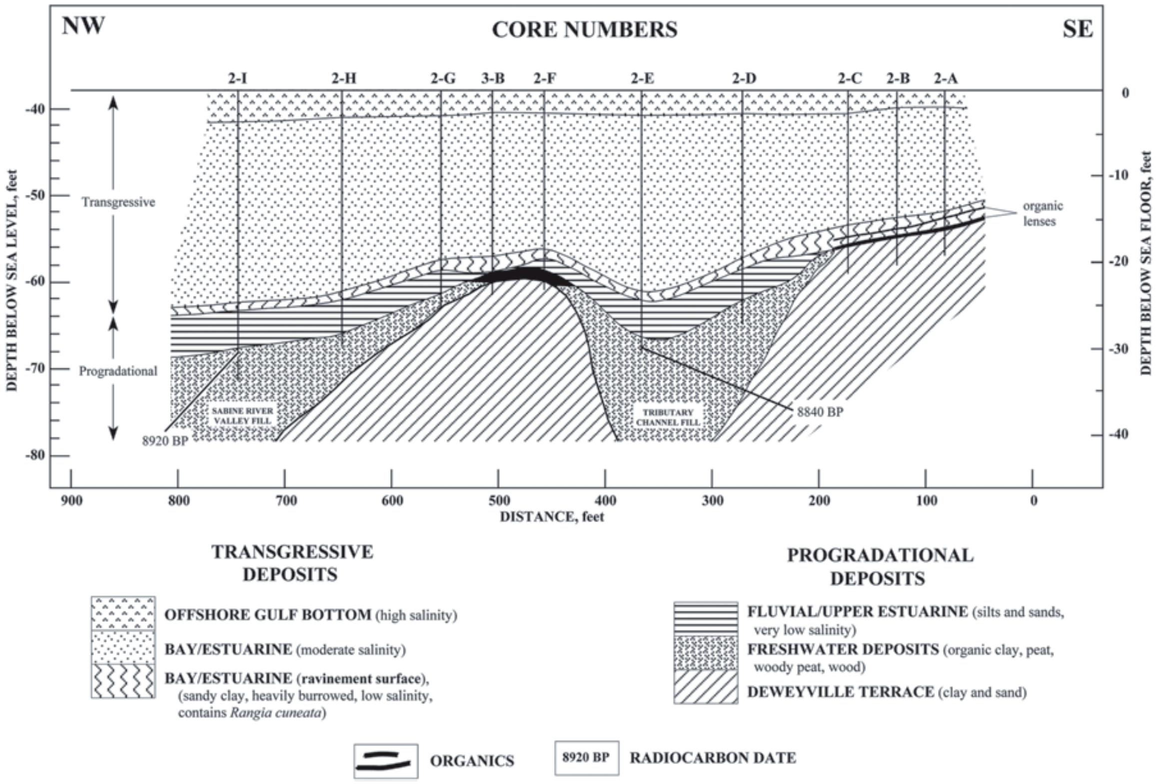

Fig. 4.3 Geological cross section of Line 2 in Sabine Pass Block 6, as interpreted from vibracores (after Pearson et al. 1986, Figs. 5–3b and 5–19). The locations of radiocarbon dates from preinundation, freshwater organics are shown

of Deweyville terrace clays and, in the stream and the Sabine Valley, undisturbed freshwater organic deposits laid down prior to marine inundation of this area. Immediately above these organic deposits is a silty clay facies interpreted as river-mouth deposition. Blanketing this deposit is a thin stratum of sandy-to-silty clay that is heavily burrowed and contains numerous shells of the brackish-water clam *Rangia cuneata*. Foraminifera species in this deposit indicate moderate salinities. This facies was probably formed with the initial expansion of estuarine systems into the area. This blanketing, disturbed zone was noted in most of the vibracores taken during this study and is identified as the ravinement surface representing the erosional boundary between underlying preinundation, progradational deposits and overlying transgressive deposits. The ravinement surface marks the landward migration of the shore zone during sea-level rise (Nordfjord et al. 2009, p. 232). Archaeological materials are expected to be found primarily within or beneath this deposit.

Above the ravinement surface is a massive deposit of gray clay that represents bay/estuarine fill (see Fig. 4.3). The homogeneity of this deposit suggests relatively rapid sedimentation. The uppermost stratum in the section consists of heavily burrowed clay containing varieties of marine shell. This represents modern, open-Gulf seafloor deposits.

Deposits of archaeological interest at this location included (1) a thin concentration of bone resting atop the Deweyville terrace bordering the filled stream and (2) a deposit of brackish-water clam (*R. cuneata*) shell located a short distance away, adjacent to and within the channel fill of one of the tributary streams (Fig. 4.4). The bone deposit was encountered in several vibracores and lies immediately below the ravinement surface and appears to be largely intact and undisturbed by marine transgression. The vibracores indicated that the bone concentration covered a relatively small area of about 100 ft (30 m) across. Radiocarbon dates from this location suggested that the organic deposit dated to around 8,800 BP. Pollen samples from this deposit contained high percentages of grasses and a diversity of arboreal types, suggesting an upland/swamp interface. Analysis of vibracore samples produced large quantities of charred wood and vegetation, nut hulls, seeds, fish scales, and bone from fish, reptiles, birds, and small mammals. Identified bones included a vertebra from a water snake (*Natrix* sp.) and a fragment of a long bone from a rabbit or squirrel. Much of the bone was carbonized. The quantity of bone fragments is extremely high; some of the samples produced projected counts of over 700 fragments of bone per kilogram of sample. Although minor amounts of bone occur in certain natural deposits, Coleman (1966) does not report its occurrence in the organic marsh facies he examined in coastal Louisiana; where it does occur in other sorts of marine and nearshore deposits, only fish bone is reported. In their comparative study of the sedimentary characteristics of coastal archaeological sites and natural landforms, Gagliano et al. (1982) found that the presence of bone was among the strongest indicators that a sediment sample was archaeological in origin.

The nearby *R. cuneata* shell deposit was encountered in two vibracores and measures at least 150 ft (46 m) across. Samples from the shell deposit yielded well-preserved Juniper (cedar) pollen showing no evidence of degradation or damage, as was found in samples from other cores in other blocks. This suggested that the

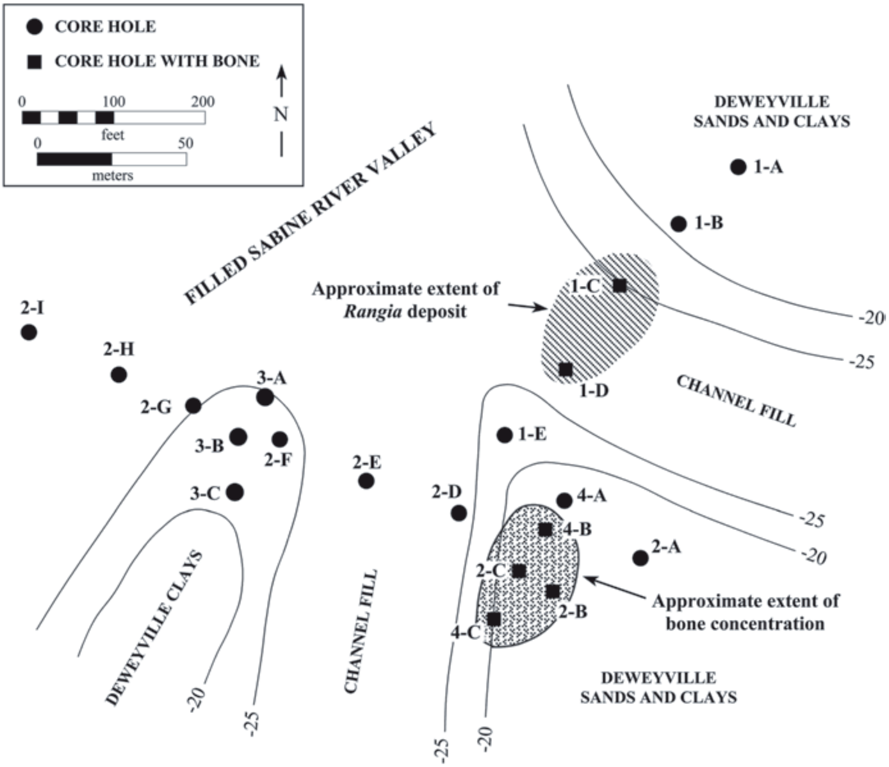

Fig. 4.4 Plan view of the area examined by vibracores in Sabine Pass 6, depicting locations of features interpreted as cultural deposits. (after Pearson et al. 1986, Figs. 5–29)

shell deposit once was exposed subaerially and remained relatively intact and undisturbed following marine transgression. Also recovered in the shell deposit were wood fragments, charred vegetal matter, and a small number of fish bones; including one burned gar (*Lepisosteus* sp.) scale. A sample of fragmented *Rangia* shell from this deposit yielded a radiocarbon date of 8,055 ± 90 BP (UGa-5450). This shell deposit is quite different from others encountered in the study area in that it lacked any quantity of intermixed oyster (*Crassostrea* sp.) or marine shell species and showed little evidence of disturbance. In terms of its content, geometry, and location it closely resembles known prehistoric shell middens common in coastal areas of Louisiana and Texas and is markedly different from natural shell reefs and similar features reported from the region (Aten 1983; Coleman 1966; Gagliano et al. 1982; Morton and McGowen 1983).

The critical question, of course, is whether or not the bone concentration and *Rangia* shells are cultural deposits. In the very small samples collected, finding an identifiable artifact was considered a low probability. Rather, it was the sedimentary character and content of the deposits that was going to be useful in making this assessment. This involved comparing the vibracore samples against similar samples taken from known coastal archaeological sites and from a variety of natural landform features comparable to those found in the offshore Sabine River Valley (Gagliano et al. 1982). The shell deposit and the organic/bone concentration in Sabine Pass Block 6 exhibit a number of characteristics in content, configuration, and location that are consistent with those of known archaeological deposits. In all of the parameters examined, including pollen, geochemical and particle content, these two deposits statistically resemble similar samples taken from onshore coastal archaeological sites as reported in Gagliano et al. (1982). Further, they differ significantly from all of the natural landform features examined. In addition, the location of these deposits represents an optimum setting for prehistoric site occurrence. If this locale was occupied around 8,800 years BP, as is suggested by the radiocarbon dates, it would have been at the juncture of two streams representing relict and filled Deweyville channel segments located near the modern valley wall, overlooking the Sabine River floodplain and/or estuary. Numerous prehistoric sites have been found in similar settings onshore in the modern Sabine River Valley. The combined evidence suggests that these remains are, indeed, archaeological in nature. As such, they represent a unique set of archaeological data, providing clear evidence of prehistoric use of this portion of the continental shelf. Additionally, they demonstrate that early prehistoric sites can remain preserved on the continental shelf, given certain conditions.

Sea-Level Curve

A series of radiocarbon dates was obtained from a variety of facies identified in the study area. A primary objective was to use these dates to establish the age of any archaeological materials found, as has been discussed above. In addition, these dates serve to refine the sea-level curve for the region and, in conjunction with other sets of data, to reconstruct in some detail the presubmergence landscape and natural setting of portions of the offshore Sabine River Valley during the Holocene. Radiocarbon dates obtained from brackish to saline, nonshell deposits were considered the most useful in establishing the true position of sea level. Dates were obtained on *R. cuneata* shell, but their exclusion in reconstructing a sea-level curve eliminates questions about the radiocarbon “reservoir effect” of marine samples. In addition, careful attention was paid to the effects of compaction and subsidence, both of which can seriously affect the vertical position of a sample in the area, introducing error into relative sea-level estimates. Ultimately, five dates obtained from obviously unsubsided or uncompacted brackish and freshwater marsh environments were used to calculate sea-level change in the offshore Sabine River area. These data indicate a relatively steady rise in sea level of about 0.43 m per century from ca. 9,000 to about 7,400 years BP. Usable radiocarbon dates from this study cover only a short time span (ca. 1,600 years), but the curve developed from them is consistent with composite Holocene sea-level curves recently developed for the northern GOM (Milliken et al. 2008; Törnqvist et al. 2004).

Paleogeography of the Sabine River Valley, 10,000 BP to 8,000 BP

With the various sets of data collected, the authors have been able to reconstruct in some detail the presubmergence landscape and natural setting of portions of the offshore Sabine River Valley, specifically that area falling in Sabine Pass Blocks 3, 6, and 9, extending along the eastern edge of the Sabine River Valley from about 6–20 km off the present coastline (see Fig. 4.1). Critically important is the understanding that for almost 18,000 years the offshore Sabine River Valley was a dynamic and constantly changing environment, adjusting to slowly rising sea level. As sea level rose, portions of the valley went through a predictable sequence of natural settings, changing from a typical river-valley floodplain environment to a brackish estuary with marshes and lakes, to saline marshes and bays, and finally to open marine water. This changing landscape occurred over time as well as space, beginning at the edge of the continental shelf and slowly moving northward to the present shoreline. Human populations occupying the river valley adapted to these changes with adjustments in settlement and subsistence systems. The term “paleogeography” is used to characterize this changing landscape and the human adjustments to it.

Figure 4.5 portrays this evolving landscape during three time periods for the area around Sabine Pass Blocks 3, 6, and 9. The first time frame depicts the area prior to 10,000 BP when the Deweyville stream system was still active and the principal environmental zone along most of the valley consisted of bottomland hardwood riverine and backswamp settings (Fig. 4.5a). By 10,000 BP, the Sabine River had decreased in size to its present dimensions and the old Deweyville channels were relict and occupied by underfit streams. They also rested on a slightly elevated terrace, left as the Sabine River incised deeper into its valley. Fresh-to-brackish-water marsh environments slowly migrated up the river valley as sea level rose (Fig. 4.5b). It is believed that the sites in Sabine Pass Block 6 were occupied when this portion of the river valley was under the early influences of marine inundation and the slightly higher Deweyville terrace features overlooked brackish-water and saline marshes and bays within the now-inundated Sabine River Valley (Fig. 4.5c). People, no doubt, utilized this location to exploit the highly productive open-water bay and brackish-marsh ecosystems in a coastal setting. By about 8,000 BP, however, rising seas flooded all of the Block 6 area; forcing human population to retreat northward up the river valley to take advantage of the optimal environmental settings emerging there.

Conclusion

This study of a small area of the North American continental shelf produced a large amount of data, only a small portion of which has been presented here. Most importantly, this study represented an early approach that integrated available evidence on prehistoric settlement patterns, geologic history, presubmergence landscapes, and

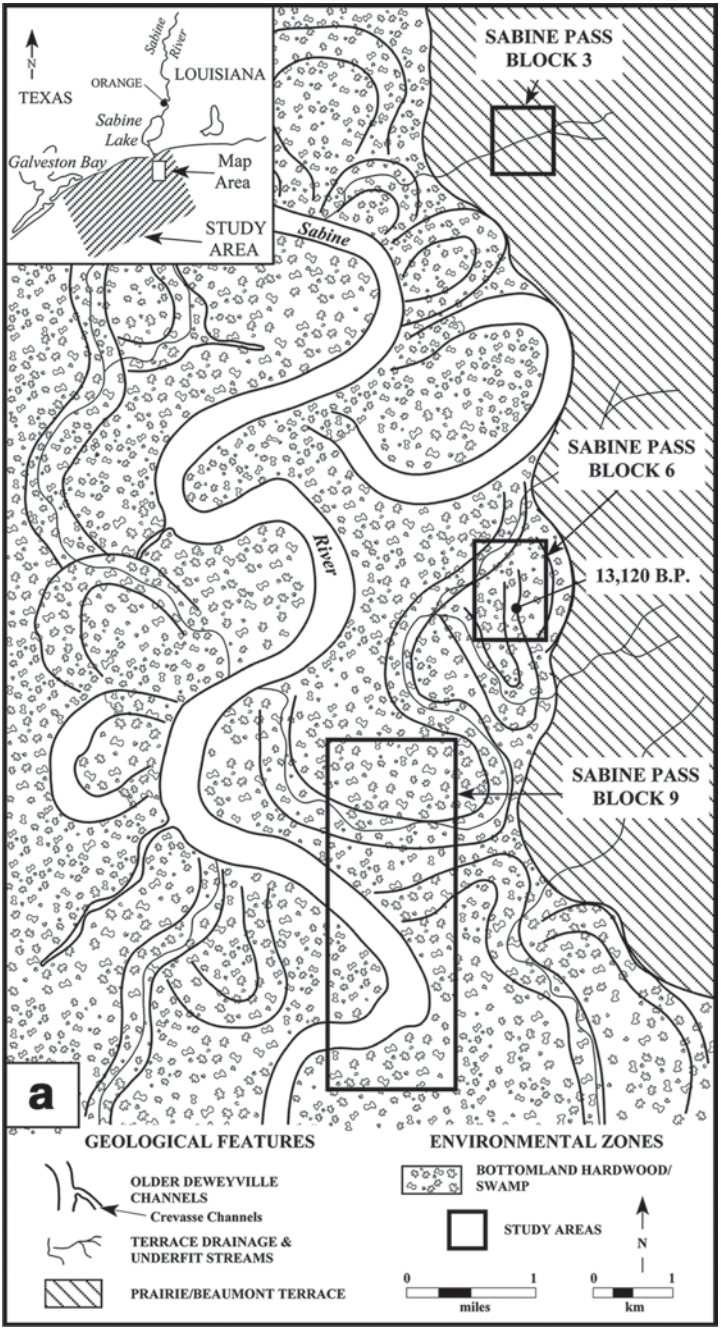

Fig. 4.5 Reconstructions of the evolving paleolandscapes in the area around Sabine Pass Blocks 3, 6, and 9 (after Pearson et al. 1986, Figs. 6–5 through 6–7). The locations of radiocarbon dates used in the reconstructions are shown. Floodplain channel features outside of surveyed blocks are schematic. **a** Interpreted landscape for the period prior to 10,000 BP when sea level was lower and the Deweyville fluvial system was active. The Sabine River Valley in this area was a floodplain consisting of bottomland forests, backswamps, the active river channel, and numerous abandoned channel segments. Note the large size of the Deweyville channels, approximately five times larger than equivalent modern Sabine River features.

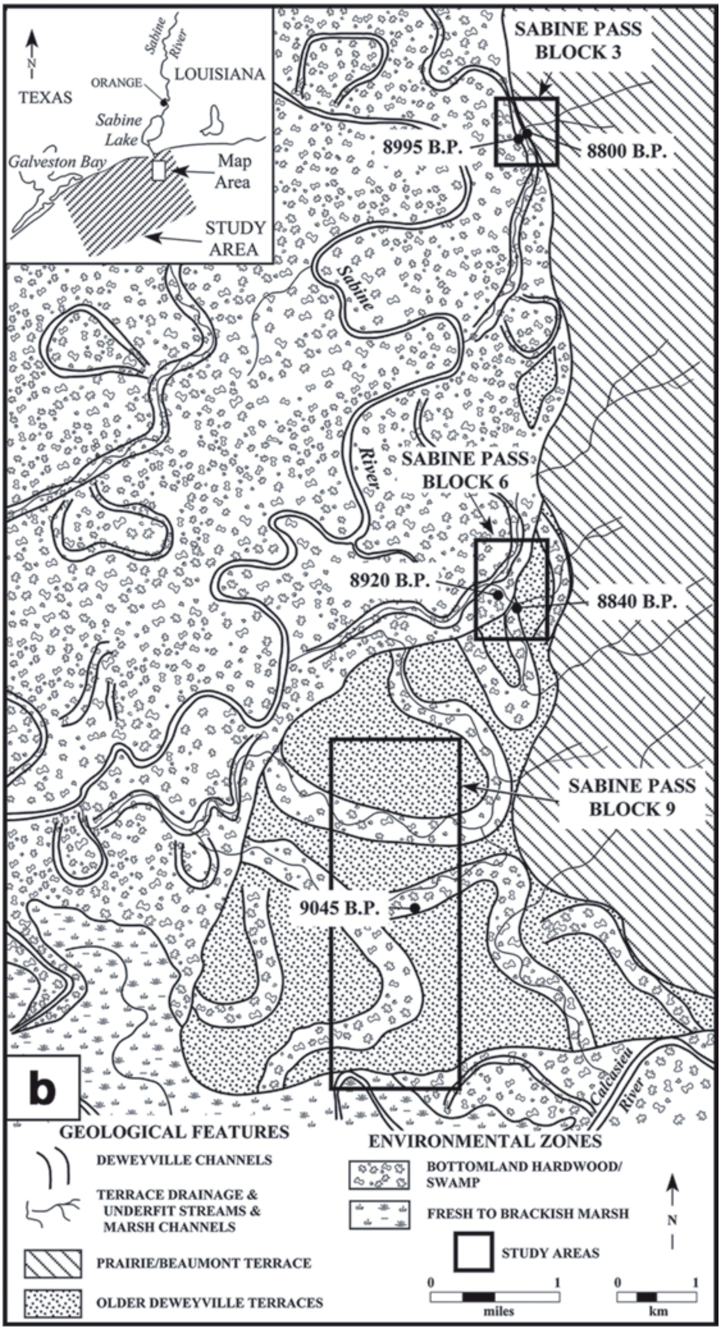

Fig. 4.5 (continued) **b** Interpreted landscape for the period ca. 10,000–8,800 BP. Portions of the Older Deweyville floodplain exist as terrace remnants, while the modern-regime Sabine River occupies the valley proper. Fresh-to-brackish marsh habitats are encroaching into the southern part of the area as rising sea level inundates the river valley.

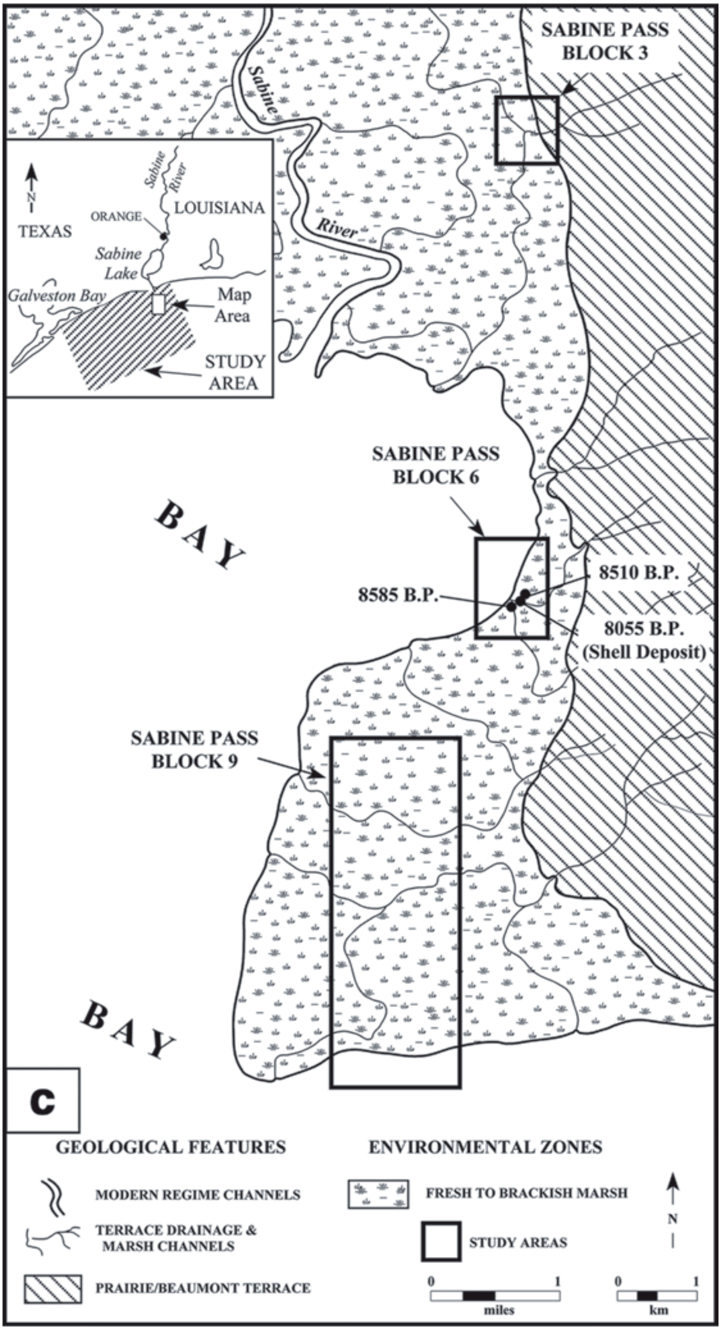

Fig. 4.5 (continued) **c** Interpreted landscape for the period ca. 8,500–8,000 BP. Rising sea level has flooded much of the valley, leaving marsh atop higher elevations and at the northern end of the valley. Human occupation of the bayside in Sabine Pass Block 6 seems to have occurred during this time.

landform preservation potential into a successful search for archaeological sites in the offshore Sabine River Valley. Since this study was undertaken, only a few attempts have been made to locate and study submerged prehistoric sites on the GOM OCS. The focus of the work that has been done has been on the examination of artifact assemblages located at or near the seafloor in karst environments in the eastern GOM (Dunbar et al. 1989; Faught 2004; Faught and Donoghue 1997). Despite this relative lack of work in the GOM, the methodology used in the offshore Sabine River Valley 25 years ago has general applicability in the study of other areas and in furthering an understanding of paleolandscapes and prehistoric human utilization of the continental shelves of the world. This study has demonstrated specifically the archaeological potential of the offshore Sabine River Valley and, more generally, the potential of the entire outer continental shelf of the northwestern GOM.

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Chapter 5
New Evidence for a Possible Paleolithic Occupation of the Eastern North American Continental Shelf at the Last Glacial Maximum

Dennis Stanford, Darrin Lowery, Margaret Jodry, Bruce A. Bradley, Marvin Kay, Thomas W. Stafford and Robert J. Speakman

Introduction

Researchers have postulated the presence of submerged archaeological deposits on the Middle Atlantic continental shelf of North America for decades (Emery and Edwards 1966; Edwards and Emery 1977; Kraft et al. 1983). However, archaeological discoveries on the continental shelf made during commercial shellfish dredging have gone unrecorded or have escaped detection. By contrast, numerous vertebrate remains including the bones, teeth, and skulls of mammoth, mastodon, and walrus

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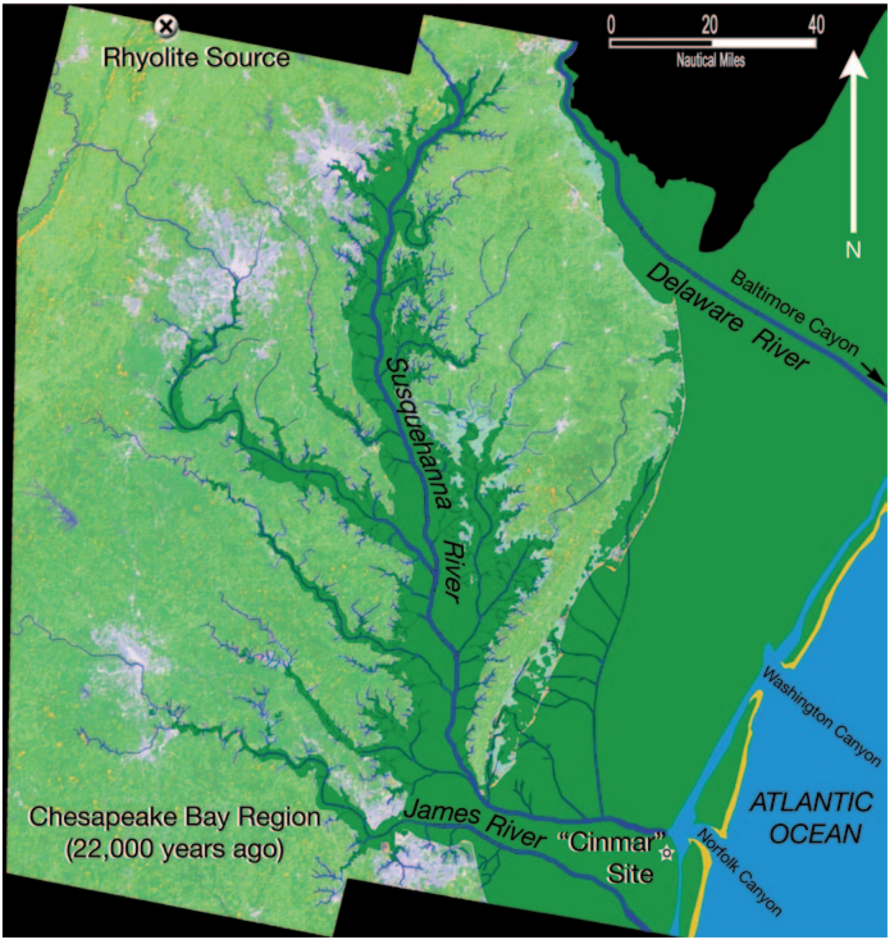

Fig. 5.1 Last Glacial Maximum Susquehanna River drainage showing locations of the Cinmar site and Ryolite Quarry

have been reportedly discovered by deep-sea fishermen and dredgers on the continental shelf (Edwards and Merrill 1977; Whitmore et al. 1967).

In 1974, Captain Thurston Shawn and the crew of *Cinmar*, a scallop trawler working 100 km east of the Virginia Capes, were dredging at a depth of 70 m (Fig. 5.1). Just after starting their run, the dredge became very heavy and when reeled in, it contained a mastodon skull. While cleaning the bone from the dredge, a large bifacially flaked rhyolite knife was discovered. Shawn carefully plotted the water depth and the exact location of the find on his navigation charts and noted that all of these items were dredged at the same time. To expedite getting back to dredging, the *Cinmar* crew broke up the skull and removed the tusks and teeth for souvenirs, throwing the rest of the bone overboard. Later the tusks were sawn into pieces and distributed among the crew.

Table 5.1 Measurements and proportions (in mm) of the Cinmar stone tool

Length	186 (est. 190)	Length/maximum width	3.5
Maximum width	54	Maximum width/thickness	7.7
Thickness	6 (at maximum width)		
Width at 1/4 length	44	Width at 1/4 length	7.3
Width at 1/2 length	53	Width at 1/2 length	6.6
Width at 3/4 length	39	Width at 3/4 length	4.3 (at "stack")
Thickness at 1/4 length	6	Mean width ($n=4$)	6.5
Thickness at 1/2 length	8		
Thickness at 3/4 length	9		

Captain Shawn retained for himself a tusk section, a complete tooth and the biface, and gave one of the molars to his sister, Mrs. Sylvia Cannon of Mathews, Virginia. Shawn was not an artifact or fossil collector and, subsequently, sold his specimens to Dean Parker of Hudgens, Virginia. Parker in turn loaned them to the Gwynn's Island Museum where they have been on exhibit since 1974 (Stanford and Bradley 2012).

The significance of the *Cinmar*'s discovery was not recognized until Darrin Lowery conducted an archaeological survey in Mathews County, Virginia, and saw the biface, mastodon tooth, and tusk segment at the museum. Subsequent interviews with Captain Shawn and his sister confirmed the fact that all of the specimens were recovered at the same time and place, as described here. The importance of the Cinmar evidence concerning the timing of the New World settlement and human occupation of the now-submerged coastal settings initiated the study reported here.

The find location, designated the Cinmar site, is on the edge of the outer continental shelf, south of the last glacial maximum (LGM) Susquehanna Paleo-River Valley, which is referred to as the Cape Charles channel (Fig. 5.1). During the LGM, 19,000–26,500 years ago (Clark et al. 2009), sea stand is estimated to have been 130 m below the present sea level (Milliman and Emery 1968; Belknap and Kraft 1977). The site was on the edge of the LGM James Peninsula, immediately west of a LGM barrier island and channel. This terrestrial landscape, which existed between at least 14,500 years ago and possibly more than 25,000 years ago, would have been 10–14 meters below sea level (mbsl) by the time Paleoindians occupied North America approximately 13,500 years ago (Waters and Stafford 2007).

The Cinmar stone tool is a large, thin knife with evidence of well-controlled percussion thinning flake scars on both faces (Fig. 5.2). It represents the workmanship of a highly skilled flint knapper because rhyolite is very difficult to flake correctly. The obverse face has a full face, possibly large overshot flake across the basal half. Because the overshot flake resulted in the removal of an excessive portion of the artifact's surface, subsequent flaking adjustments were made, resulting in a slight longitudinal curve and variable thickness. For measurements and proportions of the Cinmar stone tool, see Table 5.1.

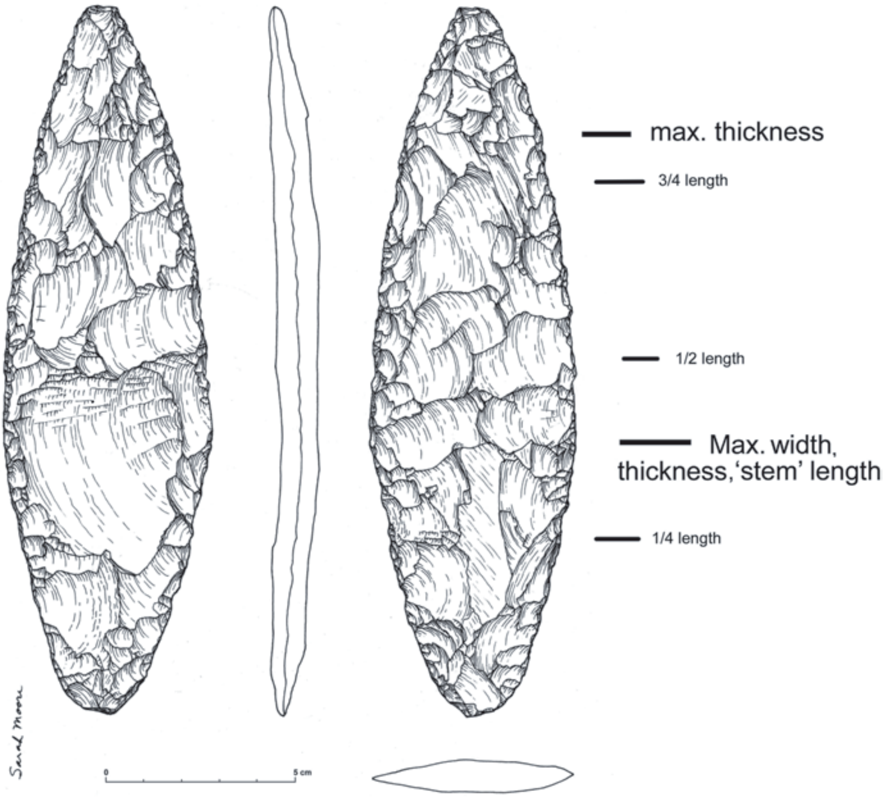

Fig. 5.2 The Cinmar Biface

Use-Wear Evaluation of the Cinmar Biface

High-power microscopic examination of the artifact using a reflected light, differential-interface binocular microscope with polarized light and Nomarski optics ranging between 100 and 400 diameters identified linear microstriations and polishes typical of knife use, including up-and-down and back-and-forth movements on the distal surfaces of the blade. The proximal end (base) exhibits microscopic linear striations that are typical of haft wear. Evidence that the knife was resharpened before being lost or discarded consists of noninvasive percussion retouch along the distal edges that is not overprinted by use-wear traces. The preserved condition of the flake scars, together with the preservation of surface microstriations and polish, indicate that the biface did not experience episodes of redeposition by water transport, nor was it abraded by surf action.

Separating the irregular crystal polygons evident on the banded rhyolite reference specimens and the artifact from microscopic wear traces proved a simple task, as the wear traces are largely striated residues, or additive "microplating" features, which develop progressively with tool use (Kay 1996, 1998). Microplating residues are impervious to ultrasonic cleaning with concentrated strong alkali (KOH) and acid (HCL), and occur on siliceous artifacts from varied depositional environments and ages in excess of at least 100,000 years. Experimentation demonstrates that microplating residues develop and harden coincident with tool use, are a biochemical byproduct of moisture and direct contact with a material worked by a stone tool or adhering to it, and, in an elegant way, express tool motion kinematics. Characteristic of microplating residues are flow features; among them are filled-in striations, desiccation cracks on drying, abrasive particle capturing, and crystallization filaments. Abrasive particles and crystallization filaments occur on the trailing edge or surface opposite the direction(s) of movement of a tool stroke. They are also instructive of handholding the tool or complementary movement of the tool in its handle. Microplating features are ubiquitous on the artifact and overprint other tool use-related abrasion and abrasive wear traces. They do not occur on an examined banded rhyolite comparative specimens and are easily distinguished from the irregular crystal polygons. These wear traces fall into two complementary categories, due to either use or from movement in a handle.

The Cinmar biface has diagnostic and common wear traces characteristic of having been a hafted knife. The haft wear traces do not resemble those far less developed and readily observed from handholding an experimental stone knife. The haft element wear traces (Fig. 5.3, *i*) are the mirror opposite of the blade element. These wear traces are indicative of complementary movement within the handle as a result of tool use. Haft wear includes more extensive abrasive rounding of arises but not true abrasive planing. The cutting wear traces (Fig. 5.3, *j*) are invasive and originate on either blade edge and at the broken tip. Multiple tool strokes are recorded oblique to the two blade edges and from the tip. The final tool strokes appear to be directed from the tip, and either further penetrated or were withdrawing from the worked material. Blade edge angles vary from 55° to 75°. Haft edge angles are 50° or less. Blade edge steepening with use and resharpening seem likely, especially since the blade edges only occasionally have use-wear. Most often the wear traces are on the older and higher flake arises, and it was easiest to track them to these spots. The blade edges are damaged, mostly rounded and crushed with micro step fractures. The invasive cutting wear, the tool edge damage, and experimental analogs all point to this knife having cut through a material that enveloped its surfaces while breaking and dulling the tool edges too. The contact material would have had paradoxical qualities—hard and unyielding and yet soft and allowing deep penetration. Consistent with experimental tool use-wear analogs, the likely and predominant contact material would have been bone and cartilage within a carcass. This tool appears to have been a heavy-duty butchering knife that was sharpened at least once and that ultimately failed in use (Fig. 5.4).

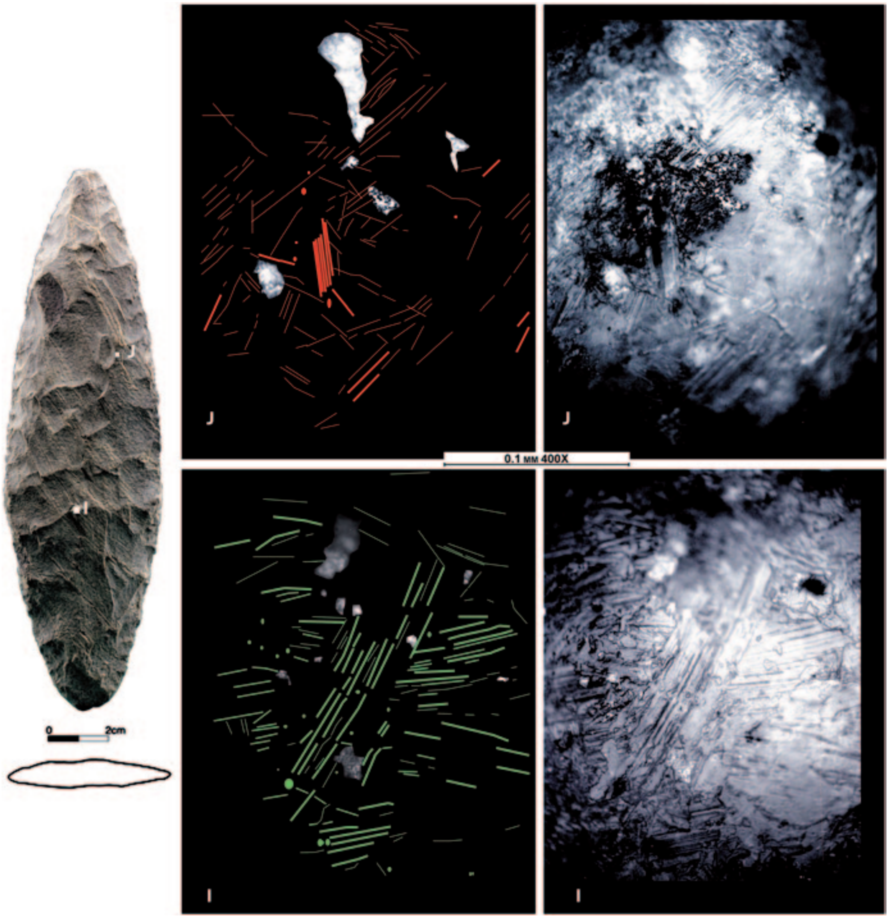

Fig. 5.3 Oriented photomicrographs of microplating residues and kinematic diagrams of striations (*colored linear features*), abrasive particles (*ovals*) and crystallization filaments (*gray-white "cloud" features*) for areas *i* and *j* on reverse face of the Cinmar artifact. The inferred directions of movement for each location are the mirror opposite of the other: area *i* pertains to the haft element, area *j* the blade element. The final movement is, respectively, diagonal to the longitudinal axis for the haft element (*i*) and just slightly off parallel to the longitudinal axis and bidirectional for the blade element (*j*)

Identification of the Source of the Rhyolite Used to Make the Cinmar Biface

Volcanic rocks, such as obsidian and rhyolite can be linked to their geologic source with a high degree of reliability by using analytical techniques such as instrumental neutron activation analysis (INAA), X-ray fluorescence (XRF), and inductively-coupled plasma mass-spectrometry (ICP-MS). These volcanic rocks typically occur

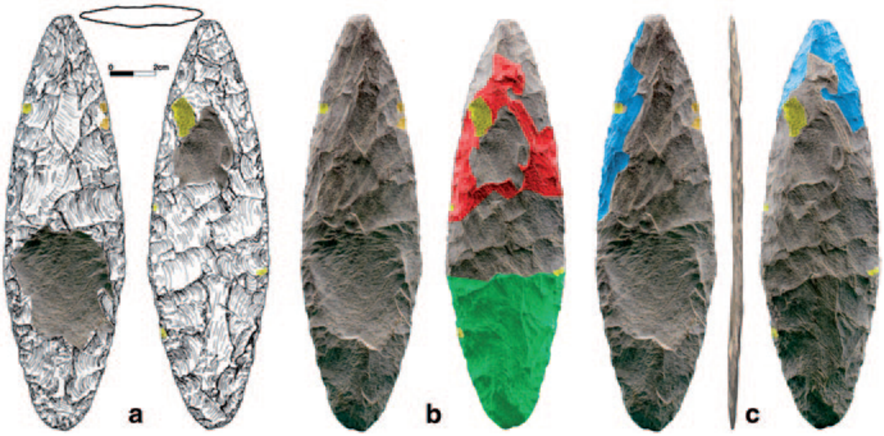

Fig. 5.4 Use history diagram for the Cinmar biface artefact. **a** Primary (*gray shaded areas*) and mostly secondary flaking that crosscuts the recently damaged areas exposing the original cortex (*shaded yellow*) on both faces. **b** Functional zones identified by microscopic evaluation of use-wear on reverse face (haft element is *shaded green*, blade element cutting wear is *red*). **c** Blade element resharpening (*shaded blue*) on both faces

in spatially discrete and relatively localized contexts. Such sources are typically chemically homogeneous, and individual sources have unique chemical characteristics. With sufficient field and laboratory work, the spatial extent of a specific geochemical type of volcanic rock, including primary and secondary deposits, can be established such that a source area can be defined (Speakman et al. 2007; Glascock et al. 1998).

As a starting point for the geochemical source study, more than 350 vouchered rhyolite specimens from eastern US localities ranging from Maine to North Carolina (e.g., rhyolite, metarhyolite, and felsite) housed in the Rock and Ore Collection of the Smithsonian Institution's National Museum of Natural History, Department of Mineral Sciences, were visually examined. More than 30 samples exhibiting banding, as well as a few random samples, were analyzed by XRF and compared to data from the Cinmar biface. When compared to other geologic samples from the Eastern US, the Cinmar biface is chemically and visually distinct because of its high (> 800 ppm) Zirconium (Zr) content and its unique banding and color.

Of the eastern US rhyolite samples examined in the National Museum of Natural History's mineral collection, only one was identified as a likely match: a sample of banded metarhyolite (NMNH 60892) from the Catoctin formation of South Mountain, Pennsylvania. The specific provenance of the sample is listed as "Maria Furnace Road, 1 mile from Tom's Creek Railroad Trestle." The sample presumably was collected by Smithsonian archaeologist W.H. Holmes who visited and described the quarry in 1893–94 (Holmes 1897). Maria Furnace is ca. 10 miles southwest of Gettysburg on Toms Creek, which is a branch of the Monocacy River. Following the identification of the probable source as South Mountain, the authors visited the Maria Furnace locale and collected additional rhyolite samples for XRF analysis.

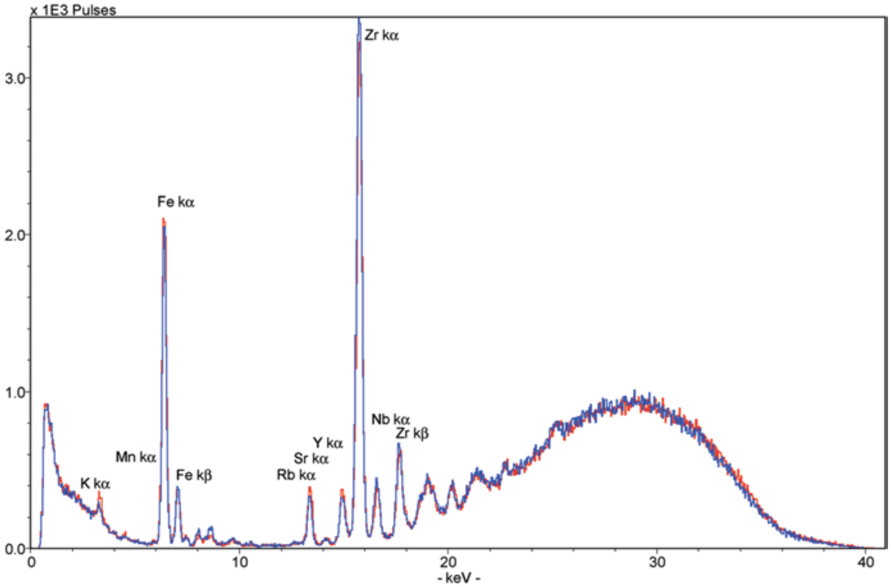

Fig. 5.5 Comparison of XRF spectra from the Cinmar biface (*blue*) and NMNH 60892 (*red*)

XRF analyses were conducted using a Bruker AXS Tracer III-V XRF. The analyses permitted quantification of the following elements: Mn, Fe, Ga, Rb, Sr, Y, Zr, Nb. The artifact and geologic specimens were analyzed as unmodified samples. The instrument is equipped with a rhodium tube and a SiPIN detector with a resolution of ca. 170 eV FHWM for 5.9 keV X-rays (at 1,000 counts/s) in an area 7 mm^2. All analyses were conducted at 40 keV, 15 μA, using a 0.076-mm copper filter and 0.0306-mm aluminum filter in the X-ray path for a 200-s live-time count. Peak intensities for the above listed elements were calculated as ratios to the Compton peak of rhodium, and converted to parts-per-million (ppm) using linear regressions derived from the analysis of 15 well-characterized rhyolitic glasses that previously had been analyzed by neutron activation analysis (INAA) and/or XRF.

Metarhyolite from South Mountain is widely recognized as a major lithic source used for production of prehistoric stone tools throughout the US Middle Atlantic Region (Stewart 1984, 1987) and an unpublished INAA study (Bonder 2001) has demonstrated that metarhyolites from South Mountain are chemically discrete from other sources in Maryland, Virginia, and North Carolina. Both visual examination and chemical analysis confirm that the material used to manufacture the Cinmar biface originated from the South Mountain Catoctin formation. Examination of the XRF spectra (Fig. 5.5) and the plots of the data (Fig. 5.6) demonstrate that rhyolite from outcrops near Maria Furnace are most similar chemically to the Cinmar biface. The authors caution, however, against stating that the stone used to produce the Cinmar biface originated from the vicinity of Maria Furnace given that numerous Catoctin formation metarhyolite outcrops occur throughout the South Mountain area of the Pennsylvania Blue Ridge.

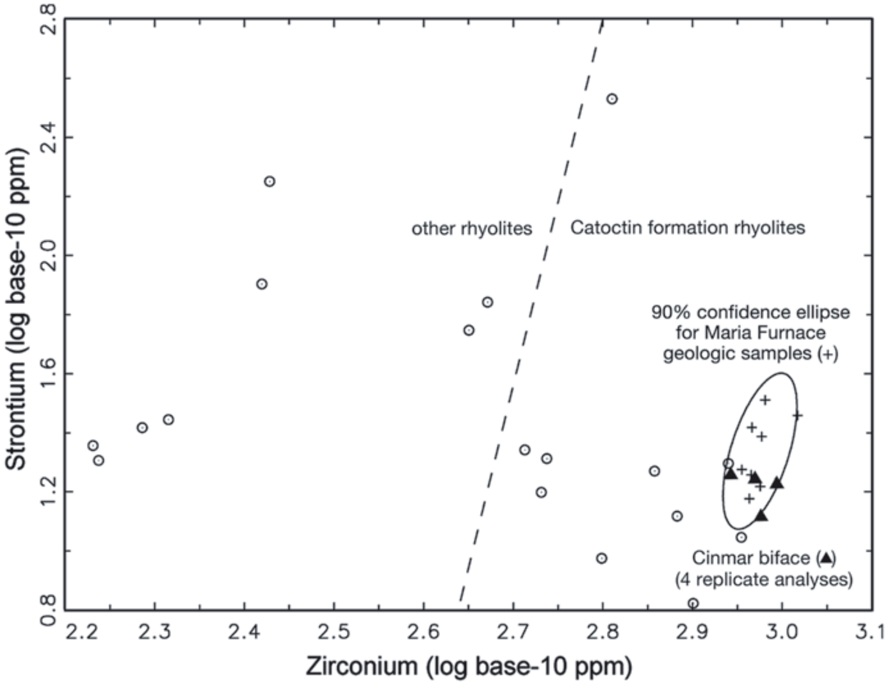

Fig. 5.6 Plot of zirconium and strontium-based ten logged concentrations for samples analyzed by XRF. Data for the Cinmar biface (two replicates are projected against the 90 % confidence ellipse calculated from six Maria Furnace geologic samples and two replicate analyses of NMNH 60892, also from Maria Furnace)

The Mastodon, Carbon Fourteen Dates, and Environment

The diameter of the mastodon tusk section is small, measuring 83 × 73 mm. The tooth, an upper right third molar, is also small, measuring 90 mm in width across the tritoloph and 155 mm in length. Wear on the tooth has entered stage 2, indicating a mature animal of approximately 30 years of age (Saunders 1977). The size and age characteristics of the molar and tusk indicate that the Cinmar mastodon was a small female.

Two sections of the tusk were sampled to obtain bone collagen for accelerator mass spectrometry, 14C dating. The resulting age was 22,760 ± 90 RCYBP (UCIAMS-53545). This age determination is consistent with the LGM sea level data and led the authors to conclude that the mastodon died on the outer margin of the continental shelf during the initial phase of the last glacial maximum.

Limited data are available for environmental reconstruction of the mid-Atlantic outer continental shelf during the last glacial maximum. Freshwater peat dated to 15,500 years ago was dredged from depths of 64–66 m (210–216 feet) near the Washington Canyon, north of the Cinmar site (Emery et al. 1967). Pollen extracted from the peat suggests that spruce, water lily, sedge, pine, oak, and fir were growing on the continental shelf shortly after the last glacial maximum. Another pollen sample, recently extracted from a soil sample taken from the Miles Point site dated to greater than 25,500 years ago on the Eastern shore of the Chesapeake, and revealed krummholz yellow birch, red spruce, balsam fir, and C3 grasses (Lowery et al. 2010). These data are evidence that the adjacent terrestrial vegetation likely extended as an unbroken biome onto portions of the continental shelf that were dry land during the LGM. The likelihood of abundant freshwater springs and ponds along the margin of the continental shelf (Faure et al. 2002), and the shrubby environment of the adjacent inter barrier island lagoon, as well as a relatively large number of mastodon remains reported from the continental shelf (Whitmore et al. 1967), indicate an ideal environment to support a reasonable mastodon population.

Rhyolite Artifact Weathering and Patination in Coastal Plain Environments

The Atlantic coastal plain contains a mix of chemical conditions and environments that can differentially affect rhyolite (Lowery and Wagner 2012). Rhyolite or methyolite artifacts that are buried quickly retain a fresh appearance (Fig. 5.7a). Conditions for rapid burial usually include anthropogenic features created by human activities. Natural processes also rapidly bury rhyolite artifacts and can result in fresh unweathered appearances. If a rhyolite artifact erodes from an upland setting via fetch-related coastal processes, prolonged exposure to the “swash and berm” zone results in abraded, smoothed surfaces with rounded edges (Fig. 5.7d). The rhyolite specimen shown in Fig. 5.7d is also patinated, however, the edges and surface of the point are rounded and polished due to prolonged tumbling and abrasion in the surf. Inevitably, tidal marshes accrete over former uplands as a byproduct of marine transgression.

As a result of the formation of an overlying tidal marsh, iron-rich rhyolite artifacts situated within the submerged upland stratum, like Fig. 5.7a, will undergo *sulfidization* in the organic-rich anaerobic surroundings. Because the iron in the rock is chemically altered to dark-colored iron sulfide, the outward appearance of the rhyolite artifacts in these settings may become darker, resembling the fresh forms of rhyolite. Slow rates of sea-level rise can erode the archaeological deposits from the drowned upland stratum beneath the tidal marsh peat. In these environments, the sulfidized rhyolite artifacts from beneath the anaerobic tidal marsh will be subjected to aerobic conditions in the nearshore area. During periods of rapid marine transgression, however, tidal marshes become inundated and bioturbation by marine organisms will reintroduce oxygen to the underlying archaeological deposits. In either of these aerobic settings, the reoxygenated iron-rich artifacts will undergo the *sulfuricization* process. As a result, a uniform chemically related sulfuric acid corrosion patina will develop (Fig. 5.7b) on rhyolite artifacts. In buried or intact settings, rhyolite artifacts will retain sharp cutting edges and any original use wear (Fig. 5.7c). In abrasive, exposed nearshore and offshore areas, artifacts can

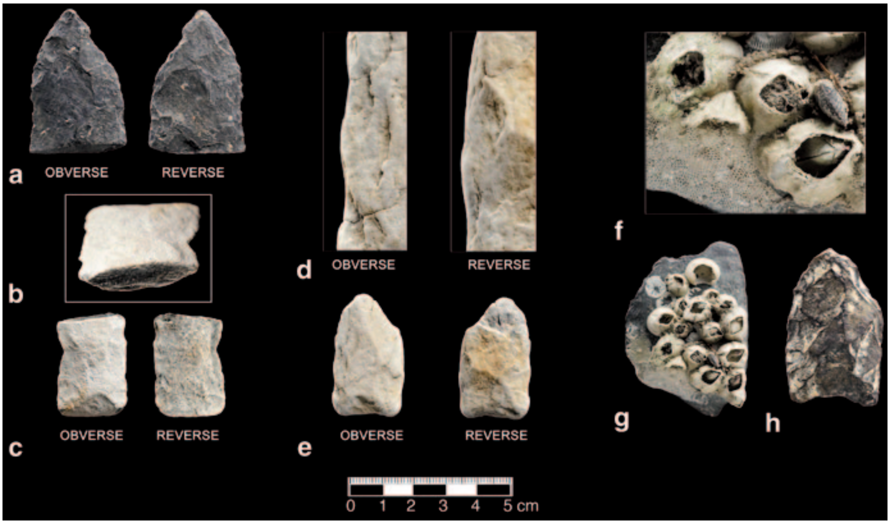

Fig. 5.7 Rhyolite artifacts exposed to marine and near shore environments. **a** Unaltered artifact from a buried onshore environment. **b**, **c** Artifacts patinated by chemical corrosion. **d** Edge of artifact subjected to prolonged abrading in the surf. **e** Chemically corroded artifact subjected to surf abrasion. **f–h** Marine organisms attached to rhyolite artifacts

become dislodged from the intact drowned archaeological deposits. Under these conditions, the edges of artifacts become heavily rounded (Fig. 5.7d–e). Depending on the proximity to the coastline, the dislodged artifacts are tumbled and rounded by currents in offshore sub-tidal settings or transported to abrasive nearshore areas. Artifacts exposed for protracted periods of time on the surface of the water bottom will generally accumulate a mix of attached marine organisms (Fig. 5.7f–h). For a full-detailed discussion of both the *sulfidization* and the *sulfuricization* process in nearshore coastal settings see Lowery and Wagner (2012, pp. 690–697). In contrast to the variables impacting rhyolite artifacts along shorelines, similar artifacts deposited on interior upland archaeological site surfaces will only develop a patina on surfaces that have been exposed skyward.

The unrounded surfaces retaining use wear with relatively sharp cutting edges and even patination of the Cinmar biface indicate that the artifact originated from an intact archaeological deposit. As a result of elevated sea levels at the end of the Ice Age, ca. 14,500 years ago, tidal marsh peat developed over the archaeological deposit containing the Cinmar biface. As a result, the iron in the rhyolite underwent the *sulfidization* process associated with a brief exposure to the organic carbon-rich anaerobic tidal marsh surroundings. The accelerated sea level rise during Meltwater Pulse 1A quickly inundated the tidal marsh, and bioturbation from the offshore marine organisms reintroduced oxygen to the underlying archaeological deposit. The introduction of oxygen caused the Cinmar biface to undergo the effects of *sulfuricization*. Like the specimen shown in Fig. 5.7b–c, a uniform, chemically mediated, corrosion patina developed. Unlike the specimen shown in Fig. 5.7b–c, the sulfuric acid

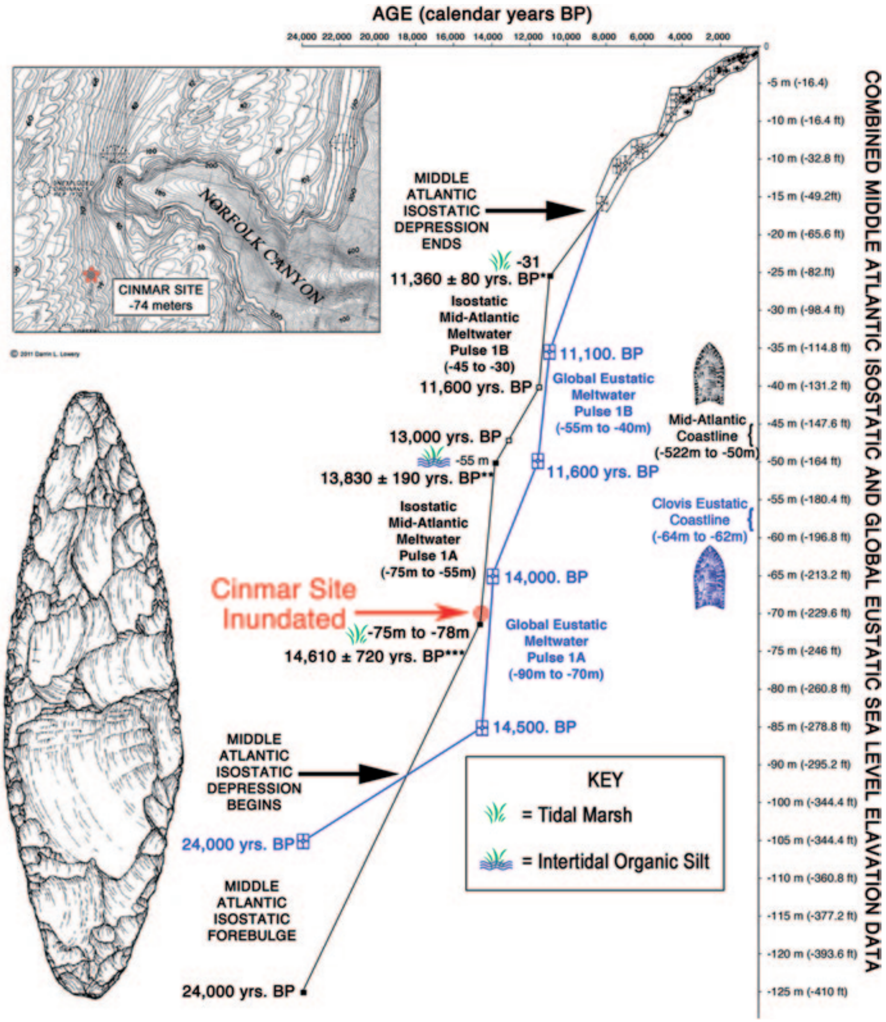

Fig. 5.8 The Cinmar site relative to Middle Atlantic Isostatic and Global Eustatic Sea Level data. (Based on Mallinson et al. 2005; Oldale et al. 1993)

corrosion patina on the Cinmar biface is noticeably less. The degree of patina can be equated to the duration of exposure to the anaerobic conditions when buried beneath an overlying tidal marsh. Given the slow rates of late Holocene sea level rise (Fig. 5.8) for the Middle Atlantic (Nikitina et al. 2000) and the documented one-meter thickness of tidal marsh peat overlying the drowned archaeological deposit that produced the artifact shown in Fig. 5.7b–c, the authors conclude that this artifact was subjected to at least 1,000 years of exposure to *sulfidizing* anaerobic conditions.

Lowery and Wagner (2012) have concluded that *sulfuricization* can occur very rapidly once aerobic conditions are restored. In contrast, the setting associated with the Cinmar biface was exposed to *sulfidizing* anaerobic conditions of a tidal marsh for only a short period of time. The shortened duration and exposure to *sulfidizing* conditions resulted in limited patination to the surface of the Cinmar biface once the site was completely drowned and aerobic conditions were restored. The rates of sea-level rise (3.7–4 m per century) postulated at the onset of Meltwater Pulse 1A c 14,500 years ago (Weaver et al. 2003) would mean that the Cinmar site was situated in a nearshore tidal marsh environment for only a short period of time. The resultant situation limited the artifact's exposure to *sulfidizing* conditions and the rapid rates of marine transgression inundated the site before the archaeological deposit was eroded or disturbed.

A detailed overview of the chemical conversion of iron oxides to iron sulfides in coastal setting soils has been presented by Fanning et al. (2010) and the same process seems to impact iron-rich silicate artifacts in coastal tidal marsh settings (Lowery and Wagner 2012). The rapid conversion of iron oxides in stone artifacts to iron sulfides takes place chemically by reaction with dissolved sulfide in sea water. The chemical reaction represents the microbial reduction of sulfate during oxidation of organic matter in tidal marshes. The reduction of iron oxides in stone artifacts by hydrogen sulfide results in the formation of both iron monosulfides and iron disulfides (pyrite). The black monosulfides that result tend both to form quickly and to fade quickly upon exposure to oxygen. Exposure to oxygen can be the result of bioturbation in an offshore setting or simply a by-product of being brought to the surface. Pyrite (FeS_2) takes more time to form in an artifact and it is more persistent after formation. With respect to the patination observed on the Cinmar biface, some portion of the iron oxide in the parent rock was also altered to pyrite by long-term exposure to the anaerobic conditions of a tidal marsh. When a stone artifact experiences an aerobic environment, acidity is generated from the oxidation of the sulfides, and the hydrolysis of the iron. Bioturbation within a drowned tidal marsh peat deposit introduces oxygen into the deeper anaerobic strata. In an aerobic setting, the surface of the artifact creates its own chemical weathering patina.

When the Cinmar biface was dredged from the bottom, it was already patinated. The conditions outlined above would explain why the Cinmar biface is uniformly weathered or patinated on all surfaces, which is unlike the asymmetrical patination typical of rhyolite artifacts lying on the surface in a terrestrial environment.

Questions of Association

The question of whether or not the biface was associated with the mastodon remains is critically important for an accurate interpretation. Did Paleolithic people use the knife while butchering the mastodon or was the close spatial relationship fortuitous? There are three kinds of events that might have produced a spurious association between the artifact and the mastodon remains: lateral transport, prehistoric coincident, and fraud. These possibilities are dealt with in turn.

Lateral Transport

The biface was initially deposited elsewhere and was transported to a location near the mastodon remains via fluvial or tidal processes, or perhaps even dredged from another location some distance away from the mastodon bone. The authors reject this hypothesis for the following reasons:

Redeposition of a large stone tool in a high energy water transport system is known to produce taphonomic alterations that modify flake scars and tool edges, and overprint microscopic use-wear polish and striations with signatures of transport that include fractured or rounded tool edges (Shea 1999; Grosman et al. 2011), flattening of dorsal ridges, and patterns of abrasion that are similarly expressed on the distal and proximal ends of artifacts subjected to redepositional forces. The combined effects of sediment and debris-laden ocean currents tumbling the knife, had it washed out to sea, would have compromised the flake ridges and knife edges and obliterated the microscopic polish and use-wear scars. Moreover, lithic artifacts eroded from coastal prehistoric sites stay within the "swash and berm" zone (Lowery 2003) and move laterally along the shoreline, and over the long-term they are redeposited inshore, not offshore (Lowery 2008).

It might be conjectured that the knife was dredged and dragged from another location before the trawler hit the mastodon remains. This hypothesis is rejected for the following reasons:

- The dredge consists of a welded iron frame with a flat iron bar that drags along the bottom. As the flat iron bar at the bottom of the dredge scrapes the sea floor, scallops and other objects on the surface of the sea floor enter the dredge and are captured. Behind the dredge is a large enclosure with a series of welded iron bars with interwoven iron rings, or a monofilament seine-like bag. The sizes of the interwoven iron rings vary but the mesh is generally between 4 and 5 in. (~10 and 13 cm). The mesh size limits what is retrieved from the bottom. Smaller objects usually slip through the rings and only the larger objects are brought to the surface. Archaeological objects on the Middle Atlantic continental shelf may have escaped detection by commercial shell fishermen because small artifacts such as debitage, flake tools, and projectile points less than 10–15 cm lying on the surface of the continental shelf would easily fall through the larger size of mesh of the equipment used to scrape the bottom for scallops before being lifted to the surface. The large size of the dredge scalloping mesh may explain why large Ice Age animal remains are commonly reported from drowned localities on the Middle Atlantic continental shelf, while lithic or bone artifacts are rarely reported. In the case of the discovery made by Captain Thurston Shawn, the large size of the artifact allowed it to be recovered.
- The scallop dredge is tethered to the boat by a line or a large cable. Scallop fishermen prefer to dredge stretches of the ocean floor with common or uniform bathymetric depths to ensure that the dredge remains on the bottom. The distance that a dredge travels across the bottom at a common or uniform bathymetric

> depth can vary greatly. Generally, the captain or crew gauge the dredge retrieval time based on the stresses placed on the boat. The stresses on the boat are caused by the weight of material trapped in the dredge. As such, a scallop dredge can be pulled across the sea floor for either short or long distances. The distance traveled across the floor depends on how quickly the dredge is filled with scallops and other debris. In the case of the Cinmar discovery, the stress caused by the weight of a mastodon skull and associated tusks caused the transect run to be terminated and the dredge pulled and cleaned as soon as the remains were encountered. Because the biface was only slightly damaged by the iron frame, bars and rings of the dredge the artifact was not pulled for any distance across the sea floor, and therefore was dredged at relatively the same time as the mastodon remains.

The interpretation is that, the skull and knife were deposited together as part of a single archaeological assemblage. Again, if they were moved for any significant distance by the dredge, they would have been heavily damaged by tumbling in the metal framework of the trawler's net. Moreover, Shawn reported that they had just begun a transect when they encountered the heavy weight of the bones causing the net to be reeled in unexpectedly. Trawlers in this area run parallel to the coastline in order to maintain a constant fishing depth, so if the knife was not associated with the bone, it would have been situated at the same elevation, and because of the anaerobic modification of the rhyolite it would have had to have been dredged from an ancient saltwater marsh, as were the bones. Thus, given the fresh untumbled surfaces and sharp edges of the Cinmar biface, and the matching amount of oxidation color change on both the biface and mastodon remains, the authors conclude that the knife originated from an archaeological deposit associated with the mastodon or near where the mastodon was dredged from the sea floor.

Prehistoric Coincident

The knife was lost or deliberately thrown overboard by a prehistoric mariner traveling the ocean subsequent to sea-level rise and it came to rest with or near the mastodon.

The authors submit that hypothesis 2 is a priori extraordinarily weak because of the near absence of laurel leaf bifaces in the later middle Atlantic archaeological record, coupled with the odds against some prehistoric hunter losing a knife while on an ocean voyage some 100 km out in the Atlantic and that same knife settling down over 70 m onto the same area in the ocean floor where a mastodon died millennia earlier. Moreover, if such an event had transpired, the artifact would not have been subjected to the chemical environment that caused the geochemical patination and weathering of its surfaces. The 16 m or more rise in eustatic sea level in less than 300 years quickly drowned the tidal marsh and the sediments were partially oxidized.

The short-term exposure of the iron-rich stone artifact to the anaerobic conditions of the tidal marsh limited the degree of patination; however, the localized acidic condition created by the reoxygenation of the site resulted in a uniform color change of both faces of the knife.

Fraud

The association of the knife and the mastodon skull was fabricated. This hypothesis is rejected because the discoverers received no glory from their find, unlike the typical archaeological fraud. Moreover, it would seem unlikely that from all the artifacts that would have been accessible for fraudulent activities, the perpetrators of a fraud would likely not have had a rare laurel leaf biface, let alone that they might understand the cultural and temporal significance of a laurel leaf. It is important to remember that both the mastodon remains and the biface had also been on display since 1976 with a label outlining the circumstances of their discovery.

Thus, the authors conclude that the Cinmar discovery has major implications for understanding New World prehistory. If the artifact is associated with the 22,760 RCYBP radiocarbon date, it would imply that humans were living on the LGM continental shelf of eastern North America at least 10,000 years before any other reliable radiocarbon dated archaeological sites. If it is not associated with the mastodon in the freshwater marsh, the biface would be no younger than the saltwater marsh formed at the onset of Meltwater Pulse 1A, making it at its youngest 2,000 years before the advent of Clovis, and is the oldest dated formal tool yet found in the Americas.

The distance from the Cinmar site to the rhyolite sources in Pennsylvania is nearly 320 km, suggesting that by the time the Cinmar biface was manufactured, early cultures had explored the interior of the Chesapeake drainage basin and discovered useable stone resources. Therefore, the Cinmar date is an estimate for the timing of human occupation in eastern North America and it nearly doubles the length of human occupation in the New World.

Chesapeake Bay Bifaces

The Cinmar biface is typologically unusual for the Middle Atlantic region. It is significant that only three laurel leaf-shaped bifaces were identified during an inventory of the Smithsonian Institution's extensive archaeological collection of nearly 300,000 artifacts from the Middle-Atlantic region representing Paleo-Indian through historic time periods. The authors also examined private collections from the region, collections at artifact shows, and conducted an artifact identification weekend at Gwynn's Island that resulted in identifying eight additional bifaces.

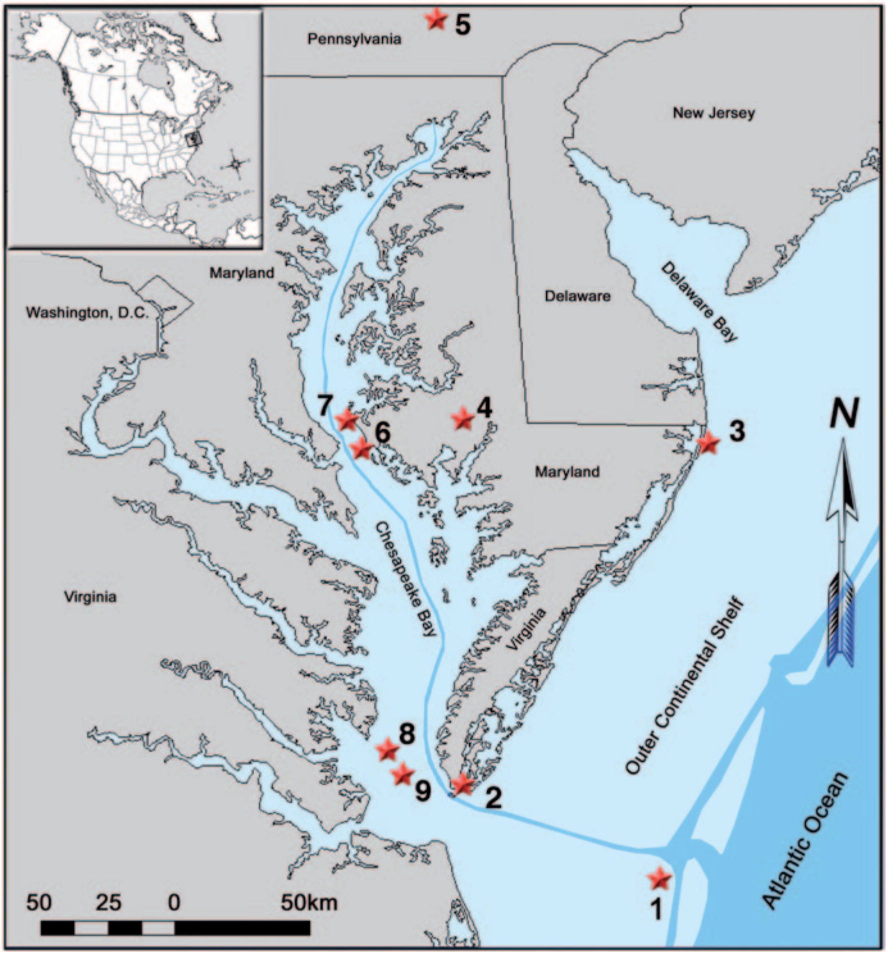

Fig. 5.9 Locations of Chesapeake Bay laurel leaf bifaces: *1* Cinmar site; *2* Hampton, Virginia; *3* Ocean City, Maryland; *4* Gore site; *5* Dauphin County, Pennsylvania; *6* Tar Bay, Maryland; *7* Taylor's Island, Maryland; *8* and *9* Mopjack, Bay Virginia

All but one of these bifaces were found within the Chesapeake Bay drainage system (Fig. 5.9). The single outlier came from sand dredged from offshore to replenish the beach at Ocean City, Maryland. Another was found while leveling a LGM sand dune (Fig. 5.9, 4) and a third was found eroding out of the LGM terrace adjacent to the Susquehanna River in Dauphin Co., Pennsylvania (Fig. 5.9, 5). A large quartzite biface in the Smithsonian's collection was found at Hampton, Virginia and donated to the museum in 1868 (Fig. 5.9, 2). The rest of these specimens were dredged from the Chesapeake Bay.

A specimen made of local quartzite was dredged from the shallow water between Tar Bay and Punch Island Creek off Dorchester County, Maryland (Fig. 5.10c). This

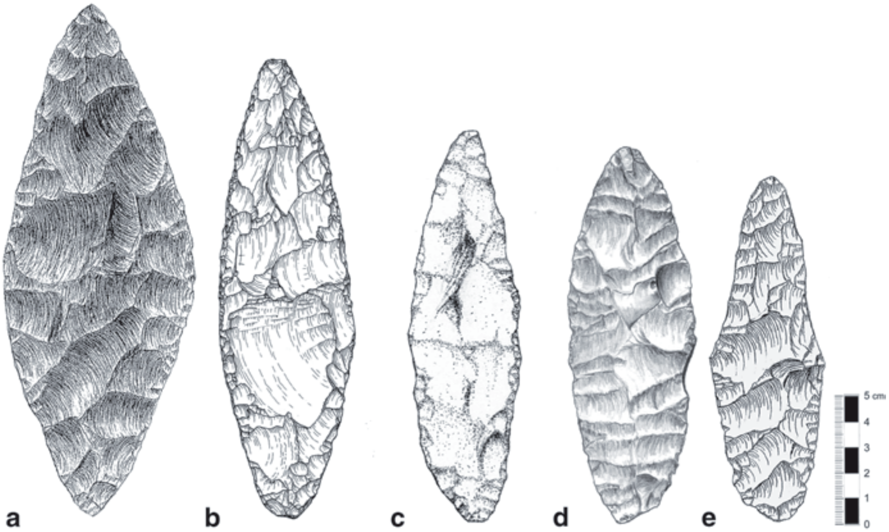

Fig. 5.10 Laurel leaf bifaces from underwater contexts. **a** Mopjake Bay. **b** Cinmar. **c** Heavily tumbled biface from Tar Bay. **d** Taylor's Island. **e** Heavily resharpened knife from Mopjack Bay

specimen was at one time in the near shore zone and is an example of damage seen on artifacts that have been heavily tumbled by "swash and berm action." Another specimen (Fig. 5.10d) was found within a drowned upland landscape underneath a thick covering of tidal marsh peat on the west side of Taylor's Island, in Dorchester County, Maryland. The knife is made of jasper; however, because it was sulfidized in the tidal marsh, it is highly stained, preventing identification of the source material. A large knife (Fig. 5.10a) made of quartzite was dredged from the bottom of Mopjack Bay near Norfolk, Virginia. Use-wear studies suggest that it was not hafted, but rather it was hand-held. A heavily resharpened biface (Fig. 5.10e), was also dredged from Mopjack Bay. Like the Cinmar biface, this tool was made of banded rhyolite and was used as a hafted knife.

It is important that these specimens were found in circumstances indicating that they were used and lost on the now-submerged continental shelf or the adjacent lowlands along the LGM Susquehanna River channel. It is also evident that they were all heavy-duty tools; likely used for butchering larger animals such as mastodons rather than smaller fauna.

If people settled eastern North America sometime between 23,000 and 15,000 years ago, why has this earlier archaeological record been so elusive? Perhaps one reason is that the initial population of Paleolithic people favored the rich diversity of the terrestrial and aquatic habitats of the now-submerged Continental margins and adjacent major drowned river systems. As these coastal ecosystems shifted westward due to rapidly rising sea levels approximately 14,500 years ago and as the human population increased, settlement accelerated into the upland interior, whose archaeological record is not buried as it is on the inundated coastal plain.

It is important to note that the manufacturing technology used to produce the Chesapeake Bay bifaces and the tool types themselves reflect the same technology as that used by the Solutrean people of southwestern Europe during the LGM (Stanford and Bradley 2012). Although more evidence is needed, it is not beyond the realm of possibility to hypothesize that this early settlement of the East Coast of North America resulted from a European Paleolithic maritime tradition. There is little question that the Cinmar discovery indicates that exciting new chapters in the story of Paleolithic people will be uncovered as archaeologists continue to investigate the continental shelves of oceans worldwide (Earlandson 2001). (Note: Funding has been obtained to conduct remote sensing survey of the area of sea floor noted by Capt. Shawn during the summer of 2013).

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Chapter 6
Gateway to the Americas: Underwater Archeological Survey in Beringia and the North Pacific

James E. Dixon and Kelly Monteleone

Introduction

Unlike other areas of the world where shipwreck archaeology has produced spectacular treasure, tales of tragedy at sea, and pirates, the continental shelves of northern North America and Asia hold a scientific treasure that is perhaps key to understanding the last great dispersal of humans on the planet, and the first colonization of the American continents. The provocative concept that North America and Asia were connected by land in the high northern latitudes has captured the minds of Western scholars and explorers since the late 1500s. In 1589, Fray de Acosta (1604) suggested the possibility that North America and Asia was, or had been at some time in the past, connected by land. By 1728, Vitus Bering, a Scandinavian navigator employed by the Russian Czar Peter I (Peter the Great) to explore Russia's Pacific frontier, established that the two continents were separated by sea. The ocean and the relatively narrow strait between the two continents subsequently were named after Bering.

By the late 1800s, exploration had made it clear that the Bering and Chukchi Seas (Fig. 6.1) were relatively shallow and that the continental shelf stretching between Asia and North America had been exposed as dry land at various times during the Pleistocene, when sea level was lower (Dawson 1894). Beringia received its name in the 1930s from botanist Eric Hultén, whose research of the flora on both sides of the Bering Sea demonstrated that the vast areas of extreme northwest North America and northeast Asia had been connected by a land bridge in the not-too-distant past. W. A. Johnston (1933) estimated that sea level was low enough during

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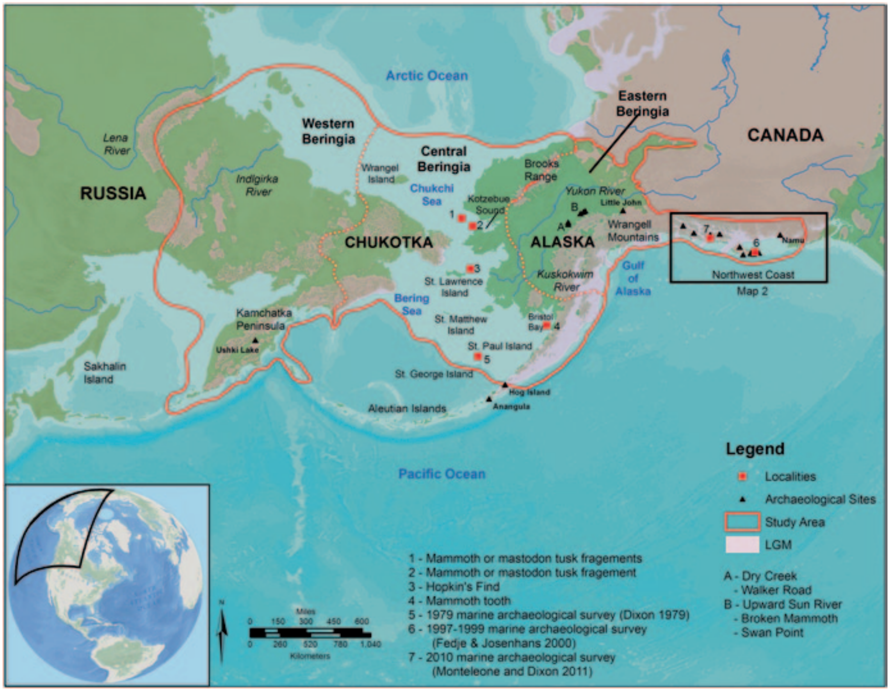


Fig. 6.1 Map of Beringia depicting sites and locations

the last glaciation to expose the continental shelf between the two continents and form a land bridge between Chukotka and Alaska.

The continental shelf underlying the Bering and Chukchi Seas became known as the Bering Land Bridge, and the larger geographical region, including the Bering Land Bridge and adjacent areas of Asia and North America, became known as Beringia. Beringia can be divided into three parts: western Beringia in Asia, central Beringia consisting of the submerged continental shelves and near-shore terrestrial areas of the Bering and Chukchi Seas, and eastern Beringia in Alaska, and unglaciated areas of British Columbia and the Yukon Territory (Fig. 6.1). The submerged continental shelves of Beringia are extensive (approximately 2,500,000 km^2) and the evidence of its ancient plains, shorelines, estuaries, and river channels are submerged beneath cold ocean waters.

D. M. Hopkins realized the importance of the Bering Land Bridge in shaping the modern world and his research served as a catalyst for science that emphasized synthetic interpretation of Beringia's role in the development of northern environments and cultures (Hopkins 1967; Hopkins et al. 1982). Although there has been a strong tradition of scientific research in the Pleistocene paleoecology and geology of Beringia since the late 1800s, it was not technologically feasible to search for archeological sites submerged on Beringia's continental shelves until the mid-late twentieth century. The difficulty and expense of this type of research in high northern latitudes has greatly limited the ability of archaeologists to search for underwater archeological sites. As a result, no underwater surveys for submerged nonshipwreck archaeological sites have been undertaken in western Beringia, only one in central Beringia, and two in eastern Beringia.

Since the 1930s, the Bering Land Bridge has been the cornerstone in explaining the human colonization of the American continents. Most archaeologists believe that humans first came to eastern Beringia from Asia sometime between 17,000 and 14,000 cal years ago. The Bering Land Bridge migration model explained human colonization of the Americas as the result of hunter-gatherers originating in Asia gradually settling unoccupied territory to the east and eventually colonizing the Land Bridge and then eastern Beringia. More recently, a coastal migration model postulates that migrants from Asia to the Americas may have used watercraft to travel along the coastal areas that are now submerged. These two models are not mutually exclusive and archaeological research suggests that people were living along the coast and inland at this time. Although subsequent sea level rise separated the two continents for the last time shortly prior to 10,000 cal years ago, contact between the people of Asia and North America continued across the Bering Strait until modern time.

Archaeology of Early Beringia

An important reason to believe that there are submerged ancient occupation sites on the Bering Land Bridge is that the earliest residents of eastern and western Beringia practiced similar life styles and used similar distinctive technologies including microblades and other tools. In Russia, this distinctive technological tradition is called Diuktai culture; while in North America, it is referred to as the American Paleoarctic tradition or Denali complex (Anderson 1970; Goebel and Buvit 2011; West 1996). This technological tradition is older in Eurasia than in North America, demonstrating that it originated in Asia. Several Russian researchers have presented evidence suggesting that microblade technology may have developed first in Siberia, possibly as early as 35,000 cal BP (Derevianko 1996; Mochanov 1984; Mochanov and Fedoseeva 1984). Others think microblade technology may have originated in northern Japan, Sakhalin Island, and the maritime regions of eastern Asia (Goebel 2002; Goebel and Slobodin 1999; Goebel et al. 2000; Graf 2011; Ikawa-Smith 2004; Kuzmin et al. 2005). Although the origins of Beringian microblade traditions are not fully understood, they are well dated to about 20,000 cal BP in the periglacial regions of the Eurasian steppe (Dikov 1993; Mochanov 1984; Mochanov and Fedoseeva 1984).

The earliest reliably dated archaeological sites in eastern Beringia are Swan Point (Holmes 2011; Holmes and Crass 2003) and the Little John Site (Easton et al. 2011). Both of these sites date to 14,000 cal BP and demonstrate that humans were established on both sides of the Bering Land Bridge at the end of the Late Pleistocene when the Bering Land Bridge still connected North America and Asia. Additional evidence that people occupied eastern Beringia during Land Bridge times is suggested by the analysis of obsidian from early sites in Alaska and the Yukon. Several Late Pleistocene/Early Holocene archaeological sites in eastern Beringia (including Swan Point, Little John, Dry Creek, Walker Road, and Broken Mammoth) contain obsidian from the Wiki Peak area of Alaska's Wrangell Mountains and Batza Téna on the south side of the Brooks Range (Hamilton and Goebel 1999). The great distances between these sources suggest that widespread trade networks had developed in interior Alaska by circa 14,000–13,500 cal BP, and that these sites should be regarded as conservative limiting dates for the colonization of eastern Beringia. The region must have been occupied earlier in order to locate these sources of obsidian and for the population to increase sufficiently to facilitate the exchange of obsidian for other goods. These perspectives, along with a number of equivocal early discoveries, such as artifacts recovered from the Fairbanks muck deposits (Dixon 1999; Rainey 1939) imply that older sites remain to be found in eastern Beringia.

The archaeological remains left by early hunter/gatherers/fishers in eastern and western Beringia at sites such as Ushki Lake in Kamchatka (Dikov 1977, 1993) and Swan Point in Alaska (Holmes 2011) suggest that the intervening Bering Land Bridge and adjacent unglaciated areas of the continental shelves also were occupied at this time (Goebel and Buvit 2011; West 1996). Like their neighbors to the east and west, people living inland and along the coasts of the Bering Land Bridge during the Pleistocene must have left archaeological traces of their occupation that are now submerged under water.

Migration Routes

Most archaeologists believe that people colonized the area south of the continental glaciers of North America from eastern Beringia. The two leading hypotheses regarding how this may have occurred are: (1) by moving south along the Northwest Coast using watercraft, and (2) by moving southward through the interior following deglaciation. During the Late Pleistocene, eastern Beringia remained a terrestrial extension of Asia terminating in a "cul de sac" blocked by glaciers until a biotically viable deglaciation corridor was established about 13,000–12,500 cal BP (11,000–10,500 ^{14}C BP). A biologically viable corridor stretched along the Northwest Coast from the southern coast of the Bering Land Bridge to regions south of the continental glaciers by about 16,000 cal BP (13,500 ^{14}C BP) (Dixon 2011, 2012). Consequently, people may have been able to move south from eastern Beringia along the coast several thousand years earlier than they were able to do so through the interior.

Inferential evidence for human settlement on the former Land Bridge and adjacent continental shelves comes from several important archaeological sites along the coasts of the North Pacific Ocean. These sites were occupied immediately following the rapid rise in sea level at the end of the last glaciation. They are often preserved at locales along the coast where Early Holocene land–sea levels have remained in approximate equilibrium as a result of tectonic or isostatic processes.

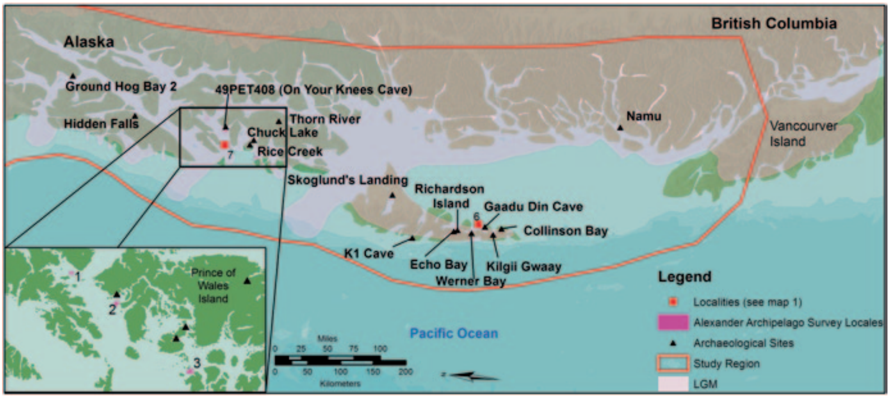


Fig. 6.2 Significant sites, geographic features, and survey locales along the Northwest Coast of North America

Originally, archaeologists thought these sites represented early Holocene maritime adaptations originating from noncoastal gathers that began to develop maritime adaptations at the end of the Pleistocene. However, it is equally plausible that these sites are evidence of maritime people who may have been living along the coast during the Pleistocene when sea level was lower and retreated landward as sea level rose at the end of the last Ice Age.

With the discovery of unglaciated areas along the coast that supported plants and animals, known as coastal refugia, and new information about comparatively early dates for deglaciation along the Northwest Coast of North America (NWC), there has been increased interest in the NWC migration hypothesis. This idea postulates that people using watercraft were able to move east along the coast of Beringia and the Gulf of Alaska (Fig. 6.1) and then south along the NWC (Fig. 6.2) as early as 16,000 cal years ago, or possibly earlier. This coastal route may have enabled people to move southward several thousand years earlier than the inland route (Dixon 2012). However, the Late Pleistocene coast is now underwater and evidence of early coastal occupations now may be as much as 165 m beneath the sea. Increased interest in the NWC migration hypothesis has stimulated interest in archaeological survey of the NWC continental shelf.

Potential for Underwater Archaeological Sites

Archaeological evidence from terrestrial sites in eastern and western Beringia can be used to identify locales most likely to contain archaeological remains that may be preserved on the continental shelf. It is reasonable to expect that underwater sites should be similar to sites that have been found, excavated, and reliably dated on both the Asian and North American sides of the Bering Strait. These sites indicate that the early inland inhabitants of Beringia were hunter-gatherers-fishers.

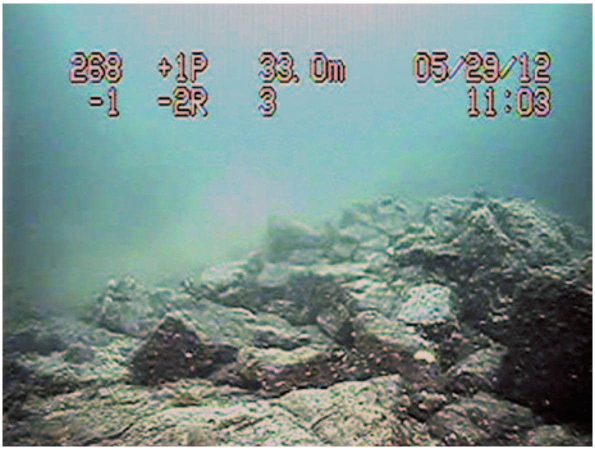
Campsites consist primarily of hearths around which stone tools have been found along with faunal remains of large and small mammals, fish, and birds. Evidence of structures more than 10,000 cal years in age have been documented at Ushki Lake in Kamchatka (Dikov 1977, 1993) and at the Upward Sun River site in Alaska (Potter et al. 2011). The paleoecological settings of these, and other types of sites, can be used to extrapolate similar types of geographic contexts in which to search for sites that may have been submerged by rising sea levels. Although archaeological sites of this nature may be difficult to identify using remote sensing techniques, larger features such as semisubterranian house pits, shell middens, or fish weirs may be more visible.

The Bering Land Bridge is the paleogeographic feature that many archaeologists have considered essential to explain how people could have migrated from Asia to North America without the use of watercraft. However, several significant North American archaeological sites are documented from the Aleutian Islands to British Columbia dating to the time when sea level approximated its current position circa 11,000–9,000 cal years ago including: Anangula (Laughlin 1975), Hog Island (Dumond and Knecht 2001), Ground Hog Bay II (Ackerman 1992, 1996a), Hidden Falls (Davis 1989), Rice Creek (Ackerman et al. 1985; Ackerman 1996b), Thorn River (Holmes 1988; Holmes et al. 1989), Chuck Lake (Okada et al. 1989; Okada and Okada 1992), On Your Knees Cave (Dixon 1999, 2001; Dixon et al. 1997), Namu Site (Carlson 1996), Skoglund's Landing (Fladmark 1979, 1990), Richardson Island and Echo Bay sites (Fedje et al. 1996), Collison Bay (Fedje et al. 2011), and Kilgii Gwaay, Gaadu Din 1, and K1 Caves (Fedje et al. 2004). The frequency and age of these sites demonstrate that people occupied areas adjacent to the continental shelves of the Bering Sea, the Gulf of Alaska, and along the Northwest Coast during the Late Pleistocene. Data from coastal and interior sites provides strong inferential evidence suggesting that two major types of ancient archaeological sites may be preserved on the continental shelves: (1) artifacts and features left by terrestrial hunters and gatherers who likely occupied the interior regions of the Bering Land Bridge, and (2) the remains of coastal and near coastal sites resulting from maritime subsistence.

Although it is difficult to conduct underwater archaeology in arctic and subarctic waters, there are also factors that may facilitate recognition of submarine archaeological sites in some regions. For example, the temperate rain forest of the NWC consists of dense vegetation that makes terrestrial archeological survey difficult. The forest makes it difficult to recognize surface features, and extensive root systems make it hard to excavate test pits. However, in the adjacent areas that are underwater, marine transgression has eliminated terrestrial vegetation and surface features are visible (Fig. 6.3). In other areas of the continental shelf, erosional surfaces or exposed geomorphic features make ancient landforms more visible.

Although there have been a number of reports of animal bones and artifacts accidently recovered from Alaska's continental shelves by fishermen and nonarcheological research projects, it has not been possible to document most of these discoveries with certainty. In a few instances, however, fossil remains have been recorded and documented accurately. Proboscidean tusk fragments and a mammoth

Fig. 6.3 ROV image illustrating the nonvegetated visual characteristics of the sea floor. (North San Fernando Island, 2012)



(*Mammuthus* sp.) were collected from two different locales in the Chukchi Sea (Kotzebue Sound), and a mammoth molar was collected in the southern Bering Sea (Bristol Bay) (Fig. 6.1). Analysis of the finds suggested that they were not ice rafted and were probably in situ, or had undergone minimal transportation. Although no archaeological remains were recovered in association with the faunal remains, their discovery demonstrates the ability of paleontological sites (and by analogy, archaeological remains) to survive marine transgression in this region (Dixon 1983).

Topography of the Bering Land Bridge

The Bering Land Bridge was not glaciated during the Pleistocene. The broad continental shelf stretching between Asia and North America is a relatively flat and featureless plain that terminates at its southern extreme in a submarine escarpment that descends steeply to the deep Pacific basin. This deep water separated the Aleutian Islands from the Bering Land Bridge during the Ice Ages. The Aleutians were not part of the Bering Land Bridge. The available archaeological evidence suggests the Aleutians were colonized later from east to west along the island chain.

The Bering Land Bridge extended more than a thousand kilometers from north to south. The northern edge of the Land Bridge slopes gradually into the basin of the Arctic Ocean (Brigham-Grette et al. 2004; Creager and McManus 1967; Hopkins 1959; Hopkins et al. 1982; Hoffecker and Elias 2007). The treeless islands of the Bering and Chukchi Seas are the peaks of mountains that rose above the Beringian plains over which the Yukon and Kuskokwim Rivers meandered to the Pacific Ocean.

GIS reconstructions that juxtapose rising sea level with bathymetric data from central Beringia have revealed an island archipelago that formed along the southern margin of the Bering Land Bridge during the Late Pleistocene (Fig. 6.4). This archipelago comprised areas of the continental shelf that were relatively higher than

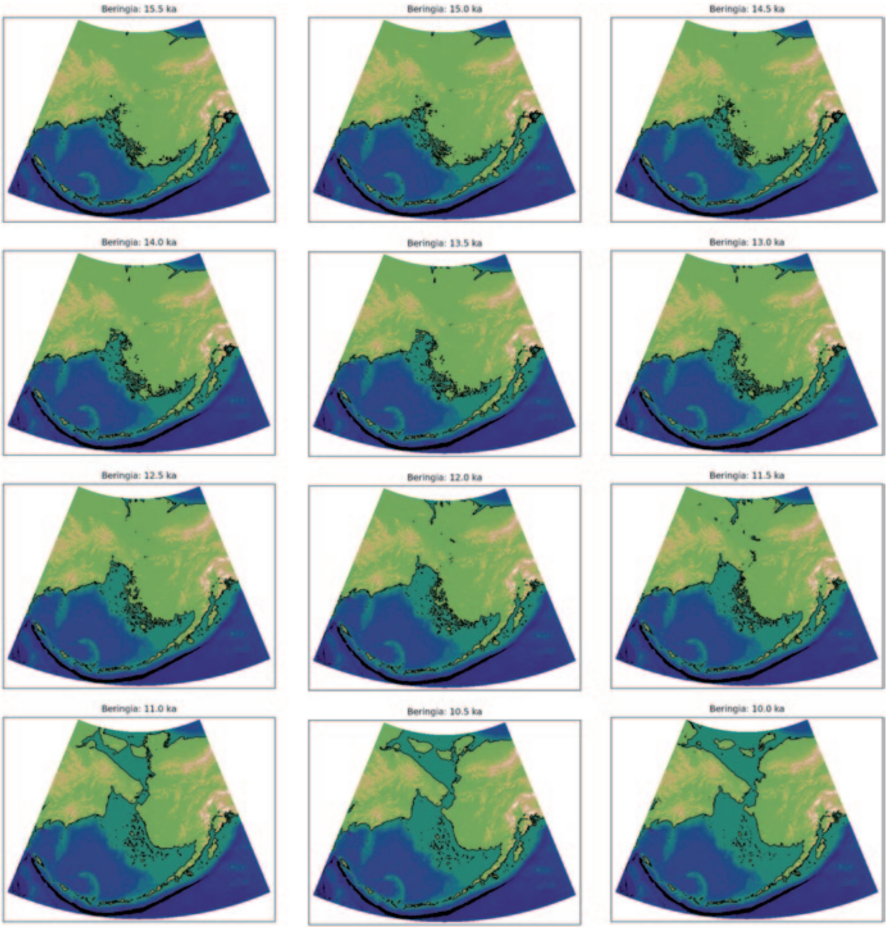


Fig. 6.4 Sequence of Beringian land and sea relationships at 500-year intervals between 15,500 and 10,000 cal years ago

the surrounding terrain that became separate islands as sea level rose. The southern Beringian archipelago emerged approximately 16,000 cal years ago and persisted until approximately 11,000 cal years ago (Brigham-Grette et al. 2004; Manley 2002). It is significant because this long-lived geographic feature possibly offered a complex system of coves, bays, and intertidal features that may have been biotically productive and provided maritime subsistence resources and sheltered channels suitable for coastal navigation.

The eastern Beringian continental shelf along the Gulf of Alaska and the NWC is much narrower. It extends in an arc along the southern side of the Alaska Peninsula eastward and then south to British Columbia (Fig 6.1). Several researchers have recognized the potential significance of this relatively narrow area along the NWC as a possible Late Pleistocene migration corridor from central Beringia to areas farther south in the Americas (Fladmark 1975, 1979; Gruhn 1994; Heusser 1960). However, early geologic interpretations indicated a continuous ice sheet extending westward from the mainland that terminated at or near the edge of the continental shelf that had covered this region (Coulter et al. 1965; Nasmith 1970; Prest 1969). These early interpretations now are known to be incorrect and recent research indicates that sizable areas were ice-free along the inner continental shelf during and toward the end of the last glacial maximum (LGM) (Ager et al. 2010; Carrara et al. 2003; Clague et al. 1989; Kaufman and Manley 2004; Mann 1986; Mann and Hamilton 1995; Misarti et al. 2012; Reger and Pinney 1992).

Resources to Support Human Habitation

Like the adjacent regions in Alaska and Russia, the exposed Land Bridge supported terrestrial plants and animals in its interior regions and fish, shellfish, and marine mammals along its coasts. These resources were virtually identical to those that supported people living in eastern and western Beringia. Fossils from the Bering Land Bridge document the survival of mammoth and possibly other Pleistocene fauna well into the Holocene. The remains of dwarf mammoths have been recovered from Wrangel and St. Paul Islands (Fig. 6.1). These animals were separated from the mainland and isolated on the islands by rising sea level. The species gradually became smaller as a result of nutritional stress caused by their shrinking habitat until they were almost 75 % of their original size. Mammoths survived on Wrangel Island until about 4000 ^{14}C BP (Vartanyan et al. 1993, 1995) and on St. Paul Island they persisted until at least 5700 ^{14}C BP (Crossen et al. 2003; Guthrie 2004; Yesner et al. 2010). Significantly, one of the St. Paul specimens dated to 6,200 ^{14}C BP is from a submarine context and was dredged from St. Paul Harbor (Yesner et al. 2010).

Possible Archaeological Discoveries from the Continental Shelf of Central Beringia

In the 1960s, David Hopkins recovered what were suspected to be stone artifacts from the floor of the Bering Sea. The stones were found at a depth of 40 m, 13 km east of Northeast Cape, St. Lawrence Island. The specimens are granite, and they were analyzed by John M. Campbell and later by Dixon (1979). The specimens lack attributes indicative of stone artifacts flaked by people and the ventral surfaces of the flakes and the corresponding flake scars on the parent cobbles are rough and irregular. These attributes indicate that the stones were not flaked by people and were probably fractured by frost spalling when sea level was lower and the Bering Land Bridge was exposed to subaerial geologic processes (Dixon 1979).

Michelle Ridgeway reported another possible archaeological site discovered while conducting multibeam survey along the southern margin of the former Land

Bridge. Her survey documented an extensive surficial exposure of mollusk shells that surficially appeared to be remarkably similar to shell middens characteristic of Holocene archaeological sites (Ridgeway 2010, personal communication). However, additional research is required to determine if the deposit is an archaeological site or the result of noncultural geologic or biologic processes.

The Search for Submerged Prehistoric Sites in Central Beringia

There have been only three scientific attempts to search for ancient submerged sites on the continental shelves of Beringia (Fig. 6.1). The first took place in central Beringia and was undertaken in 1976 with funding from the US Department of the Interior's Bureau of Land Management Outer Continental Shelf Office (now called the Bureau of Ocean Energy Management) in an attempt to assess the feasibility of surveying for and locating archaeological remains on the former Land Bridge prior to proposed offshore oil leasing (Dixon 1979). The survey was conducted in the Bering Sea approximately 2 km northeast of St. George Island.

The research was conducted prior to the existence of adequate bathymetric maps, Global Positioning Systems (GPS), and Geographic Information Systems (GIS). Survey locales thought to exhibit high potential for site discovery were identified using archaeological site potential modeling based on bathymetric data, paleoenvironmental reconstructions, and sea level history. This analysis attempted to identify areas of high archaeological potential based on high latitude hunter-gatherer subsistence and settlement patterns. However, the selected underwater survey site was changed due to high winds and seas of the Bering Sea storm that occurred during the study period. High seas required the selection of a survey locale on the lee side of St. George Island (Fig. 6.1) that had not been identified as an area of high archaeological potential. The survey was conducted using a hull-mounted sub-bottom profiler, side-scan sonar, and proton magnetometer. On-shore radio navigation stations established at prominent locations on St. George Island were used to achieve navigational accuracy of ± 50 feet (15 m). Although no archaeological remains were identified, the survey demonstrated the feasibility of searching for submerged archaeological sites in high latitudes (Dixon 1979).

The Search for Submerged Prehistoric Sites in Eastern Beringia

The second marine archaeological survey associated with Beringian archaeology was undertaken almost 30 years later and was conducted in coastal waters of British Columbia by Josenhans et al. (1997). Recent studies in this region have shown that sea level was as much as 150 m lower about 12,000 years ago in Haida Gwaii (formerly called the Queen Charlotte Islands) of northern British Columbia, situated adjacent to the southern border of Alaska. A total of 10 km^2 of the sea floor in Juan Perez Sound in western Hecate Strait (Fig. 6.2) were mapped in 1997 using high-resolution multibeam sonar, side-scan sonar, and a remotely operated underwater vehicle (ROV). The sonar imagery revealed landscape dominated by alluvial fans, deltaic plains, and a meandering and migrating river system. In 1998 and 1999, Fedje and Josenhans (2000) focused on targets from the digital elevation model (DEM) generated from the multibeam survey to concentrate on investigation for archaeological sites and to facilitate dating Late Pleistocene shorelines. Using a clamshell grab sampler, they recovered and hydraulically screened sediment from which they recovered buried wood and other evidence of the ancient terrestrial environment. They made the significant discovery of a retouched basalt blade-like flake from sediment recovered from a depth of 53 m in Werner Bay. They concluded that this artifact was probably deposited on the continental shelf at a time when sea level was lower.

Dixon and Monteleone began the third survey effort in 2010 investigating three locations on the continental shelf of the Alexander Archipelago (Fig. 6.2, *inset*) in areas where fishermen and sea urchin divers have reported finding a number of artifacts on the ocean floor. Like some of the Bering Sea finds, it has been impossible to verify the specific locations of these discoveries. Most of these artifacts are ground stone, which is generally associated with later archaeological periods and may have been deposited as a result of later fishing, marine mammal hunting, capsized vessels, or lost overboard. These areas were investigated along with other locales identified by archaeological site potential modeling.

Gateway to the Americas Project

The Gateway to the Americas Project is designed to search for Late Pleistocene archeological sites on the continental shelf of the NWC. It was similar to the research conducted by Josenhans and Fedje and was designed to search for evidence relevant to the coastal migration hypothesis. The work in SE Alaska was guided by paleoecological modeling designed to identify specific areas on the continental shelf exhibiting potential for archaeological site occurrence and preservation. The project developed a digital elevation model (DEM) of the ocean floor using bathymetry data (NOAA Hydrology 2010; NOAA Multibeam 2010; additional data obtained from Scientific Fishery System, Inc.) and current land elevation (USGS Earthexplorer 2009; USGS Seamless 2009). Specific locales exhibiting high potential for archaeological site occurrence and preservation were identified using principles of environmental, settlement pattern, and landscape archaeology (Anschuetz et al. 2001; Butzer 1982; Dincauze 2000; Maschner 1992, 1996). The model identified geomorphic features on the ocean floor similar to those known to contain archaeological remains in terrestrial contexts such as stream junctions, outcrops likely to contain caves or rock shelters, lake inlets and outlets, sheltered bays and inlets,

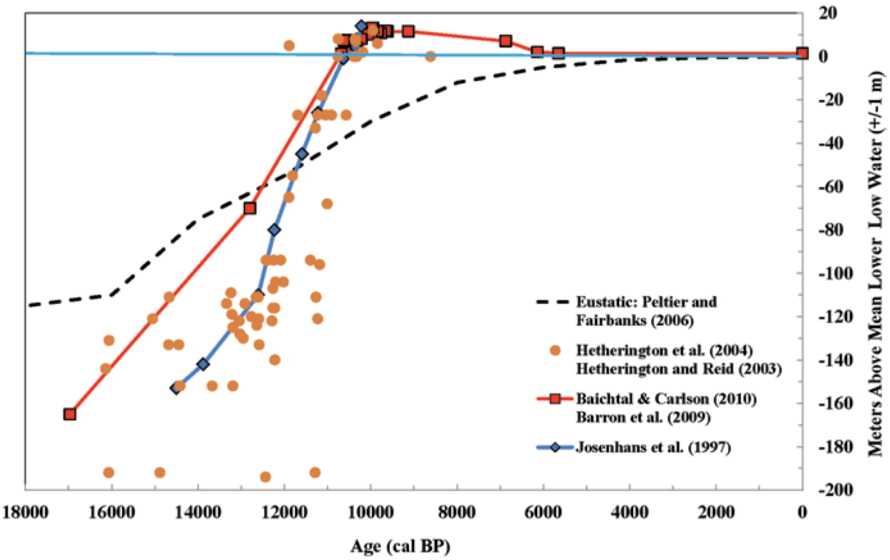


Fig. 6.5 Composite Late Pleistocene and Holocene sea level curve for the outer islands of the Alexander Archipelago and for Haida Gwaii. (Baichtal and Carlson 2010; Barron et al. 2009; Hetherington and Reid 2003; Hetherington et al. 2004; Josenhans et al. 1997; Peltier and Fairbanks 2006)

headlands, and areas of fresh water discharge along shorelines. These features were used to help focus the marine archaeological survey to explore for possible Late Pleistocene age habitation sites. Preliminary sea level reconstruction suggests that the sea level curve for SE Alaska is similar to the sea level history for Haida Gwaii (Fedje and Josenhans 2000) (Fig. 6.5).

The 2010 fieldwork was conducted between June 16–24, 2010, aboard the 86 feet (26.2 m) FV Crain. The seafloor was imaged using a dual beam adjustable frequency Imagenex Model Yellowfin side-scan sonar (330 kHz) and ground truthed using an ROV and Van Veen grab sampler. The ROV had two video cameras, a wide and normal view, and external light sources. Trimble XRS DGPS with integrated (internal) coast guard beacon provided real-time satellite corrections and submeter accuracy. Surveys were overlapping 125 m transects (swaths) and the side-scan depth was controlled by a combination of vessel speed and deployed cable. Optimal vessel speed was 1.7 knots but varied based on wind and sea conditions. The combination of the sonar and ROV video provides a high-resolution image of landforms comparable in scale and resolution to aerial photographs. The ROV mechanical arm and Van Veen Grab Sampler and hydrologic screening were used to physically collect and examine sediment and samples.

Survey locale 1 was an underwater canyon in Keku Strait (Fig. 6.2) where a local fisherman reported finding a ground slate projectile point in 2004. The artifact was reportedly adhering to the mud on a shrimp pot that had been set at a depth of about 90 m (approximately 300 feet). The fisherman bracketed the GPS coordinates

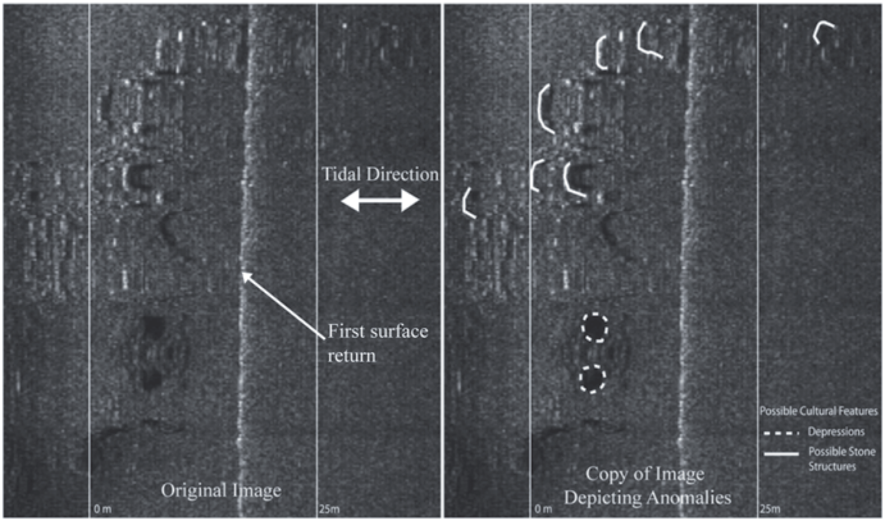


Fig. 6.6 Side-scan image of the ocean floor, Shipley Bay, Prince of Wales Island, Alaska depicting anomalies

of his discovery. This area was subject to side-scan survey in 2010, and examination of the imagery identified one rectangular anomaly. The location was too deep for the FV Crain to anchor, making it impossible to deploy the ROV or to use the Van Veen grab sampler. Extrapolation from the sea level curve suggests this locale was inundated by rising sea level about 13,400 cal years ago. However, ground slate technology in the North Pacific region of North America is not known prior to 6,000–7,000 years ago. These data suggest that the location of the discovery may not have been reported correctly, or the artifact may have been deposited at this locale by other mechanisms, such as lost overboard by early hunters or by a wounded marine mammal.

Survey locale 2 was the potential confluence of several submerged stream channels and/or a paleoestuary in Shakan Bay (Fig. 6.2). This was a difficult location to survey because of the many sub-surface pinnacles rising from the sea floor. However, with careful navigation, the area was surveyed and several anomalies were identified following postprocessing of the side-scan data (Fig. 6.6). Figure 6.6 depicts what were interpreted as seven semicircular stone formations and two circular depressions about 2 m in diameter. These features are located in approximately 52 m of water. Extrapolation for the regional sea level curve suggests they would have been inundated by rising sea level approximately 12,300 cal years ago. Although the semi-circular distributions of stones appear similar to intertidal fish weirs commonly associated with archeological sites along the NWC, additional survey and testing are required to determine if these anomalies are cultural in origin, or if they result from noncultural biologic or geologic processes.

Survey locale 3 was the possible outlet for paleolake Esquibel on the southwest end of the Gulf of Esquibel, a marine basin west of Prince of Wales Island (Fig. 6.2).

When sea level was significantly lower, the Gulf of Esquibel was a fresh water lake. It was later flooded by the rising sea that ultimately formed the present-day Gulf. Barron et al. (2009) analyzed and dated a sediment core (EW0408-11JC) from the Gulf of Esquibel. The core documents the Gulf as a freshwater lake between 14,200 and 12,800 cal BP that transitions to brackish water sometime between 12,800 and 11,100 cal BP. A radiocarbon determination run on shell by Barron et al. (2009) and adjusted for the marine reservoir effect and calibrated to 11,324–11,773 cal BP by Baichtal and Carlson (2010) also provides a minimum limiting date of circa 11,500. The sea level curve (Fig. 6.5) is based on the diatom record from Barron et al. (2009).

Based on contemporary bathymetry, the lowest topographic point along the basin's margins is circa −70 m (Baichtal and Carlson 2010). This is the probable point at which rising sea level breached the Esquibel basin. A small locale in this area which is interpreted to be an isthmus between paleolake Esquibel and the sea was surveyed in 2010 using side-scan sonar and an ROV. Several rock outcrops observed in the side scan and ROV images appear to contain possible rock shelters. The ROV was deployed adjacent to two rock outcrops. The Van Veen grab sampled sediment adjacent to one of the rock outcrops. Grab samples were screened hydrologically for the presence of bone, shell, charcoal, lithic specimens, macrofossils, or cultural debris that may indicate cultural occupation. Although no definitive archaeological remains were identified, the outcrops are potential targets for future multibeam survey and testing.

This research is based on the premise that submerged archaeological sites are most likely to be found in geographic and environmental contexts similar to adjacent terrestrial and coastal settings where sites are known to occur. Paleolake Esquibel is located beyond the limits of the LGM ice, yet within areas that were above LGM sea level. Shakan Bay and possibly Keku Strait are located in areas that were deglaciated by about 14,000 cal years ago but not flooded by rising sea level until about 10,000 cal years ago. Imaging of the sea floor in these areas further refined the identification of specific geomorphic features and selection of likely survey targets (e.g., former lake margins, stream junctions, prominent points and headlands along submerged shorelines, etc.) on the inner shelf that were above sea level during the Late Pleistocene. Although no artifacts were recovered during this preliminary survey in the Alexander Archipelago, it has led to a larger 3-year project (2012–2014) funded by the National Science Foundation to continue the search for ancient habitation sites preserved on the continental shelf of Southeast Alaska.

Summary

People occupied coastal and interior regions of Beringia when the Bering Land Bridge spanned the two continents. The archaeological evidence is clear that there is technological continuity between the earliest archaeological sites in Asia (western Beringia) and the earliest sites in Alaska and Canada (eastern Beringia) more than 2,000 years prior to the time that post-Pleistocene sea level rise separated the two continents for the last time. Research to locate and document submerged habitation sites on the continental shelves of Beringia is in its formative stages.

High latitude marine archaeological survey is expensive and difficult. It is dangerous; logistic problems are formidable; and ship's crew procedures for surveys in northern latitudes are not well established. Precise bathymetric mapping, satellite global positioning, high resolution multibeam sonar, and sophisticated ROVs have made it possible to conduct precise underwater surveys, particularly in the more sheltered waters along the NWC. This research holds promise to revolutionize our understanding of timing and character of early NWC maritime adaptations and to provide new insights and discoveries relevant for evaluating the coastal migration hypothesis.

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Chapter 7
The Inter-Tidal Zone Site of La Olla: Early–Middle Holocene Human Adaptation on the Pampean Coast of Argentina

María Cristina Bayón and Gustavo G. Politis

Introduction

Argentina has a maritime littoral zone of more than 2,500 km spanning two great natural regions, the Pampa and Patagonia. This remarkable latitudinal extent results in a wide variability in climates and coastal morphology (Cavallotto 2008). In the Pampean region, the coasts show a gentle declivity, are low, sandy, and interrupted by scanty cliffs such as those of Miramar or Monte Hermoso (MH). In contrast, abrupt coasts predominate on the Patagonian littoral, with the presence of occasional stretches of inactive cliffs, accompanied by gravel or sandy beaches (Cavallotto 2008). Coastlines of both regions were inhabited in pre-Hispanic times by hunter-gatherer groups since at least 7,400 years BP (see synthesis in Orquera and Gómez Otero 2007).

The coastal archaeology of Argentina is relatively well known, and there are sections of the coast that have been studied intensively particularly from 1980 on (i.e., Bonomo 2005; Borrazzo 2004; Borrero and Barberena 2006; Castro and Moreno 1998; Castro et al. 2004; Favier Dubois et al. 2006, 2009; Franco et al. 2004; Gómez Otero 2006, 2007; Orquera and Piana 1988, 1999; Zangrando 2009). This research has shown that since at least the Middle Holocene (ca. 7,000–3,500 years BP) there has existed in some regions of the Pampean–Patagonian littoral an adaptation to the exploitation of the marine resources (sea mammals, fish, mollusks, etc.), which is observable not only in the archaeological assemblages but also in the results of isotopic studies on human remains (e.g., Barberena 2002; Borrero et al. 2009; Favier Dubois and Kokot 2011; Gómez Otero 2007; Politis et al. 2009). Almost all the data

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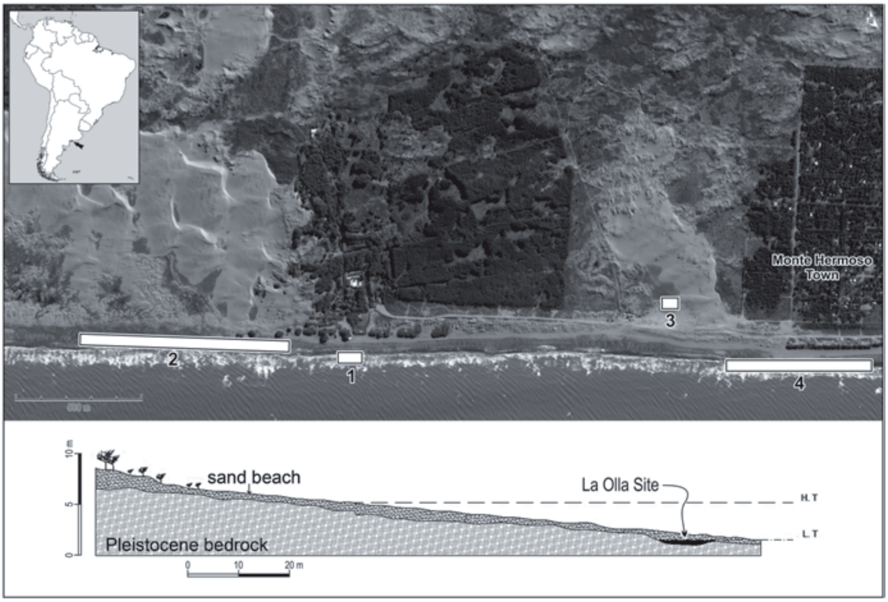

Fig. 7.1 Map of the study area showing archaeological and palaeontological sites mentioned in the text and schematic section of beach at La Olla site: *1* La Olla, *2* Monte Hermoso 1, *3* Barrio Las Dunas, and *4* El Cangrejal

used to characterize these maritime littoral occupations come from emerged sites found on the shell middens at the bottom of beaches and their adjoining flats, coastal dunes, or on the coastal slopes and cliffs (e.g., Bonomo 2005; Cruz and Caracotche 2006; Ercolano and Carballo 2005; Orquera and Piana 1991). But for a few isolated exceptions, such as the wooden fishhook discovered on the North Patagonian Coast (Gómez Otero 2007), no finds have been reported from submerged pre-Hispanic archaeological sites on the Atlantic seaboard.

In this chapter, the authors synthesize the information from the La Olla (LO) site (38° 59′S 61°21′W), the only pre-Hispanic archaeological site which is most of the time submerged in the South Atlantic littoral. This site is located 6 km west of the MH seaside resort (Fig. 7.1). The most noticeable characteristic is the integrity and resolution of the archaeological deposit, as also the exceptional preservation of organic remains, bones, and particularly plant materials, which have allowed the bone and wood technology to be known and characterized. Presently, the site is situated at the limit of the lowest tide and remains almost permanently covered by water and saturated sands. Only sporadically, once every so many years, it is left exposed. These appearances depend on several factors such as the position of the seashore sand bar, the daily tidal variations, and the direction and speed of wind. When certain combinations of the above conditions are present the sediments containing the archaeological materials are in full sight for only 2–3 h at low-tide (Fig. 7.1).

LO has four sectors, named LO1, LO2, LO3, and LO4, established not only on account of their spatial location, but because each was left exposed at four different moments from 1983 to 2008. Thus, not only are the four sectors of the site discrete spatial units but represent diachronic moments of observation and sampling. The data from La Olla 1 and 2 (LO1 and LO2) have already been partially published and are only synthesized in this article (Bayón and Politis 1996; Johnson et al. 2000; Politis and Lozano 1988). The results of the excavations and analyses at La Olla 3 and 4 (LO3 and LO4), discovered in 2008, are presented here. In the first place, the interpretations on the formation of the site are summarized, on the basis of Adriana Blasi's sedimentological analyses (Blasi et al. 2013) and a series of new radiocarbon datings. Secondly, the lithic, bone, and wood technology of both sectors is analyzed. Complementarily, the zooarchaeological study carried out by Leon and Gutiérrez (2011) is summarized. Finally, the LO site is related to two nearby sites with a similar chronology: MH 1 (Bayón and Politis 1996) and Barrio Las Dunas (BLD) (Bayón et al. 2012). As a corollary, the information from this microregion is discussed in relation to the models of human occupation along the South Atlantic littoral.

The Local Paleoenvironmental and Archaeological Context

In order to understand the formation of the LO site, it is necessary to know the South Atlantic coastal dynamics over the last 20,000 ^{14}C years BP, as the Argentine littoral was affected by sea level variations during the Late Pleistocene and the Early–Middle Holocene. At the maximum of the last glaciation, the fall in the sea level moved the coastline out eastwards over hundreds of kilometers. For example, the Patagonian region was almost double its present size (Zárate in Flegenheimer et al. 2007, pp. 44–45; Guilderson et al. 2000). At the beginning of the Holocene, the rise in sea level began, reaching its maximum height (around 2 m) some 6,500–6,000 years BP (Isla et al. 1986; Isla and Espinosa 1995). This resulted in the coasts having a sometimes transgressive position, and in other cases very close to the present according to the variations of the littoral morphology. In the southwest of Buenos Aries province, the environmental conditions in the Early–Middle Holocene were inferred from different proxies (Quattrocchio et al. 2008, pp. 135). The greater humidity suggested for this period as well as the increase in the phreatic level favored the formation of pools in the fluvial valleys and coastal interdunes (Quattrocchio et al. 2008, pp. 135).

The present coast of the study area has an east–west direction, with broad beaches near 150 m wide, and a gentle inclination of around 2°. Toward the continent, a continuous field of sand dunes is found which, in the area under study, is up to 4 km deep (Monserrat 2010), and has fixed dunes with patches of active ones (Marcomini et al. 2005). This is part of the Southern Dune Barrier (Barrera Medanosa Austral), extending from Miramar to Pehuencó, and comprises a complex of different generations of dunes, formed in three periods of the Holocene (Isla et al. 2001). The beach shows a characteristic backshore, foreshore, and shoreface profile (Fernández et al. 2003). On the backshore, a stable berm is formed, but at the foreshore and shoreface sand bars and shifting canals are created. The mean amplitude of the tide is 3.12 m. The beach is directly exposed to the waves predominantly from the south and southeast, with a wave mode between 0.30 and 0.60 m. The storms that affect the beach from the south (locally known as "sudestadas") are especially strong with waves 1.50–1.80 m high (Fernández et al. 2003).

On the southern coast of the Pampean region, over a 4 km stretch of shore in the southeastern sector (Fig. 7.1), three archaeological sites are to be found: LO, MH 1, and BLD, and a paleontological site, El Cangrejal, all of them dated at the end of the Early Holocene and the beginning of the Middle Holocene. Three of these sites (MH1, LO, and El Cangrejal) are located on emergences of the present beach and are affected in different ways by the tide. Whereas, MH1 and El Cangrejal have a more elevated position on the foreshore, and are only covered at high tide, LO is in a lower position and remains under water most of the time. BLD is located on the coastal dunes, very close to the beach, and was exposed in 1995 due to the erosion produced by a deflationary hollow (Fig. 7.1). In Table 7.1 are synthesized the most relevant published characteristics for each of the three sites close to LO, and complement the regional understanding of the natural and cultural processes of the Early–Middle Holocene (Aramayo et al. 1992; Aramayo et al. 2005; Bayón and Politis 1996, 1998; Bayón et al. 2012; Quattrocchio et al. 2008; Gutiérrez Téllez and Schillizzi 2002; Zavala et al. 1992).

The La Olla Site

The LO site presents four discrete sectors (LO1, LO2, LO3, and LO4), which are close to one another along an extension of approximately 150 m (Fig. 7.1). The infilling pools or depressions that characterize LO are some 40 or 50 m distant from each other and are similar in their areal development. They show a suboval shape and maximum diameters of ca. 17 m. At none of the four sectors was it possible to carry out a systematic excavation. All the tasks had to be effected extremely fast before the advance of the tide and waves made it impossible to carry on. In every case, the fieldwork was limited to extracting the abundant materials that emerged from the interlamination of sand and silt and recording their spatial and stratigraphical placement. The exposed surface was divided into grid squares and each object was registered three-dimensionally (Fig. 7.2). Samples of sediment were also extracted and at LO4 it was possible to obtain four sediment columns from the Holocene deposits from a depth of 0.80 m–0.40 m.

LO1 (38°59´374″S 61°21´064″W) was discovered in December 1983 by Vicente Di Martino, the Director of the local museum. The rescue work was carried out in January 1984 by Licentiate Luis Guzmán (Johnson et al. 2000; Politis and Lozano 1988). Then the site was totally covered over for 10 years until 1993 when LO1 was once more left exposed for a few days, and it was possible to carry out a hurried rescue of the materials that appeared (Bayón and Politis 1996). During this time Fontana (2004) carried out paleoenvironmental studies by means of different

Table 7.1 Early-Middle Holocene sites close to La Olla site with its archaeological and paleoenvironmental interpretation

Sites	^{14}C dates	Current setting	Description	References
Monte Hermoso 1	7,125 ± 75–6,795 ± 120 years BP	Emersions on the beach: located at the foreshore	Palaeoenvironmental context: Ostracods of continental origin: *Sarscypridopsis aculeata; Lymnocytere sp,* and *Cyprinotus salinus* suggest a body of water having little connection with the sea. The whole population is represented and indicates a low-energy environment. The precipitation of carbonates points to a restriction of the body of water. The pollinic profile reflects the development of a vegetation community characteristic of coastal dunes (psammophytic herbaceous) and interdune ponds with a slight marine influence. The finely laminated sedimentary sequence with alternance of pelitic and sandy layers indicates a predominance of decantation processes. Throughout the whole sequence *Ruppia sp* seeds are found. Archaeological context: Hundreds of children, women, and men's footprints registered in the soft mud. The assemblages also include human bone remains of two individuals—found in the backshore—scanty faunistic remains, and a few wood artifacts	Bayón and Politis 1996; Zavala et al. 1992; Quattrochio et al. 2008
Barrio Las Dunas	6,924 ± 69 years BP	Coastal dune	Palaeoenvironmental context: This is an interduna palaeoenvironment on the margins of the crab bed Archaeological context: Faunistic remains of black sea bass (MNI = 6) and Otaridae (MNI = 6), with evidence of human action. The assemblage includes 984 stone artifacts	Bayón et al. 2012
El Cangrejal	6,500 and 6,900 years BP	Emersions on the beach: located at the foreshore	Palaeoenvironmental context: *Cyprideis salebrosa* is the dominating ostracod species. The site presents *Chasmagnathus granulata Dana* crab galleries; these evidences together with the ostracod and diatom species indicate the existence of a transitional marine environment such as an estuary or lagoon. No archaeological material has been found so far	Aramayo et al. 2005

Fig. 7.2 Panoramic view of La Olla 4

proxies. In 1995, LO2 was briefly exposed, and it was only possible to collect a few materials (mainly sea mammal bones). Finally, between January and March 2008, an exceptional movement of sands took place which allowed fieldwork on an intermittent basis during 8 weeks at LO3 (38°59′22.5″S 61°21′3.3″W—very near LO1) and LO4 (38°59′22.44″S 61°21′8.16″W). It was possible to carry out the most detailed sedimentological studies at LO4 due to the longer exposure time and the success in obtaining a complete column of the Holocene deposits. The sedimentological analyses have allowed identification of two lithofacies: silicoclastic sands and silty sands, and two biosedimentary ones, such as sandy silt microbial mat and diatomaceuos earth with evaporated crystals, which are part of different sedimentary facies (Blasi et al. 2013). Each of these facies is characterized by a set of lithological and biological content features, and allows the characteristics of the medium during its deposition to be defined. Facial changes evidence environmental changes, sometimes recurrent or alternating, that have occurred during the depositional process that took place at the site (see Fig. 7.3 in Blasi et al. 2013). These facies are, from top to bottom:

Facies A Dark gray sandy silt. This is made up of a bioturbated silt and sandy silt (Fmb), and is dark gray in color. These sediments show many ancient crab burrows. Only isolated archaeological remains were found in this facies.

Facies B Silicoclastic biolaminites. These facies correspond to an interbedding of biofilms or microbial mats (MM), are dark gray in color and a few centimeters to millimeters thick, and include laminates of diatomaceous

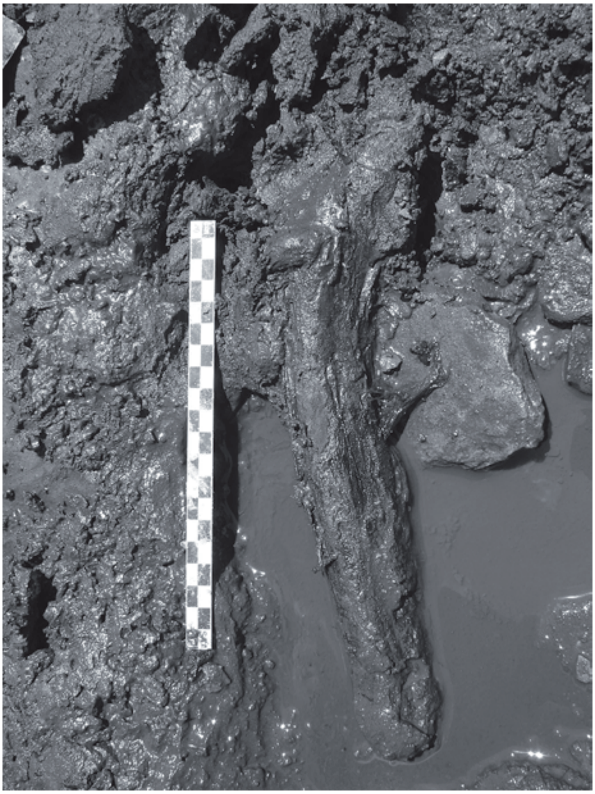

Fig. 7.3 Hafted ax recovered in La Olla 3

earth with authigenic evaporite precipitates. In the field, this facies shows a complex biosedimentary structure related with mat growth which appears in the cores with strong inclination of the upper layers. This facies contained the great majority of the archaeological remains.

Facies C Interbedding of thin MM and gray silty sands. It consists of an intercalation of light gray silty sands and MM. The light gray silty sands show an organic matter content <1 %. This facies hardly had archaeological remains of any kind.

Facies D Brown sand with sporadic isolated MM. This is made up of light-colored sands. It is composed of medium to fine yellowish-brown sands, moderately sorted with a symmetrical to very fine skewness and very leptocurtic unimodal (fine sand modal class) distribution. No archaeological remains were found in this facies.

It must be stated that the facial variations in the succession from the lower section (Facies D and B–C) to the upper (Facies A) lead to the inference of a gradual passage from a supratidal subenvironment to a lower supratidal–upper intertidal and finally intertidal zone. This passage is presumably closely related not only to climatic factors, mainly the wind, but to the transgressive process, with the consequent displacement of estuarine conditions (from the outer estuary) inlandwards. This aspect closely coincides with the advance of the coastline around 6,000 years BP inferred by Grill and Quattrocchio (1996) (Blasi et al. 2013).

The micropaleontological studies were carried out on the basis of ostracods with samples from LO3 (Martínez et al. 2010). An association made up of dominant and highly abundant populations of *Cyprideis salebrosa,* together with scanty *Sarscypridopsis aculeata* valves, was detected. The presence of these taxa coincidentally indicates low-energy bodies of salt water enriched in Cl^- and Na^+ by the influence of sea water (Martínez et. al. 2010). The association of microfossils also points to a shallow marginal marine environment, similar to a littoral lagoon or a myxohaline marsh.

In LO1, almost 300 faunal remains were identified as to element and taxon, with *Otaridae* (MNI=41) predominating, both *Arctocephalus australis* and *Otaria flavescens*. Bones from *Lama guanicoe*, *Ozotoceros bezoarticus,* and *Rhea americana* were also recovered. The assemblage includes stone, bone, and wood artifacts. Especially notable is a wooden spatula-like artifact decorated with zigzag engraving and red paint. An expedient bone tool dynamically fractured from the proximal end of a pinniped tibia was also recovered in the assemblage. Lithic materials ($n=38$) include tools ($n=25$), cores ($n=7$) and debris ($n=6$). The tools include pieces marginally retouched ($n=5$), choppers ($n=2$), hammerstones ($n=3$), and anvils ($n=2$). Flaked tools could be considered informal. There are several fragments of artifacts with active surfaces (*manos, metate,* and abraders). Regarding raw material selection there is a clear predominance of quartzite rocks ($n=18$), basalt pebbles ($n=6$), muddy sandstone ($n=5$), sandstone ($n=2$), and other rocks ($n=7$) were less used. Two dates from otaridae bones from the archaeological assemblage of LO1 gave ages of 7,314 ± 55 and 6,640 ± 90 ^{14}C years BP (see Table 7.2). Fontana (2004) obtained older dates, ranging from 7,040 ± 55 (considered by Fontana as an outlier) to 7,920 ± 90 years BP. However, most of them seem to have been obtained from the lower levels, which did not contain archaeological remains.

LO2 is ca. 50 m west of LO1. A small number of pinniped bone and few stone tools ($n=4$) were recovered on that occasion. A ^{14}C date from otariid bone gave an age of 7,400 ± 95 ^{14}C years BP. As previously stated, this was the less exposed sector of the site and therefore there are very few data from it.

The technological assemblages from LO3 and LO4 are composed of 14 stone artifacts, 3 of bone, 11 shaped in wood, and 1 unmodified cobble. The faunal assemblage comprises 303 bone remains and 12 gastropods—10 specimens of *Adelomedon brasiliana* and two of *Adelomedon beckii*, one of them almost 30 cm long (Farinatti 2011 pers. com.). Also, 35 macroplant remains have been recovered from the site.

The zooarchaeological analysis performed by Leon and Gutiérrez (2011) was based on the 101 faunistic specimens recovered at LO3. The most represented taxon is that of the Otaridae (NISP=77). Within this, the southern sea lion (*O. flavescens*—NISP=22, MNI=3) and the southern fur seal (*A. australis*—NISP=14, MNI=4) were identified. Forty one could not be assigned at a genus level. In

Table 7.2 ^{14}C dates for the La Olla site

Sector	Sample code	Material dated	Lab. number	δ13C	Date in ^{14}C in yrs BP
La Olla 1	LO1a	Otaridae bone	LP-303	–	6640±90
La Olla 1	LO1b	Otaridae bone	AA-7972	−13.7	7315±55
La Olla 1[a]	Prof. 0–1.1	*Ruppia sp.*	NSRL 11044	–	7580±60
La Olla 1[a]	Prof. 5.5–6.2	*Ruppia sp.*	NSRL 11045	–	7750±60
La Olla 1[a]	Prof. 8.3–8.9	*Ruppia sp.*	Ua 16106	–	7635±75
La Olla 1[a]	Prof. 22.1–23.1	Macrovegetal remain	NSRL 11046	–	7040±55
La Olla 1[a]	Prof. 33.7–34.4	*Ruppia sp.*	NSRL 11047	–	7920±90
La Olla 2	LO2a	Otaridae bone	AA19292	−12.3	7400±95
La Olla 3	L03-52	Wood	AA-80666	−26.1	6885±47
La Olla 3	L03-99	Wood	AA-80668	−25.4	6898±47
La Olla 3	LO3 42	Otaridae bone	AA-80663	−10.2	6904±71
La Olla 4	LO4m1	Organic matter	LP-1946	–	6480±140
La Olla 4	LO4m2	Organic matter	LP-1949	–	6700±110
La Olla 4	L04-142	Wood	AA-80667	−27.3	6931±47
La Olla 4	L04-166	*Lama guanicoe*	AA-80664	−19.9	6960±71
La Olla 4	L04-60	Otaridae bone	AA-80665	−13.1	7176±91[b]

[a] From Fontana (2007)

[b] Laboratory reported problems in the line during the dating process

addition, other marine species were identified, such as the sea catfish (*Netuma barbas*—NISP=2, MNI=2), cetacea (NISP=5, one of them belonging to a Mysticetos, whale, MNI=1), and gasteropods (*Adelomelon brasiliana*—NISP=3, MNI=3 and *Adelomelon beckii*—NISP 1, MNI=1). Terrestrial mammals were also found, such as the guanaco (*L. guanicoe*—NISP=7, MNI=1) and the pampa deer (*O. bezoarticus*—NISP=1, MNI=1). With reference to the anatomical representation of pinnipeds, elements from the whole skeleton were recorded, but with an under-representation of the axial in relation to the appendicular (NISP=17 versus NISP=60). Specimens with cut-marks were found (NISP=14) that indicate skinning, disarticulation, and removal of the flesh in Otaridae, Three thermo-altered specimens were also recovered. Such evidence of processing and consumption was also identified on guanaco elements (NISP with cut-marks=1 and NISP thermo-altered=1) and cetacea (NISP with cut-marks=2). Finally, two bone tools made from guanaco ribs were identified.

At LO4, a larger number of specimens were recovered (NISP=202) (Leon and Gutiérrez 2011). The most represented taxon in remains (NISP=156) as well as individuals (MNI=19) is Otaridae. But in contrast to the previous case, the southern sea lions are more abundant here (*O. flavescens*—NISP=53, MNI=9 and *A. australis*—NISP=15, MNI=3). A greater diversity of taxa was recorded: sea catfish (*Netuma barbas*—NISP=1, MNI=1), black sea bass (c.f. *Pogonias cromis*—NISP=1, MNI=1), cetacea (Mysticetos, whale, NISP=1 and MNI=1 and Odontocetos, dolphin, NISP=5 and MNI=1), and gasteropods (*A. brasiliana*—NISP=7, MNI=7, and *Adelomelon beckii*—NISP 1, MNI=1). In addition, continental species were recognized, such as the guanaco (*L. guanicoe*—NISP=8, MNI=1), felidae (NISP = 1), and three fragments of ñandú (*R. americana*) eggshells were recognized.

The anatomical representation of the Otaridae is similar to that at LO3, with elements from the whole skeleton being determined, the axial being under-represented in comparison with the appendicular (NISP = 57 versus NISP = 99). Twenty-two specimens with cut-marks were identified, indicating disarticulation, removal of flesh, and scraping. Seven burnt specimens were also identified. These signs of processing were also found on dolphin elements (NISP with cut-marks = 2). Lastly, a tool fashioned from a guanaco shin bone was also recognized (Leon and Gutiérrez 2011).

Lithic artifacts are scarce (LO3, *n* = 8; LO4, *n* = 6), and include flaked tools (*n* = 7), cores (*n* = 2), hammerstones (*n* = 2), flakes (*n* = 2), and one artifact manufactured by pecking and abrasion. Marginal flaking predominates, both unifacial and bifacial. Among the artifacts discovered two tools are to be noted: an ax (LO51) and a double-chopping tool (LO3 84). The former is the most amazing tool since it is a hafted ax with a partial marginal bifacial cutting edge (Fig. 7.3). Its handle (LO52) was carved laterally on the top and filled with an adhesive substance in order to support the lithic component which was finally secured to the handle by fibers. Its full weight is 561 g, 249 g the lithic tool and 312 g the handle, respectively. The latter is a large 392 g cobble with a bifacial chopper at each opposite end. Both ridges show heavy signs of impact as if it had been used as a heavy stone wedge.

Quartzite is the most frequently used raw material (*n* = 7); some of the artifacts have the cortex of fluvial cobbles. Basalt (*n* = 2), muddy sandstone (*n* = 1), orthoquartzites of Sierras Bayas Group (*n* = 1), and Balcarce Formation (*n* = 1) were also used as raw materials. The wooden tools from the LO site make up an absolutely novel record for the region. Diverse kinds of tools were fashioned and different production processes were employed. Among the artifacts shaped, there are three complete wooden points (LO3 47; LO3 81; LO4 168) and two medial fragments. The apex and distal ends are carefully shaped and were fire-hardened. A second group is that of artifacts with a cylindrical body and a blunt, wide, thick end (LO4 102 and LO4 32), resembling wooden clubs (Schick and Toth 1995). The third group is that of the previously described handle with the bark partially retained. Together with the tools, probably naturally accumulated, macro plant remains were also found. This assemblage includes seeds, stem fragments, roots, and even leaves. There are also a few bark fragments.

Radiocarbon Dates

Altogether, 16 radiocarbon dates were carried out for the LO site on samples of different provenance, 5 of them corresponding to Otaridae, 3 on woods, 4 on seeds, 1 on plant macroremains, 1 on a land mammal, and 2 on organic material. Eight datings have already been published (Bayón and Politis 1998; Fontana 2004) from LO1 (the sector with the most datings) and from LO2 (with just one dating) (Table 7.2).

Dating from LO4 that showed the most recent ages were carried out on organic matter from the Facies A (bioturbated dark gray sandy silt), and yielded dates of 6,480 ± 140 and 6,700 ± 110 ^{14}C years BP. They belong to a remaining block that was lying on the top of the sedimentary sequence**.** These ages are less precise than the rest owing to the nature of the sample (Holliday 2004; Wang et al. 1996) but agree with those of the underlying levels. On this facies, the rate of deposition of archaeological remains is far smaller, and the environment in which they took shape suggests a situation more affected by the daily tides and therefore less suitable for a more stable human occupation.

The other 5 ages, 3 on wood and 2 on Otaridae bone, came from the silicoclastic biolaminites (Facies B) from LO3 and LO4 and give ages very similar to one another, ranging from 6,885 ± 47 (wood) to 7,176 ± 91 (sea lion bone) ^{14}C years BP. This last dating, however, was taken when the counter had slight calibration problems (as noted by the laboratory), so it should be accepted with caution. Therefore, the more secure range of the deposition of material in Facies B is between 6,885 ± 47 (wood) and 6,931 ± 47 (wood) ^{14}C years BP. The next older date is 6,960 ± 71 ^{14}C years BP, obtained from a guanaco bone located in the in the upper biosedimentary laminae of dark gray sandy silt (Facies C) at LO4. In consequence, the five datings from Facies B and the upper laminea of Facies D at LO3 and LO4 are statistically the same at 95 % (Test T = 1,05, Xi2 = 9,49) and give a mean pooled radiocarbon age: 6,911 ± 24 years BP. An important point to mention, but which is not discussed in this chapter, is that at LO3 the datings on Otaridae bone and wood taken from the same stratigraphic level—from the same laminae—gave similar ages (see Table 7.2) suggesting very low reservoir effect values, and therefore not supportive of the offset $\Delta r = 783 \pm 55$ ^{14}C years BP calculated for LO1 by Fontana (2007).

Final Remarks

The body of evidence recovered from LO allows the proposal that the hunter-gatherers occupied this place on the southern shore of the Pampa region at the end of the Early–Middle Holocene, at least from ca. 7,400 to ca. 6,480 ^{14}C years BP. Yet, both are extreme dates in a series of datings with a more restricted distribution (Table 7.2). For LO3 and LO4, the lapse of the occupation would have been much more limited, with a maximum antiquity of 6,960 ± 71 ^{14}C years BP and an estimated mean of 6,911 ± 24 ^{14}C years BP. The datings on organic matter from the sediments covering the LO4 sequence contained less evidence of the remains of human activity, which suggests a change in sedimentation in the marsh, a different microenvironment, and a progressive human abandonment of the occupation at that locus.

On the basis of the analyses of LO4 and integrating the available information for LO1 and LO3, it can be concluded that the sedimentary succession of the LO site represents coastal environmental changes during the Early–Middle Holocene in the preingressive stage (Blasi et al. 2013). The lower part of the sedimentary succession probably developed before ca. 7,500 years BP, and was interpreted as the accumulation of sands from nearby dunes or beaches and the development of an area sporadically prone to flooding similar to a supratidal zone. Later, around ca. 7,000 years BP, they were probably more often affected by high-spring tides or wind-induced ones (Facies B and C). During this time, a mixohaline marsh developed in this upper intertidal–lower supratidal zone (Blasi et al. 2013). It is in this period and in this environment when LO was occupied by humans more intensively.

Gradually, toward ca. 6,400 years BP, this sector of the tidal flat was probably reached more frequently by the tides, with the origination of an intertidal subenvironment and the development of a crab bed. The site is abandoned during this period and the signal of human activity is extremely scarce. The upper sedimentation events will coincide with the transgressive maximum.

It is not yet clear whether people occupied these floodable seaside hollows at periods of greater dryness (as some upper level indicators that show a lengthy exposure to air seem to suggest), or only the more raised places within the microtopography of the terrain, while using the depressions of the swampy hollows simply to discard artifacts and bones. A combination of both phenomena is also possible, that is, that part of the LO archaeological material may have been washed away from the adjacent upper parts and trapped in the lower parts of the hollow during exceptional high tides.

The wood-artifact assemblage allowed the information on several aspects of the Pampas hunter-gatherers technology to be expanded. Firstly, the importance of woodwork had been made evident by studies on a microscopic basis on flaked stone artifacts (Leipus 2006), but only at LO and MH1 was it possible to recover the resulting artifacts. Secondly, the presence of bark fragments and of an artifact in the process of being manufactured would indicate that parts of the activities were being carried out on site. Among the wood technology, two exceptional artifacts stand out: an ax handle with the stone head still tied on and the spatula-like decorated piece. Additionally, for the first time wooden points were recovered in the Pampa region.

In addition to wood, bone had an important part in these hunter-gatherers' technology. Besides the expediency tool already recovered at LO1 (Johnson et al. 2000), another three guanaco-bone artifacts are added. All of this demonstrates a variety in raw materials and technology that had not been recorded at such early times in the Pampa region, and which it was perhaps possible to recover at LO thanks to the exceptional conditions of preservation.

The lithic tools recovered allow for certain technological aspects to be highlighted. First, the manufacture is informal, with a minimal investment in tool shaping. Second, different shaping techniques were employed: direct freehand percussion, bipolar technique, abrasion, and shaping by use. Third, many artifacts show concentrated impact marks and have been classified as hammerstones, which means that they were not only used to flake other tools but also to strike wedges or probably break bones. Finally, it should be noted that the supply of raw materials was complex. In the first place, local rocks within a radius of around 30 km were selected, as is the case of fluvial metaquartzite cobbles and coastal pebbles (Bayón and Zavala 1997); whereas, the less frequently employed rocks indicate wider supply radii. For instance, the muddy sandstone come from the Ventania Range, ca. 100 km away and the orthoquartzites from the Sierras Bayas Group and Balcarce Formation appear in Tandilia Range, ca. 300 km away. This varied form of supply is similar to that observed for other sites in the area showing wide mobility ranges (Bayón et al. 2012).

At LO different classes of Otaridae were identified according to age (litters, juveniles, and adults) and sex (males and females of both species). This points to the nonselective exploitation of sea lions, a complete transport of the animals, and an in situ consumption of low- to middle-yield anatomical units (Leon and Gutiérrez 2011). A virtual absence of ribs (one at LO3 and 5 at LO 4), a high-yield anatomical unit, is noticed at the site, which would indicate a selective transportation and their being discarded elsewhere. In addition to the Otaridae, both sea and land species (whales, dolphins, guanaco, and the Pampa deer) were used for nutritional and technological purposes (Leon and Gutiérrez 2011). Altogether the faunal evidence recovered at the site points to a subsistence oriented, at least seasonally, to the consumption of sea mammals, particularly Otaridae, and complemented with land mammals (guanaco and Pampa deer). The importance of marine resources is confirmed by the finds at BLD where, in addition to Otaridae (MNI = 6), there appeared the use of large black sea bass (MNI = 6) of a similar antiquity to that of LO2 and LO3 (Bayón et al. 2012). The isotopic values from human remains of two individuals found at MH 1 and dated at 7,866 ± 75 and 6,606 ± 79 ^{14}C years BP support the sustained consumption of sea resources in this sector of the coast during the Early–Middle Holocene (Politis et al. 2009). The presence of thornbush species *chañar* (*Geoffroea decorticans*) and *piquillín* (*Condalia microphylla*), in the pollen record would offer evidence of the availability of ligneous species with edible fruits at nearby locations. Although chañar wood was used as raw material at MH1, it has not been possible to confirm the consumption of its fruits.

In the regional context, LO, together with MH1 and Barrio Las Dunas, indicate an early adaptation to the South Atlantic maritime littoral toward the end of the Early and Middle Holocene. The dating of human bones from MH1 at 7,866 ± 75 marks the beginning of human occupation on this sector of the coast, which, toward the end of the Early Holocene, was an estuary possessing different microenvironments (Aramayo et al. 2005; Blasi et al. 2013; Martínez et al. 2010; Quattrocchio et al. 2008), among which there were marshes, crab beds, and lagoons among dunes. Whereas, LO can be interpreted as a temporary camp or a locus for the processing of sea mammals as its central activity on the edges of a myxohaline marsh, the site near BLD (with a similar chronology, 6,924 ± 69 years BP) may have functioned as a more stable camp, and with multiple activities in the higher sectors, on the interdune. MH1 has been interpreted as the transit area from a campsite to the edges of some littoral lagoon or marsh, probably connected to the sea.

Lastly, human occupation of this littoral estuary is relatively synchronous with the other early Patagonian sites that show that the first occupations of the coast occur in diverse sectors from between ca. 7,400 and 6,060 years BP (Orquera and Gómez Otero 2007) and seems to indicate a supraregional phenomenon of marine resource exploitation and adaptation to a coastal lifestyle.

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Chapter 8
Submerged Paleolandscapes: Site GNL Quintero 1 (GNLQ1) and the First Evidences from the Pacific Coast of South America

Diego Carabias, Isabel Cartajena, Renato Simonetti, Patricio López, Carla Morales, and Cristina Ortega

Introduction

Over the last decade, the long-held paradigm of the initial peopling of the New World from Beringia through an ice-free corridor by terrestrially adapted big-game hunting groups who rapidly spread south has been critically revised. In general, innovative theoretical views based in new multidisciplinary evidence suggest that pre-Clovis populations existed and that the colonization of the Americas was the consequence of diverse cultural processes with high diversity of habitats occupied by early hunter-gatherer groups with different subsistence strategies and technologies (Borrero 1999; Dillehay 2000, 2009; Faught 2008; Goebel et al. 2008; Waters and Stafford 2007). In northwestern North America, in particular, the growing interest in submerged prehistoric archaeology as a nascent subdiscipline critical

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The original version of this chapter has been revised:
The author Diego Carabias was incorrectly presented in the initially published online version of Chapter 8 Submerged Paleolandscapes: Site GNL Quintero 1 (GNLQ1) and the First Evidences from the Pacific Coast of South Americaâ€ . This has now been corrected.
A correction to this chapter can be found at
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to understanding early coastal occupations and migration routes (Gusick and Faught 2011) is closely related to the "coastal migration theory" initially proposed by K. Fladmark (1979). This alternative hypothesis suggests that prior to 13,000 cal BP, large coastal plains with terrestrial resources and productive marine environments were available for maritime adapted people due to Pleistocene lower sea levels enabling human and animal migrations (Dixon 2001; Erlandson 2008; Faught 2008; Mandryk et al. 2001; Waters and Stafford 2007).

Recent research projects in northwestern North America are focused on locating evidence to support the hypotheses of a coastal migration into the New World following the Pacific Rim route (Faught and Gusick 2011). By applying paleolandscape modeling and archaeological sampling these investigations have been successful in locating submerged cultural material (Easton and Moore 1991; Fedje and Christensen 1999; Fedje and Josenhans 2000; Josenhans et al. 1997). A geoarchaeological-based approach and predictive modeling have been applied off the Oregon coast (Davis et al. 2009). Finally, the southern Gulf of California's archaeological potential has been recently initially explored through a paleolandscape model and diving operations (Faught and Gusick 2011). In Southern California several hundred mortars and ground-stone artifacts (Masters 1983, 1985), and shell middens (Bickel 1978) have been reported from the early 1900s.

However, evidence for Late Pleistocene and Early Holocene sites on the Atlantic continental shelf, including areas like the Gulf of Mexico and Florida, continues to be far more substantial and recurrent than that for the Pacific (Stright 1990, 1995). This contrasting situation is evident in Florida alone, where these sites are reported to be presumably older, more abundant, and larger in size to those known along the West Coast (Faught 2004).

The relatively reduced evidence of submerged prehistoric sites along the Pacific Coast of North America has been explained due to narrow continental shelves, active volcanism and tectonism, and high-energy marine conditions which are less favorable for preservation, except in bays, inlets, and island clusters (Faught and Gusick 2011). Stright (1995), analyzing the archaeological potential of the continental shelves of North America, stresses that if the rate of relative sea-level change is held constant, the Pacific shelf would have the lowest potential for preservation of in situ archaeological deposits and the Gulf of Mexico would have the highest. Additionally, while geomorphology of the eastern Pacific coastal environments, with rocky shores and deep basins, offers natural shelters for the preservation of archaeological remains, the exceedingly high wave action of the eastern Pacific can erode away sea cliffs and cut terraces (Inman 1983), and represents a powerful disturbing agent for the submerged archaeological record (Gusick and Faught 2011).

When referring to the Americas or the New World, research reviews on marine submerged prehistoric archaeology have addressed basically projects conducted in North America (Faught and Gusick 2011; Gusick and Faught 2011; Johnson and Stright 1992; Masters and Flemming 1983). This is not surprising, since in South America with very rare exceptions, (Bayon and Politis, this volume) early submerged prehistoric sites are virtually unknown, and thus the investigation of the archaeological potential of the Pacific continental shelf is practically nonexistent.

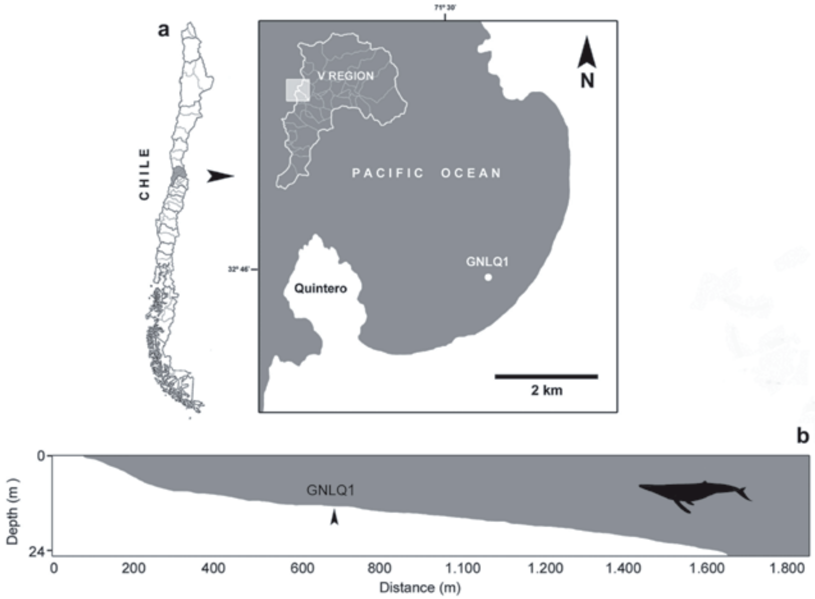

Fig. 8.1 **a** Location map for the study area in Quintero Bay, central coast of Chile. **b** Bathymetric profile of the area with site GNLQ1.

tIn this chapter, the authors provide a general overview of the research conducted on GNL Quintero 1 (GNLQ1), a Late Pleistocene paleontological submerged site located in the Pacific coast of Central Chile, and examine this evidence in light of the known association between extinct megafauna and early human adaptations in the area. Finally, the authors propose and discuss an initial digital simulation model developed to better understand this first postglacial-drowned terrestrial landscape discovered along the Andean Pacific coast.

Site GNL Quintero 1 (GNLQ1)

Site GNLQ1 is located in Quintero Bay (32°46′ S), located ~50 km north of Valparaíso, on the Pacific coast of Central Chile (Fig. 8.1a). This is a shallow embayment, ~3 miles long and ~1.5 miles wide, roughly oriented N–W with a maximum recorded depth of 55–60 m. River Campiche, located at the N–E side of La Herradura beach and some other minor streams drain into the bay, with permanent to perennial flow. Coastal lagoons and wetlands are trapped by mound dunes at the N–E and S–W ends of the bay (Villa-Martínez and Villagrán 1997). The resulting structural context is a shallow bay with gently sloping nearshore bathymetry with little sediment yield from rivers.

Quintero Bay is an active harbor and contains important energy, mining and industrial infrastructure. Site GNLQ1 located 650 m offshore and 13 m underwater (Fig. 8.1b) was discovered in 2005 during an archaeological investigation of the seabed as part of a Cultural Resource Management (CRM) project. Through extensive diver survey operations a cluster of discretely exposed and shallowly buried bone deposits were identified by archaeologists close to a rigid oil submarine pipeline installed by the National Oil Company (ENAP) during the 1970s. Intensive visual examination and hand fanning techniques revealed that these loci were formed by faunal remains deposited within a consolidated bed of sediment and partially buried under 5–10 cm of modern sands.

Methodology

As part of the CRM project, a series of subsurface test excavations and mechanical coring samples were conducted at the site in 2007 at several targeted points distributed across transects within an area of 40 × 25 m (ARKA Consultores 2008). In particular, one locus, a well-delimited bone concentration barely visible on the seabed, was selected and sampled through a test excavation 1 × 1 m unit (unit K8_2). The excavation was carried out using a 3″ induction water dredge and the material excavated was deposited first in a 6.5 mm holding basket underwater and then transferred to the surface for further examination. Skeletal remains were exposed by careful excavation using in situ decapage techniques and recovered with their sedimentary matrix in order to be microexcavated in the laboratory, thereby minimizing loss of contextual information and physical deterioration potentially caused during underwater extraction (Fig. 8.2).

A total of 224 bone specimens were recovered (Cartajena and López 2008; Cartajena et al. 2011) (Table 8.1). The remains belong mainly to excavation unit K8_2. Only two isolated bone specimens were registered deposited on the surface of unit K7, while another two surficial bones were recovered at unit K4.

Conservation

Once microexcavated at the laboratory, the structurally sound recovered bones underwent a conservation treatment to remove the soluble salts in order to make the material stable (Hamilton 1998). The salts were diffused out by rinsing in successive baths of water, starting with 100 % sea water and increasingly incorporating fresh water (local tap water) until straight fresh water was completed. Distilled water was then substituted for the fresh water until the soluble salts were removed. Mechanical removal of stains was achieved using hand tools (Morales 2008).

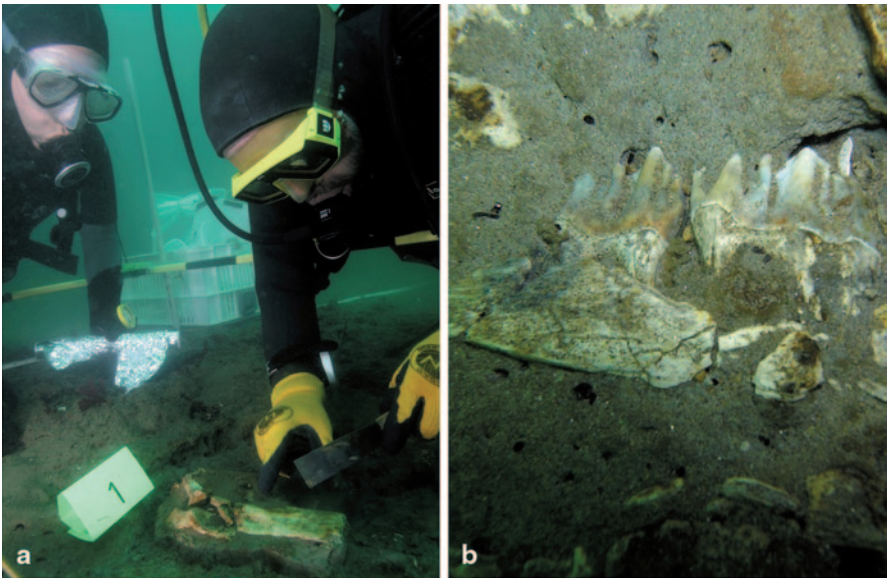

Fig. 8.2 **a** Controlled recovery of the faunal remains using underwater archaeology excavation techniques. **b** Megafauna fossil bones deposited within a consolidated bed of sediment

Table 8.1 Distribution of recovered bones in survey and excavation units

Survey and excavation unit	Level	NISP	% NISP
K8_2	1 (0–10 cm)	175	78.1
K8_2	1 (0–10 cm)	5	2.2
K8_2	1 (0–10 cm)	13	5.8
K8_2	1 (0–10 cm)	1	0.4
K8_2	1 (0–10 cm)	17	7.6
K8_2	1 (0–10 cm)	2	0.9
K8_2/K8_1	1 (0–10 cm)	5	2.2
K8_2	Cleaning	1	0.4
K4-Surface	Surface	2	0.9
K7-Surface	Surface	2	0.9
Core	Surface	1	0.4
Total	–	224	100.00

Stratigraphy

In particular, one core sample (T1) 74.3 cm long was selected for morphological and sedimentological analyses and represents a complete stratigraphic sequence for the site, with three stratigraphic units exhibiting clearly different sedimentological features (Vargas and Ortega 2008) (Fig. 8.3). Unit 1 contains surficial well-sorted fine sand that is brown in color, 5 cm thick. Underneath, Unit 2 is a clayey-gravel clast-supported formed by high hardness agglomerates of fine sand and clay and

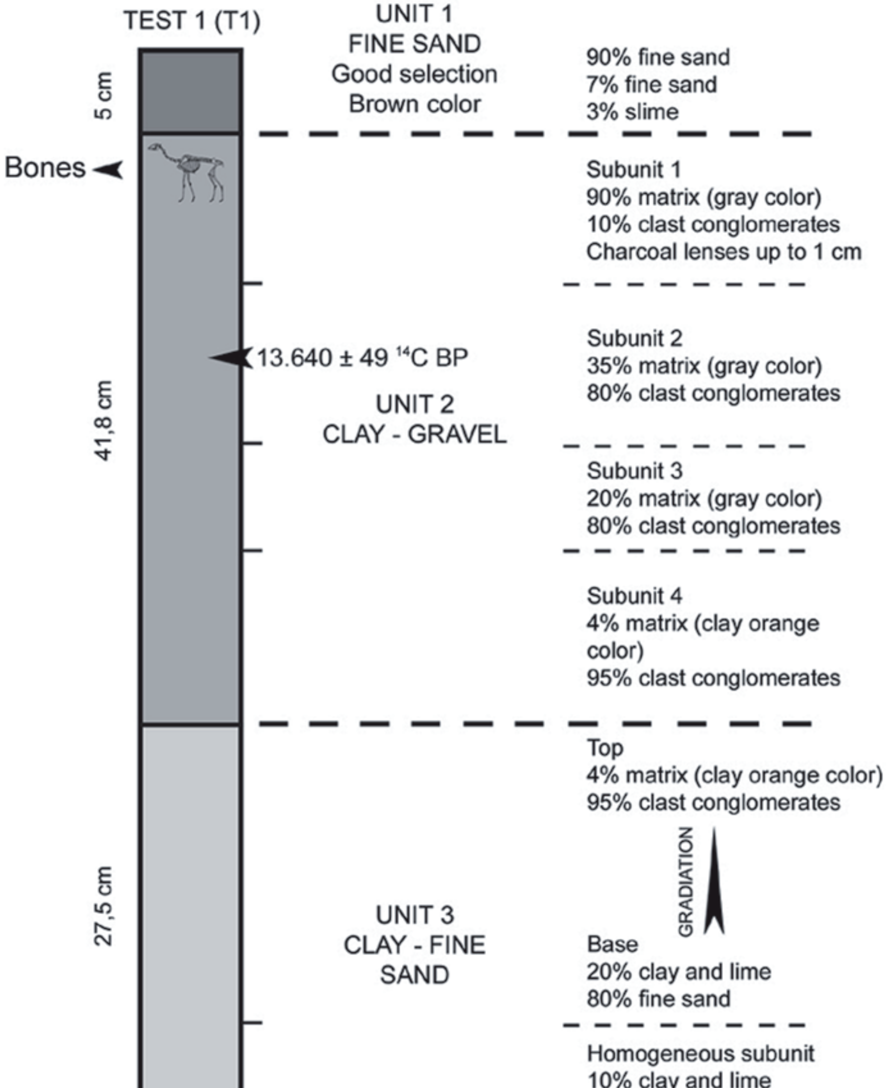

Fig. 8.3 Stratigraphic sequence of site GNLQ1

eventually microcrystalline quartz (chalcedony), orange and gray in color, some exhibiting a patina of charcoal in a fine sand-silt matrix. Millimetric charcoal lenses are intercalated In the higher and lower parts of this unit. The faunal remains were recorded in the upper portions of this deposit, horizontally distributed over an extensive area and in both clear and direct association to charcoal lenses present within the first 5 cm of Unit 2. Finally, Unit 3 consists of fine clayey sand that is brown and orange in color. Core T1 did not yield pollen remains (A. Maldonado, personal communication).

The analysis of the stratigraphic unit containing the fossil remains (Unit 2) suggests an estuarine-lagoon or wetland environment in the process of desiccation (Vargas and Ortega 2008). Although very preliminary, this evidence is consistent with other studies which suggest essentially a cold and wet environment, with a general tendency toward desiccation around ~13,000 cal BP for the study area (Kim et al. 2002; Valero Garcés et al. 2005; Villagrán and Varela 1990).

Radiocarbon Dating

Two taxon samples were selected for radiocarbon analyses, but the lack of collagen, including that of the dentine, precluded age estimation. For this reason the sedimentary matrix containing the bones was ^{14}C dated and reported 13,640 ± 40 years BP (UGAMS#9194, δ^{13}C, ‰−25.4) (16,605-16,196 cal. BP, OxCal 4.2, SH Cal 13 [Bronk Ramsey and Lee 2013]).

The Faunal Assemblage: Taxonomic and Taphonomic Analyses

Much of the research effort regarding site GNLQ1 has been focused on the taxonomy and taphonomy of the faunal assemblage recovered (Cartajena and López 2008; Cartajena et al. 2011; Cartajena et al. 2013; López et al. 2012). Most of the materials show a homogenous and slight degree of abrasion on the bone surface as expected in an aqueous environment with abrasive sediment. Early weathering stages also affected most of the sample (Behrensmeyer 1980), supporting the idea that the remains were exposed to subaerial conditions before they were buried and subsequently submerged by sea-level rise. This is coincident with the evidence of root marks on the surface of all the bones, which indicates the growth of a vegetation cover over the fossil deposits previous to the marine transgression.

Although some specimens show signs of initial states of weathering such as longitudinal cracks in diaphysis fragments, which could have affected the fragmentation of the assemblage, the conservation of the bones is optimal. A significant percentage of the assemblage could be reassembled and taxonomically determined, even up to the family level. In most of the cases the bones presented complete epiphyses or diagnostic traits such as tooth. However, some remains have been assigned to more general taxonomic categories (order level), such as a selenodont-type deciduous molar that has been assigned to Artiodactyla, due to the lack of other diagnostic traits.

A total minimal number of eight individuals corresponding to at least seven different taxa were recovered. The identified bones show a high diversity of terrestrial extinct megafauna, including Camelidae, Cervidae, Equidae, and Xenarthra but also smaller size animals such as a fox-size carnivore, a rodent, and a bird (Table 8.2).

Table 8.2 Taxonomical and anatomical unit representation, expressed in NISP and MNI

	NISP	% NISP	MNI
Mammalia	148	66.1	–
Artiodactyla	2	0.9	1
cf. *Palaeolama* sp.	23	10.3	1
Cervidae	37	16.5	1
Equidae	2	0.9	1
Xenarthra	7	3.1	1
Canidae	2	0.9	1
Cricetidae	1	0.4	1
Ave	2	0.9	1
Total	224	100.00	–

Xenarthra bones correspond to an ungueal phalanx (Fig. 8.4a), an osteoderm, and the complete sequence of molariforms of the right mandible. A Camelidae (cf. *Palaeolama* sp.) anterior superior extremity (distal humerus and radius-ulna) was recovered, which corresponds to a large size camelid in the range of *Palaeolama* (López et al. 2004; Fig. 8.4e, f). The Cervidae remains belong to the left and right mandible from a large-size cervid (Fig. 8.4g) and from Equidae two juvenile premolars were identified (Fig. 8.4b). A calcaneus and a canine tooth of Canidae were recovered, whose morphology and size are similar to the present day *Lycalopex culpaeus* (Fig. 8.4c, d). An incisor from a Cricetidae rodent of insufficient taxonomic diagnosis was also recovered. Finally, two bird remains from another unit (K7) were registered at the surface. Their morphology and size is compatible with specimens from the Phasanidae family.

The Quintero faunal assemblage exhibits high taxonomic diversity, mostly similar to that of sites yielding extinct Pleistocene fauna located around the coast of Los Vilos District, in the northern semiarid zone (31°29′ S) (Jackson 2003; Jackson et al. 2007; Méndez et al. 2004; Núñez et al. 1994b). These coincident evidences suggest similar paleoenvironmental conditions, which during the Terminal Pleistocene favored the congregation of diverse mammalian resources hunted by Paleoindian human groups around productive lowland areas such as streams, lagoons, estuaries, fertile plains, and wetlands, as has been suggested for north-central Chile by Núñez et al. (1987).

Taphonomic analysis allowed macroscopic identification of natural marks (punctures) associated with big and small size carnivores. By applying Scanning Electron Microscope (SEM) micrographs to fossil bones, marks and color alterations were identified. Marks could be related to rodent gnawing and trampling while color alterations were attributed to diagenesis processes.

The distal humerus of the cf. *Palaeolama* sp. presents a spiral fracture on the fresh bone. Although this type of fracture can be considered to be typical of that of human activity, diverse analyses determined the degree of ambiguity of this trait, as it can also be the result of natural agents (Borrero and Martin 1996; Haynes 1983a, 1983b; Myers et al. 1980). Although the humerus does not show any signs of notches or negative characteristics of human modifications, fresh bone flakes (derivates) were found.

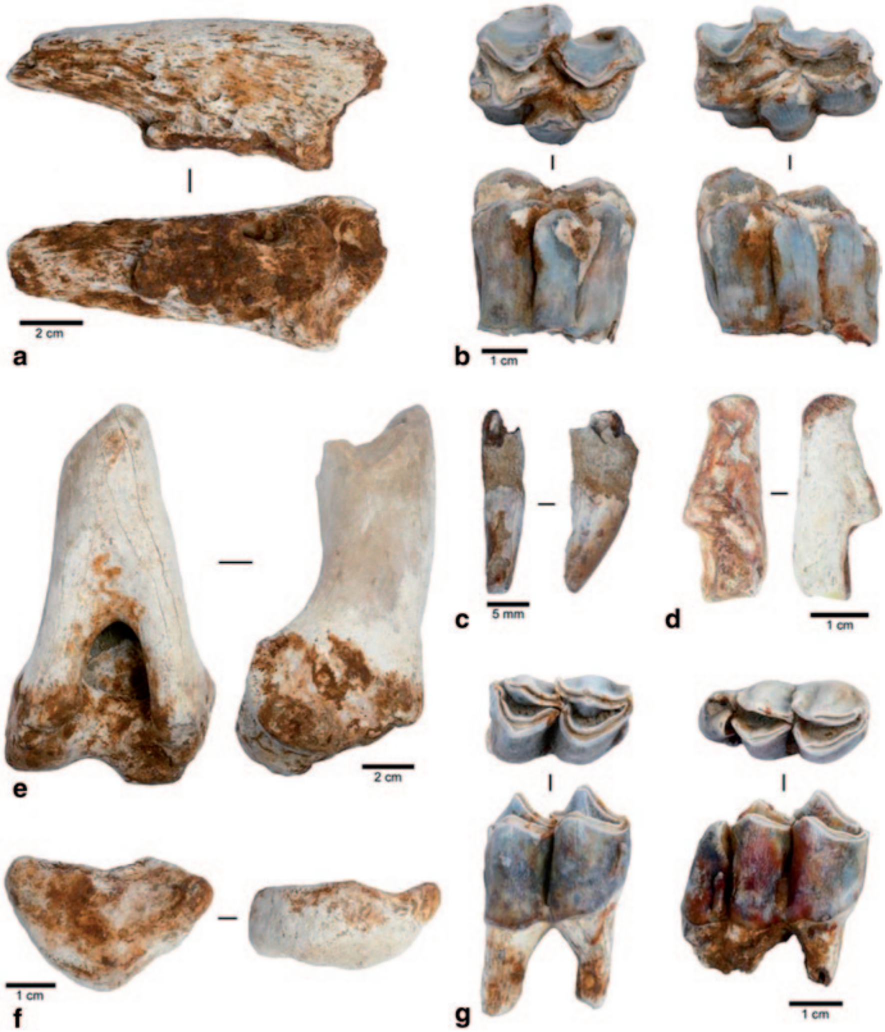

Fig. 8.4 Faunal assemblage recovered from site GNLQ1. **a** Ungueal phalanx of Xenarthra. **b** Premolars of Equidae. **c** and **d** Canine tooth and calcaneus of Canidae. **e** and **f** Distal humerus and fourth carpal of cf. *Palaeolama* sp. **g** Molars of Cervidae

By means of the use of Energy Dispersive Spectroscopy (EDS) analysis, spheroidal bodies of pyrite in the osseous matrix of the cf. *Palaeolama* sp. humerus were found, suggesting an anoxic depositional environment and the action of sulphur-reducing bacteria (Borrego et al. 2003; Brown et al. 2010; Saheb et al. 2008). This is coincident with the oxidation staining found in all the assemblage resulting from the interaction of the bones with an interface of gravel clay sediment and water, which is characteristic of the depositional environment of the GNLQ1 site (Dunbar et al. 1989; Noakes et al. 2009).

Paleolandscape

One of the critical aspects for finding submerged prehistoric sites is determining local sea-level history. Pleistocene shorelines were inundated around the world largely as a direct consequence of global, eustatic sea-level rise. Global sea levels were ~120 m lower than present at the Late Wisconsinan maximum glaciation, 20,000 to 18,000 BP (Fairbanks 1989). However, in areas directly or indirectly affected by glaciation, calculating sea-level history is far more complex due to the intricate interplay between tectonic, eustatic, and isostatic change, which may result in drastic differences from a generalized sea-level curve (Bailey and Flemming 2008; Fedje and Christensen 1999; Stright 1995). This is the case for Chile, where coastal areas register diverse uplift rates and important tectonic activity. However, uplift rates for Holocene marine deposits on the central coast of Chile where Quintero Bay is located have been calculated in a moderate range, with a minimum mean estimate of 0.4 m/ka (Encinas et al. 2006). This range is consistent with the slight Holocene tectonic uplift and low uplift rates since the last Interglacial reported for north-central Chile (Leonard and Wehmiller 1991; Ota and Paskoff 1993).

There are no Holocene sea-level curves available for north-central Chile, therefore to determine the Relative Sea Level (RSL) for Quintero Bay SELEN 3.2 (Spada and Stocchi 2007), the authors used a Fortran computer program for solving the "sea-level equation" (SLE). In this process, a linear integral equation allowed the users to determine the sea-level variations driven by the melting of the Pleistocene ice-sheets, and was corrected with an assumed constant uplift range of 0.5 m/ka.

For reconstructing the paleolandscape underwater, a navigation chart with available high-resolution local bathymetric and terrestrial elevation data was combined and merged using HYPACK Max 10 hydrographic software. Although the navigation chart worked only for general survey area purposes, local bathymetric data processing was combined with sedimentological samples. By combining this information with the SELEN Quintero RSL curve contour maps, 3D wireframe maps representing the simulation of the paleolandscape were created using SURFER 10.

According to this initial simulation, the inlet of land oriented SE which forms modern Quintero Bay did not exist prior to ~16,000 BP (Fig. 8.5). Between about 16,000 BP and 14,000 BP the sustained postglacial sea-level rise caused the progressive and substantial inundation of ~3.2 km of the coast in a general SE direction. Due to local geomorphology, the shoreline prograded ~0.9 km between 14,000 BP and 12,000 BP. Between 12,000 BP and 10,000 BP the shoreline moved forward another ~1.5 km, with most of this progress occurring during the first thousand years, when Quintero Bay acquired most of its modern shape. Site GNLQ1 was last under subaerial conditions by ~11,000 BP (Fig. 8.6).

A side-scan sonar remote sensing survey was conducted on the GNLQ1 site area in 2011. The seafloor sediments in the area are characterized by uniform low-backscatter acoustic data, typical of fine-grained sediments, with no recognizable topographic features. This surficial layer of unconsolidated modern sands exhibits ripple-marks indicating a high-energy marine environment. High-resolution acous-

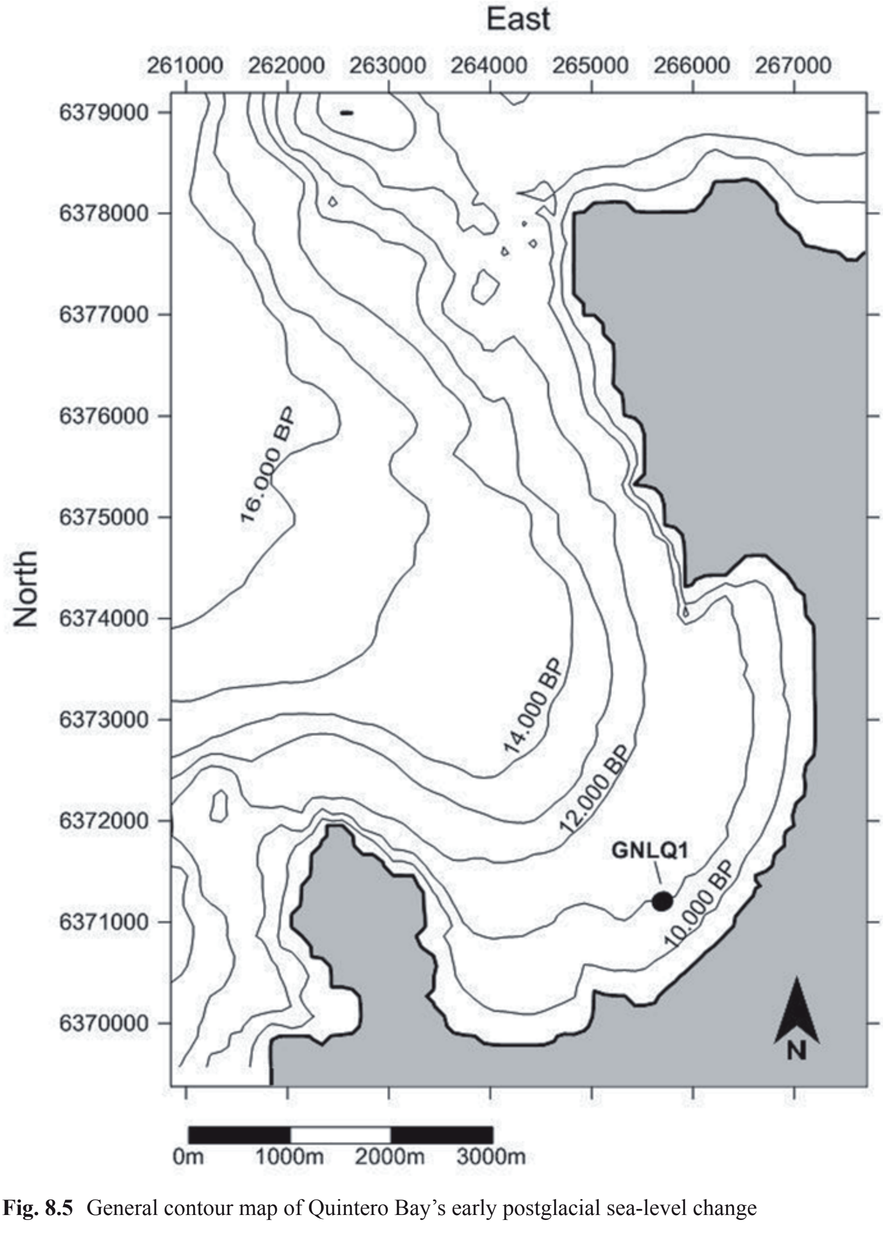

Fig. 8.5 General contour map of Quintero Bay's early postglacial sea-level change

tic images of site GNLQ1 depicts the partially exposed Pleistocene consolidated clayey gravel deposits containing the fossil bones as a discrete reflector with a general NE-SW distribution (Fig. 8.7). ENAP's Ø 42″ pipeline, orientated NW-SE is clearly visible as a strong reflector toward the center of the sonograph. Remote

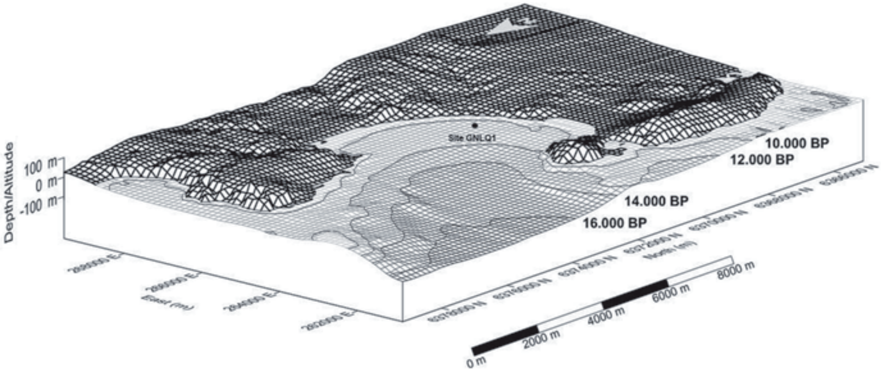

Fig. 8.6 Orthographic 3D wireframe of Quintero Bay with site GNLQ1's location enhanced by 400 % vertical. Estimated early postglacial paleoshorelines at 16 ka, 14 ka, 12 ka, and 10 ka are represented

sensing data is consistent with sediment analysis and bathymetry data processing which indicated that the area is located in the upper shoreface under the influence of tidal and wave activity dominated by SW winds (Vargas and Ortega 2008).

Discussion

The paleontological record of site GNLQ1 reveals the presence of exposed Late Pleistocene deposits on the seabed containing a primary stratigraphic context of continental faunal remains with scarce postdepositional alterations. Although located in a relatively low-depth coastal high-energy marine environment, and partially affected by development projects, the site indicates a high integrity and resolution.

As indicated, the recurrent association between extinct fauna and early human occupation of north-central Chile has been interpreted as a circum-lacustrine adaptation at the Pleistocene/Holocene transition, during which megafauna restricted to shrinking lacustrine environments subject to aridity stress, were exploited by Paleoindian groups (Núñez et al. 1987). During this period human occupations were characterized by open campsites, near to aquatic environments, and with high residential mobility (Jackson et al. 2004; Méndez 2011). Examples of classic Paleoindian occupations that exhibit definitive evidence of human-megafauna interaction dating to ~13,000 calibrated years are Quebrada Santa Julia (Jackson et al. 2007) and sites Tagua-Tagua 1 and 2 (Núñez et al. 1994a).

In the semiarid zone of Chile, despite the presence of early prehistoric sites located close to the Pacific coastline, sites do not exhibit relevant exploitation of marine resources until the Early Holocene (Jackson et al. 2007). It is noteworthy that consistently a substantial part of the paleontological records of Terminal Pleistocene fauna found near the coast corresponds eminently to terrestrial fauna as well

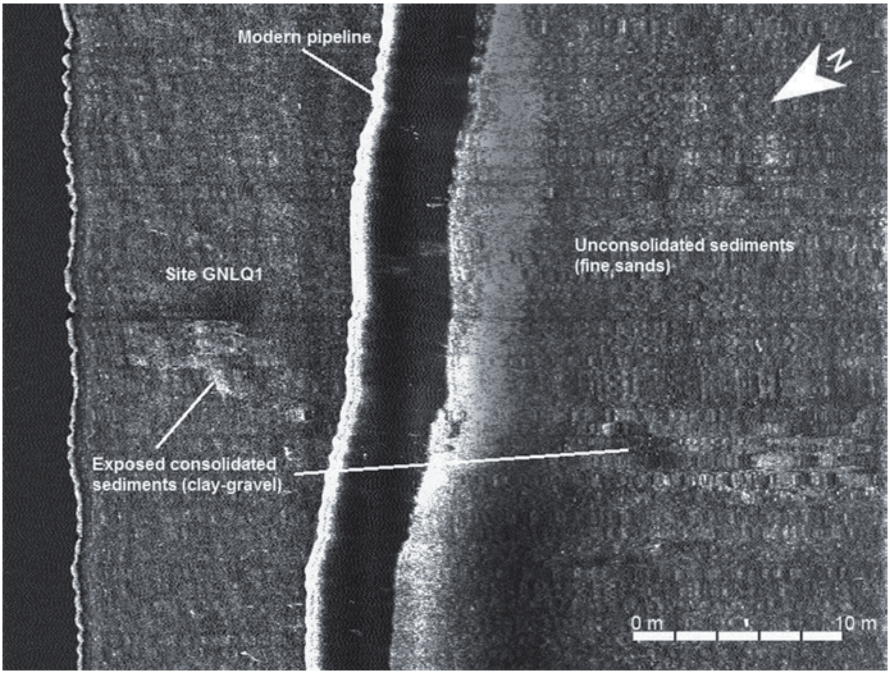

Fig. 8.7 780 kHz sonograph of site GNLQ1. Note the exposed Pleistocene-consolidated deposits with a general NE–SW distribution covered by modern sands. The National Oil Company (ENAP) Ø 42″ pipeline runs across it in a NW–SE direction

(Méndez et al. 2004). In particular, the record of site GNLQ1 and those of other sites with similar faunal assemblages like Quereo (López et al. 2004; Núñez et al. 1994b) indicate a wide distribution of grazers and browsers taxa, suggesting environments that combine pasture lands and woods (Cartajena et al. 2011; Cartajena et al. 2013). This evidence is consistent with the assumption that a significant coastal area, now covered by the sea, was available during late glacial and early postglacial periods to both fauna and early terrestrial hunter-gatherers in the New World, who occupied valleys and estuaries (Bonnichsen et al. 2005; Richardson III 1981; Sandweiss 2003).

No evidence of human activity has been inferred at GNLQ1 so far. Neither artifacts nor evident human modifications of bones were found. However, the excavated sample is still small and identifying conclusive cultural indicators on early terrestrial sites is not an unproblematic research issue. Of at least 24 known sites in the semiarid coast of Chile with Pleistocene extinct fauna there are only two, Quebrada Santa Julia and Quereo, which exhibit primary stratigraphic records of anthropogenic origin (Jackson et al. 2007). In this latter site, artifactual evidence is undiagnostic and ephemeral, and most human intervention is represented by bone artifacts and cut marks, and fractures of the bones (Jackson et al. 2004). It is known that several factors will affect the visibility of potential cultural features within the archaeological record of a prehistoric submerged site, including site functionality, taphonomic agents, and differential conservation, among others (Stewart 1999; Stright 1995; Waters 1992). Thus, human agency on underwater sites similar to GNLQ1 should be carefully evaluated and tested considering that substantial recovered prehistoric evidence on land suggests a rather discrete but recurrent human occupation of a well-delimited area during the Late Pleistocene (Méndez 2011). Applying proxy indicators might prove an efficient research strategy in light of the presence of charcoal lenses and charcoal patina in the stratigraphic unit containing the fossil remains.

At first, the AMS ^{14}C date for GNLQ1 (16,605-16,196 cal. BP) seems substantially earlier than the ~13,000 cal. BP date of the earliest human occupations in the area. However, this indicates the age of the sediments containing the fossil bones. It is worth noting that Jackson (2003) obtained a similar date for a *Mylodon* sp. sacrum associated with lithic remains from the site El Membrillo, near Los Vilos, 16,677 cal year BP, but this evidence should be interpreted with caution since it is a surface site (Jackson et al. 2007). New chronostratigraphic evidence of site GNLQ1 is needed, including AMS ^{14}C dates on single bones of stratigraphically associated taxa.

At this stage of the investigation, a precise model of the Quintero paleolandscape cannot be reconstructed without a better understanding of both local uplift rates and sea-level variations. However, the initial simulation created by combining the SELEN Quintero RSL curve with a mean estimated uplift rate of 0.5 m/ka is considered to provide a reasonably accurate model of the submerged landscape and is consistent with more global sea-level curves (Lambeck et al. 2002). The latter suggests that by early postglacial times (~16,000 BP), a significant part of modern Quintero Bay was exposed due to lower sea-levels and available for terrestrial fauna. Site GNLQ1 would have been located several kilometers inland as the paleoshoreline was farther out on the continental shelf, close to the 90 m isobath (≤5 km). This hypothesis is consistent with the taxonomical homogenous composition of the assemblage of vertebrate fossils and the absence of marine resources at the record, at least in the evidence documented so far.

In the future, a refined model of the Quintero paleolandscape should enable researchers to identify geomorphological, topographical, and sedimentary conditions most conducive to the underwater preservation and discovery of submerged landscapes. A better understanding of the formation processes involved in GNLQ1 might help explain where to search in Quintero Bay for exposed or shallowly buried terrestrial surfaces and Pleistocene landforms and the amount of marine sediment accumulation expected. According to the present model, the local paleoshoreline contemporaneous to the earliest human occupation of north-central Chile should be located close to the 50 m isobath implying necessarily a fragmentary and biased coastal archaeological record. As it has been suggested elsewhere (Bailey and Flemming 2008), this potential underwater archaeological record does not simply add to what we already know about prehistoric sites on land, but might provide critical evidence about coastal environments that are now submerged and that provided productive conditions for plant and animal life during lowered sea level, late glacial, and early postglacial times.

Conclusions and Perspectives

Site 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. Although still necessarily limited, the data presented fills a gap in the record of sites in submerged contexts in the New World while offering significant possibilities for future research.

Effectively, the high inferential status of this remarkable and unique site is extremely promising. Although identified as part of a CRM project, the paleontological record has been studied by research methods and strategies common to submerged prehistoric archaeology projects in North America (Gusick and Faught 2011). The development of an initial paleolandscape model for Quintero Bay to be tested is considered to be an important first step for further archaeological investigation of the Chilean continental shelf and may help improve our understanding of the environmental resources available for the earliest colonizing human groups in the region.

A new phase of focused research is already being conducted at GNLQ1. This geoarchaeological approach includes the comprehensive application of remote sensing tools (including high-resolution side-scan sonar and sub-bottom profiler surveys), paleoecological reconstructions, and systematic underwater excavations. The latter have enabled the recovery of a larger sample of fossil bones which confirms a high taxonomic diversity of Terminal Pleistocene terrestrial extinct fauna and substantiates site integrity and high-resolution contexts. Analysis is currently ongoing and any potential evidence of human modification is being carefully assessed.

Site GNLQ1 represents a primary and so far unknown source of data on now-submerged paleolandscapes, and although human association remains to be seen by future research, it provides a new and challenging insight into the early postglacial environment and habitats common to both extinct fauna and the initial human populations of the Andean Pacific coast.

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Chapter 9
Researching, Conserving and Managing Submerged Prehistory: National Approaches and International Collaboration

Edward Salter, Peter Murphy and Hans Peeters

Introduction

In recent years research by several teams has greatly expanded our understanding of submerged prehistoric landscapes on the north-west European continental shelf. Although the focus of this chapter will be on north-west Europe, below we attempt to summarise provision for offshore prehistoric archaeological research, conservation and management elsewhere in the world. Archaeological material on the sea floor has been studied, dating from several glacial-deglacial cycles (Peeters et al. 2009). New methodologies adapted from industry and oceanography have been developed, involving marine-geophysical survey (bathymetric, sub-bottom and 3-D seismic), vibrocoring to ground-truth the geophysics and obtain sediment samples for dating and paleo-ecological analysis, with scientific trawling and grab sampling for the recovery of faunal remains and artefacts (Gaffney et al. 2007; Glimmerveen et al. 2004; Wessex Archaeology 2007: Tizzard 2010; Marine Environment Protection Fund/English Heritage 2009: see also www.alsf-mepf.org.uk). Over the same period, the British Museum's Ancient Human Occupation of Britain Project has demonstrated, from sites on the North Sea coast, that there was hominid activity before the latest polarity reversal at 0.78 Myr ago, and up to 0.99 Myr ago, above 45° north latitude in Europe (Parfitt et al. 2005 2010). In terms of managing submerged prehistoric landscapes in north-west Europe, one very significant consequence is that offshore Pleistocene paleo-geographic features and sediments which would formerly have been thought to be too 'early' to be archaeologically relevant are now seen

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Fig. 9.1 The 2010 excavations at Happisburgh by the Ancient Human Occupation of Britain Project as viewed from the adjacent cliff top. The discovery of a number of worked flint flakes, cores and associated biological remains from a stratigraphically secure deposit at the site suggests that early Pleistocene hominins were present in northern Europe >0.78 million years ago. (Photo courtesy of Peter Murphy, English Heritage)

as having the potential to provide further data on the spread of premodern humans northwards. Submerged sediments and features of around this date have already been defined by the seabed mapping of the British and Dutch Geological Survey and other national geological services (see also Wessex Archaeology 2006). Other features and deposits are the subject of recent research (Dix 2010). Some north-west European heritage agencies concerned with the conservation and management of the historic environment are therefore confronted not just with an increase in the geographical scope of their responsibilities (from their original terrestrial locus to offshore areas), but also a temporal extension back to almost 1 Myr. This comes at an awkward time given current economic constraints (Fig. 9.1).

Traditional forms of seafloor exploitation, notably beam trawling and shellfish dredging, have long been recognised as damaging to near-surface seabed sediments; but, ironically, much of our present knowledge of prehistoric artefacts and faunal remains from the seabed has come from these very activities. Some degree of damage to submerged deposits is inevitable and so the prime concern must be to minimise the loss of scientifically important information. In the Netherlands, for instance, there is a long history of collaboration between palaeontologists, archaeologists and fishermen (Glimmerveen et al. 2004), and a comparable reporting mechanism is currently being trialled in England. Port developments have historically been damaging to the historic environment, in terms of land claim, on-shore construction and capital dredging for approach channels, but current developments are on a much larger scale than in the past. For example, archaeologists have been involved in mitigating the impacts of the extension of Rotterdam harbour in the Netherlands, and in England at Immingham, Felixstowe (East extension), Harwich (Bathside Bay), London Gateway Port (the former Shellhaven refinery), Sheerness Container Terminal and Dover (Terminal 2). All these developments had actual or potential impacts on submerged landscapes. Exploitation of offshore hydrocarbon resources followed the 1958 UN Continental Shelf Convention, in which the national limits of exclusive economic zones were ratified, permitting national licensing. Prospection and extraction followed, and has continued, though recently on a reduced scale, up to the present. Since the first wave of development preceded the EU Environmental Impact Assessment Directive (EU Directive 97/11/EC: see below), its effects on seabed prehistory cannot be determined now although, as in the case of the fishing industry, there has been a serendipitous bonus; the data obtained by the oil and gas industry during prospection has subsequently, and unexpectedly, proved highly informative in terms of paleo-landscape reconstruction (Gaffney et al. 2007). The so-called Viking Bank flint was also found as a result of the systematic sediment coring carried out in support of the offshore hydrocarbon licensing programme between Shetland and Norway in 1981 (Long et al., 1986). The now-depleted hydrocarbon reservoirs may have a new role to store a strategic reserve of imported natural gas or act as repositories for captured carbon dioxide (see, for example, www.npd.no/en/news/News/2011/November-2011/). This might necessitate new offshore construction works. Currently, the governments of all countries bordering the North Sea envisage large-scale expansion of renewable energy sources, principally wind farms, though potentially also tidal barrages, despite abandonment of plans for the Severn Barrage in the UK. Besides the footprint of oil and gas platforms, wind turbines and barrages, the laying of associated pipelines and cables has the potential to damage or disturb deposits. The offshore aggregates industry has expanded substantially in recent decades: over around 20 million tonnes of marine aggregate are dredged annually, providing 19% of sand and gravel sales in England (www.bmapa.org). Comparable volumes are dredged annually from the Dutch part of the North Sea; note, moreover, that the extension of Rotterdam harbour involved 240 million m^3 of sand. The extraction areas are concentrated, plainly, where there are Pleistocene sands and gravels related to paleo-landscape features, and known to include Paleolithic artefacts and rich faunal assemblages. Extraction can also result in disturbance of Holocene deposits of archaeological significance (Fig. 9.2). To help mitigate this, collaboration between archaeologists and industry, especially the aggregates and offshore renewable energy sectors, has resulted in the development of guidelines and protocols.

The twenty-first century is likely to bring new types of seabed exploitation, related to the development of new offshore technologies and to meet new needs. The idea of building a dam across the mouth of a major embayment of the North Sea named The Wash in eastern England, to create a vast freshwater reservoir capable

Fig. 9.2 Excavations in the Yangtze harbour basin, Rotterdam. A Mesolithic occupation layer at 20 m below the water surface is being sampled by means of a special crane. Samples are packed in large white bags, before being wet-sieved. For the first time, Mesolithic occupation remains were uncovered from a submerged landscape under relatively controlled conditions. (Photo by B. Smit, Rijksdienst voor het Cultureel Erfgoed, courtesy of the Port of Rotterdam)

of supplying over 2,700 million litres per day, was proposed in the 1960s (Morey 1968, p. 273). In view of the chronic water-supply problem for south-east England, and the prospect of increased frequency of summer droughts later in the century (Murphy et al. 2009) it is possible that similar projects might be considered again, despite the environmental consequences. There can be little doubt that the resources of the sea will increasingly be exploited in one way or another, and that new types of development are likely to impact submerged prehistoric land surfaces.

Heritage organisations face formidable challenges in terms of managing the cumulative impacts of a wide range of industrial sectors on submerged prehistoric landscapes, and these will increase. Management must not impede essential economic development, yet at the same time must ensure that economic activity does not result in the loss of significant scientific information. Moreover, since modern maritime jurisdictional boundaries are artificial constructs unrelated to submerged landscapes, international collaboration to ensure consistent approaches to research and management is essential. To explore how these aims can be achieved, we need first to examine the existing legislative and regulatory framework, to which a very brief introduction and interpretation is given in the following section, though this does not purport to provide strict legal opinion or definition.

The International, EU and UK Legislative and Regulatory Framework

The United Nations Convention on the Law of the Sea (UNCLOS 1982) makes very little reference to the historic environment, although Article 303(1) states that ‘States have the duty to protect objects of an archaeological and historical nature found at sea and shall cooperate for this purpose’. The general thrust of Article 303 is related to controlling ‘traffic in such objects’. The drafters had in mind items that might be of monetary value in the antiquities trade, but such considerations are not especially significant in terms of submerged prehistory, although, in recent years, some prehistoric artefacts, faunal, and even human remains from offshore contexts have been offered for sale on the Internet; contact with the sites involved has resulted in items being withdrawn from sale.

The UNESCO Convention on the Protection of the Underwater Cultural Heritage (CPUCH 2001) includes a preamble referring to ‘the need to respond appropriately to the possible negative impact on underwater cultural heritage of legitimate activities that may incidentally affect it’. This preamble sets out a basic principle, which is fleshed out later in the document in a series of Rules in an Annex, including ‘Rule 1: The protection of underwater cultural heritage through in situ preservation shall be considered as the first option…’ and ‘Rule 6: Activities directed at underwater cultural heritage shall be strictly regulated to ensure proper recording of cultural, historical and archaeological information’. Despite not ratifying the Convention, the UK Government has stated that it recognises the Rules of the Annex as representing good practice and all work by English Heritage is aligned thereto (Hansard; HC Deb 2005, 24 January 2005: Column 46W ref 210917. Available from http://www.publications.parliament.uk/pa/cm200405/cmhansrd/vo050124/text/50124w13.htm).

Two EU Directives have had direct application in terms of assessing and mitigating the impacts of industry on submerged prehistory. Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, is generally known as the ‘SEA Directive’ (Strategic Environmental Assessment). Its purpose is to ensure that environmental consequences of certain plans and programmes are identified and assessed during their preparation and before their adoption. Plans and programmes subject to SEA in UK include offshore oil and gas and renewable power project licensing. One outcome of this directive was the preparation of a series of reports by (Flemming 2002–2005) for the then UK Department of Trade and Industry that summarised understanding of submerged prehistory in UK seas at that time, and recommended mitigation measures to prevent damage to submerged prehistoric remains arising from oil and gas activities.

The Environmental Impact Assessment (EIA) Directive (EU Directive 97/11/EC, which amends the original Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment), came into effect in July 1988. It has a more specific purpose than the SEA Directive, being concerned with ‘projects’ rather than ‘plans and programmes’ (for a report that compares EIA and SEA see: http://ec.europa.eu/environment/eia/pdf/final_report_0508.pdf). Annex III of the EIA Directive expands on Article 5 to explain that the aspects of the environment likely to be significantly affected by a proposed project includes '… the architectural and archaeological heritage…'. In short, and in the context of submerged prehistoric landscapes, the EIA Directive has required survey and the development of programmes of mitigation, commissioned by developers from archaeological consultants that have generated substantial amounts of new information.

Other European instruments include the Council of Europe Convention for the Protection of the Archaeological Heritage of Europe (revised) (Valletta 1992). This convention reflects the change in the nature of the threats to the archaeological heritage, which now come less from unauthorised excavations, as in the 1960s, and more from the major construction projects carried out all over Europe from 1980 onwards. The revised convention established a body of new basic standards for Europe, to be met by national policies for the protection of archaeological assets as sources of scientific and documentary evidence. It applies to submerged sites and incorporates research, rather than just conservation, dimension (Articles 1.1–1.2) and provides for 'archaeological reserves' (Article 2).[1] The Council of Europe Landscape Convention has the general aims of conserving, managing and planning landscapes, and encouraging public authorities to adopt policies and measures at all levels to achieve this. 'Landscape' covers the parties' entire territories, including coastal waters and the territorial sea. It applies to 'ordinary landscapes' no less than outstanding ones. Policies should be in keeping with the provisions of the convention, and landscape should be accommodated within spatial planning and cultural, environmental, agricultural, social and economic policies. It recognises that landscapes are impacted by processes originating elsewhere, unchecked by national boundaries, and hence, an approach at a European level is necessary. It must be noted, however, that Council of Europe conventions do not carry the same legislative force as EU Directives. Moreover they are applicable only to national territories, i.e. the limit of the territorial sea, out to the 12 nautical mile limit.

In addition to international legislation and conventions, and those arising from larger political units, such as the EU, most nations have internal domestic legis-

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[1] At present, apart from wreck sites designated via the UK Protection of Wrecks Act 1973, there is no legislation permitting the establishment of 'archaeological reserves' in UK waters. However, a further EU Directive, (92/43/EEC), also known as the Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora, or the 'Habitats Directive' for short, might be helpful in some cases. The Habitats Directive provides for the definition of Special Areas of Conservation (SACs) for habitats and species considered to be of European interest following criteria given in the directive. Designation of SACs on natural environment grounds may also, but purely coincidentally, serve to protect areas of archaeological significance. For example, the UK Joint Nature Conservation Council consulted in August 2010 on the selection of UK offshore SACs, including the Dogger Bank, primarily on the grounds of seabed habitat protection. This could lead to regulation of activities on an area which is also significant in terms of paleo-geography: the Dogger Bank formed an elevated area of land in the North Sea in the early post-glacial, becoming an island *c.* 8700BP, and finally being submerged *c.* 7500 BP (Ward, Larcombe and Lillie 2006). The UK Marine and Coastal Access Act 2009 provides for designation of Marine Conservation Zones, which might be similarly helpful, but again coincidentally.

lation relating to their cultural heritage. For example, Germany has a federated 'Lander' structure, and cultural heritage is a Lander-level management responsibility, not a federal one. Such management structures cause further confusion. EU Directives have been transposed to UK legislation by domestic regulations, but there are other UK Acts of Parliament related to the historic environment: the Protection of Wrecks Act 1973; Ancient Monuments and Archaeological Areas Act 1979; Town and Country Planning Act 1990; National Heritage Act 2002; and the Marine and Coastal Access Act 2009[2]. The National Heritage Act 2002 modified English Heritage's functions within the English part of UK territorial sea (out to the 12 nautical mile limit), to include securing the preservation on the seabed, and promoting the public's enjoyment of, and advancing their knowledge of monuments in, on, or under the seabed.

In the Netherlands, the Monuments Act 1988 (revised 2007) provides the legislative basis for managing submerged prehistoric archaeology within the territorial sea. The revised Monuments Act (Wet op de Archeologische Monumentenzorg, WAMz) explicitly includes a regime based on the Valetta Convention, requiring developers to conduct archaeological investigation prior to any disturbance of the subsoil. In principle, the same regulations apply to the on-shore and near-shore heritage, in terms of the responsibilities of authorities, developers and individuals. As most of the Dutch Territorial Sea directly falls under the government's responsibility, the National Heritage Agency (RCE) is the main player in the field. However, the role of commercial companies is increasing in terms of providing advice to developers and regulators and characterising the marine historic environment.

Collaboration with Industry

Increased economic use of marine resources will pose significant challenges for managing impacts on submerged paleo-environments. However, heritage professionals, government and industry have been working together for a number of years to find ways to better manage and mitigate the impacts of development. The Joint Nautical Archaeology Policy Committee (JNAPC) formed in 1988 with the aim of raising awareness of Britain's underwater Cultural Heritage and achieving protection for sites comparable to that on land. In 1995 the JNAPC published their 'Code of Practice for Seabed Developers'. This voluntary code was the first serious attempt to establish best practice for consultation and cooperation between seabed

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[2] Although not *directly* concerned with the historic environment, the 2009 Act effects it. In very brief summary, some of the main provisions of this Act saw the establishment of a Marine Management Organisation (MMO) that, by establishing a system of Marine Planning and Licensing, now coordinate the formerly fragmented system of sectoral marine consents. In addition ten Inshore Fisheries and Conservation Authorities (IFCAs) have been established, and a system of Marine Conservation Zones is being developed. The 2009 Act is helping deliver more efficient protection of all marine resources, including an improvement in the way our marine historic environment is protected and managed.

Fig. 9.3 Aggregate industry staff at CEMEX's Leamouth Wharf inspects artefacts during a BMAPA protocol site visit. These sessions provide a vital feedback and training mechanism to the marine aggregate industry staff most likely to come into contact with archaeological material. (Photo copyright of Wessex Archaeology)

developers and marine archaeologists (JNAPC 2006, http://www.jnapc.org.uk/). Revised versions of the code have since been produced.

In 2003, English Heritage and the British Marine Aggregate Producers Association (BMAPA) jointly published the Guidance Note 'Marine Aggregate Dredging and the Historic Environment'. This represented a major advance in establishing archaeological best practice for marine developers by providing practical guidance on assessing, evaluating, mitigating and monitoring the archaeological impacts of marine aggregate dredging in English waters. It sought to provide the industry with greater clarity on dealing with archaeological issues throughout all stages of the marine aggregate development process. It sets out agreed and endorsed measures to mitigate the effect of marine aggregate extraction on the historic environment (BMAPA and EH 2003).

Following on from this, in 2005 BMAPA and English Heritage published the 'Protocol for reporting finds of archaeological interest'. This document aimed to reduce the effects of marine aggregate extraction by enabling people working in the industry to report archaeological finds (BMAPA and EH 2005). This included various mitigation and management options that allow marine aggregate operators and heritage professionals to develop practical procedures for the discovery of significant finds (Dellino-Musgrave, Gupta and Russell 2009). The procedures provide a single, sector-wide protocol applicable to all dredging areas, vessels and wharves, thereby delivering a clear and consistent approach. In order to maintain interest and awareness, feedback is essential, particularly given high employee turnover rates within the industry. A protocol 'awareness' programme ensures that information about finds is regularly disseminated to staff, and a protocol 'implementation' programme ensures that staff members receive regular training (Fig. 9.3). Since 2005, a total of 281 separate reports detailing 888 individual finds have been submitted through the protocol, from remains of World War II aircraft, to prehistoric faunal remains. These finds represent a valuable source of information for understanding the nature, date and distribution of sites within the submerged prehistoric landscape (Flatman and Doeser 2010). One of the most significant finds to date was the discovery of 88 Paleolithic flint implements, including 33 hand axes, on the discarded pile of a Dutch wharf by a private collector in 2007–2008 (Fig. 9.4). These artefacts

Fig. 9.4 A selection of the 33 Middle Paleolithic hand axes recovered from marine aggregate licence Area 240 in 2007/2008. The site of their discovery was excluded from further extraction and a subsequent programme of research and investigation of the area and the wider palaeo-environmental context has been undertaken. (Photo courtesy of Peter Murphy, English Heritage)

had been removed from a cargo taken from English aggregate licence Area 240, located some 11 km off the Norfolk coast. Following the reporting of finds to EH by the RCE, best practice was followed in accordance with the provisions of the protocol and the operators promptly instigated an exclusion zone around the dredge lanes from which the cargo had been taken. Subsequent investigations of this site by Wessex Archaeology were funded by English Heritage through the Aggregates Levy Sustainability Fund (ALSF). This multiphased assessment allowed for the first time, an in-depth investigation of a discrete area demonstrated to contain Paleolithic artefactual material. The project included the use of a full suite of investigative techniques including:

- Review of industry geophysical and geotechnical data
- Collection and analysis of new geophysical data (Side Scan Sonar, Multi Beam Echo Sounder, Boomer, Chirp, and Parametric sonar)
- Grab sampling and video survey
- Vibrocore survey
- Scientific dating and paleo-ecological analysis (Fig. 9.5).

The results of this project made a significant contribution to our knowledge of the paleo-environmental history of this area, and further work to investigate the archaeological potential of the wider dredging region, supported by the industry, is now underway.

The development of a number of these initiatives owes much to the advent of the Aggregates Levy Sustainability Fund (ALSF). Introduced in April 2002, the ALSF was a tax on aggregates won from both land and marine sources, a percentage of which is set aside to help address environmental impacts. The ALSF allowed heritage professionals to secure funds for a wide range of projects aimed at reducing or mitigating the impacts of aggregate extraction on the historic environment. English Heritage was a major distributor of the fund on behalf of the Department for Environment, Food and Rural Affairs (Defra) and also assisted in the administration

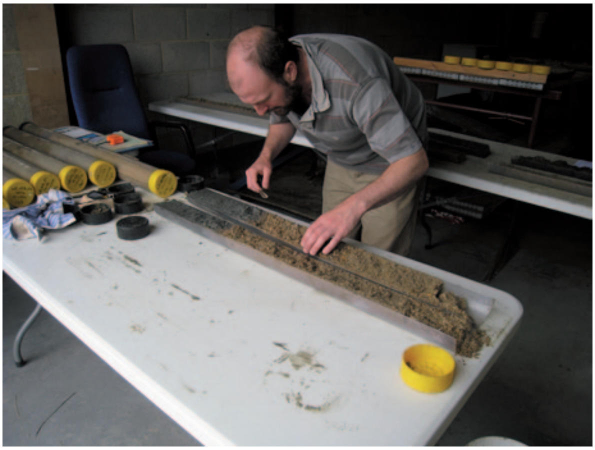

Fig. 9.5 A geo-archaeologist at Wessex Archaeology examines a parted core from marine aggregate licence Area 240 as part of the work funded via the Aggregate Levy Sustainability Fund. (Photo courtesy of Peter Murphy, English Heritage)

and distribution of a ring-fenced marine fund (MALSF) allocated to interdisciplinary projects (http://www.cefas.defra.gov.uk/alsf.aspx). Between 2002 and 2008 the ALSF funded over 250 projects involving the historic environment to a total value of £ 23.1m and between 2008 and 2011 English Heritage distributed an additional £ 4.5m, £ 1.5m of which was allocated to marine projects (Flatman and Doeser 2010). Unfortunately, the UK Government decided to discontinue the fund as of the end of March 2011.

A number of ALSF projects focused on enhancing baseline historic environment information through survey and mapping projects. The Regional Environmental Characterisations were an interdisciplinary project funded through the MALSF which aimed to acquire high-quality marine data to enhance marine mapping and broad scale characterisation of seabed habitats, biological communities and historic environment features. The South Coast REC project report was published in early 2010 and highlighted a number of areas with high potential for the survival of submerged prehistoric archaeological material (see BGS 2010). The University of Birmingham's '3D seismics as a source for mitigation mapping of the Late Pleistocene and Holocene depositional systems of the southern North Sea' pioneered GIS analysis of 3-D seismic data to identify a number of paleo-landscape structures beneath the present seabed. Further ground truthing and field validation, as part of the REC studies, established the age of some geo-morphological structures identified, and the results indicate the importance of the Dogger Bank for research on submerged prehistoric landscapes (Peeters et al. 2009). Meanwhile, Wessex Archaeology's 'Seabed Prehistory' project sought to establish best practice for the assessment and evaluation of prehistoric deposits on or beneath the seabed in the course of the marine aggregate development process (Wessex Archaeology 2008). This project also highlighted the significant contribution ALSF projects have made to our knowledge of investigative techniques and methodologies, as seen in the recent research work in Area 240. In addition several ALSF projects have delivered crucial outreach and dissemination programmes which contribute to greater understanding and awareness of the marine historic environment (see HWTMA 2008).

The examples above demonstrate how research funded through ALSF enabled better management of submerged prehistoric landscapes delivering benefits for industry and archaeologists alike. There have been significant advances in our knowledge of what remains an inaccessible and relatively poorly understood area of our heritage, allowing heritage bodies to give more informed management advice. Initiating dialogue between the two parties at an early stage of the planning process has ensured that heritage factors can be considered from the initial stages of a development project though to its completion. Such an approach has led to reduced risk and uncertainty for developers associated with unexpected finds and time delays, or the need to amend project designs. Finds reported through the protocol are now starting to deliver considerable added value as information sources for the resource assessment phases of research agendas such as the ALSF funded 'Maritime Research Framework'. This framework provides an overview of current knowledge and sets out an agreed research agenda to enable long-term strategic planning, and inform policy, funding and future projects (University of Southampton 2008 and University of Southampton 2013). The aforementioned 'Protocol' finds will similarly be an important source of information for the production of the UK Government's Marine Plans that are currently in development. The framework for preparing these plans was set out in the UK Government and devolved nations publication 'Our Seas—a shared resource: High Level Marine Objectives'. This document set the basis for the Marine Policy Statement and included important consideration of the need to incorporate cultural heritage as a component of delivering sustainable development within the marine environment. The UK Marine Policy Statement retains these core principles and clearly identifies that decision-making should take account of designated cultural heritage sites or of sites with identified significance. Importantly this document adopted a broad definition of 'the historic environment' which encompasses submerged landscapes. As such the new marine planning system will contribute to the effective management of marine activities and more sustainable use of marine resources, creating the framework for consistent and evidence-based decision-making.

Significant partnerships have been established with other marine industries, in particular the offshore renewable sector. COWRIE, or Collaborative Offshore Windfarm Research into the Environment, was a registered charity that was set up to advance and improve understanding and knowledge of the potential environmental impacts of offshore wind farm development in UK waters. Several guidance notes were commissioned by COWRIE which aim to establish best practice in managing and mitigating impacts on the historic environment. 'Historic Environment Guidance for the Offshore Renewable Energy Sector' provides generic guidance on the survey, appraisal and monitoring of the historic environment during the development of offshore renewable energy projects in the UK (COWRIE 2007). An Offshore Renewables Archaeological Reporting Protocol, similar to the aggregates protocol, has also been developed and is now used by the industry. It was produced in response to the Round Three offshore wind zone development projects. In total, these areas cover almost 27,000 km^2 of seabed out to the UK Continental Shelf, with the largest zone on the Dogger Bank (8660 km^2) being equivalent in size to

North Yorkshire, although it should be noted that only a fraction of these areas will be subject to final development (The Crown Estate 2012). In 2008 COWRIE published ‘Guidance for the Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy’. This document sought to provide guidance on the historic environment content of Cumulative Impact Assessments, a legal requirement of any Strategic Environmental Assessment (SEA) or Environmental Impact Assessment (EIA) (COWRIE 2008). COWRIE has also published guidance on the Archaeological Assessment of Geotechnical data entitled ‘Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector’. This guidance will play a key role in the future as heritage professionals seek to ground truth archaeological interpretations of geophysical data to gauge the true significance of paleo-landscape structures.

International Approaches to the Research, Management and Conservation of Submerged Prehistory

While the discussion above outlines approaches to the management of submerged prehistory in UK and Dutch waters, the submerged landscapes beneath our seas do not respect such modern territorial boundaries. During the Last Glacial Maximum (c. 22,000-20,000BP) sea levels were as much as 130 m below present levels, adding c. 40% to the present landmass of the European continental shelf alone (COST 2008). These landscapes now occupy large areas of seabed where a number of modern nations may claim territory or mineral rights under the United Nations Convention on the Law of the Sea (UNCLOS, see above). Transnational approaches to management of this unique area of our heritage must be developed. In order to do this we must first gain an understanding of current approaches to the research and management of submerged prehistory outside the UK. What work is currently being undertaken, what types of organisations are involved, what regulatory frameworks (if any) do they operate under, and most importantly what lessons can we learn?

Europe

Project Deukalion was conceived in 2008 by Dimitris Sakellariou and Nic Flemming as a multinational collaborative research programme. A Deukalion Planning Group was set up in July 2008 at the World Underwater Archaeology Conference (IKUWA3) with 16 experts from 8 European countries to convene regular meetings and draft the outlines of a multi-stranded project that might attract funding as a Large Integrated Project under the European Commissions’ Framework Programme Seven (FP7), the financial programme by which the European Union supports research and development activities (http://cordis.europa.eu/fp7). The main goals of Deukalion were to:

1. Map the 40 % of the European continental shelf that has been drowned by the 130 m rise of sea level since the end of the Ice Age
2. Exploit and integrate new technologies and data developed in Europe to conduct seabed archaeology, and
3. Raise public awareness of submerged cultural heritage, add efficiency to offshore development and improve understanding of long-term sea level and climate change

The concept of Project Deukalion is the first of its kind in the world, representing an innovative, multidisciplinary, and multinational initiative with specific aims to:

1. Investigate systematically the prehistoric archaeology and terrestrial landscapes now submerged on the European continental shelf
2. Integrate the skills of archaeological institutions and oceanographic agencies and use modern offshore, laboratory and computing technology
3. Recover valuable but threatened archives of data on the deep cultural and environmental history of Europe
4. Illuminate long-term social response to sea level and climate change

In 2009, the Deukalion Planning Group took advantage of a call under the COST (European Cooperation in Science and Technology; http://www.cost.eu**)** scheme of the European Commission (Flemming et al 2010). COST is an intergovernmental initiative, and does not fund new research projects, but rather provides funds for meetings to coordinate national research, and for dissemination and training. An application submitted by Geoff Bailey on behalf of the group was successfully initiated in November 2009 for a 4-year period as COST Action TD0902 SPLASHCOS, 'Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf'.

The aims of SPLASHCOS are to promote research on the archaeology, climate and environment of the submerged landscapes of the continental shelf, and more specifically to 'improve knowledge on the location, preservation conditions, investigation methods, interpretation and management of underwater archaeological, geological and paleo-environmental evidence of prehistoric human activity, create a structure for the development of new interdisciplinary and international research collaboration, and provide guidance for archaeologists, heritage professionals, scientists, government agencies, commercial organisations, policy makers and a wider public'. The original aspirations of the Deukalion Project remain in place and are incorporated within the SPLASHCOS initiative, and the Deukalion Planning Group continues to meet within the framework of the SPLASHCOS Action to consider long-term strategic plans and research opportunities.

This action has been developed in response to significant increases in the numbers of countries and institutions undertaking research into submerged prehistory. It has also come at a time of increasing threats from industry and other marine activities. The SPLASHCOS Action has now grown to include over 100 archaeologists, marine geophysicists, environmental scientists and heritage professionals drawn from over 60 institutions in 26 European countries, together with a wider corresponding network of individuals. At the time of writing, it is entering its final year, with two public conferences planned. A number of training opportunities have been offered for early-stage researchers. Web-based directories of information and 5 multi-authored publications are currently planned or in progress, and the SPLASHCOS initiative has directly stimulated a number of new research projects funded at national, bi-national or European level, dealing with particular areas of the European shelf, or specific problems such as the development of new technologies tailored to the needs of the underwater heritage.

North Atlantic

SLAN, or the 'Submerged Landscapes Archaeological Network' is a group of researchers from universities and government agencies in Ireland and Newfoundland who use marine geophysical tools and techniques to develop understanding of submerged archaeological landscapes across the North Atlantic (http://www.science.ulster.ac.uk/cma/slan/). Since its formation in 2006 SLAN has undertaken a number of research-led projects including:

- Archaeological assessment of data collected under The Joint Irish Bathymetry Survey (JIBS)—a partnership project undertaken by the UK Maritime and Coastguard Agency (MCA) and the Marine Institute (MI) (www.marine.ie). A number of Paleolandscape features were identified and recorded. Funding was provided by the Irish National Strategic Archaeological Research Programme (SLAN 2008/b).
- A project to map submerged landscapes off north-east Newfoundland. In 2007 an integrated coastal landscape and seabed archaeological survey was undertaken in Back Harbour in Newfoundland. During a 2008 survey numerous coastal features associated with lower sea level positions were tentatively identified during analysis of acoustic profiles (SLAN 2008/b).
- SLAN also received funding for a round table to build Government and Industry Partnerships in Seabed mapping across the N. Atlantic. Funding was provided through two grants from Memorial University, Newfoundland, and a grant from the Ireland Business Partnerships in the Department of Innovation, Trade and Rural Development, Government of Newfoundland and Labrador (SLAN 2008/a).
- More recently SLAN has conducted a number of field surveys to ground truth the paleo-landscape features recorded through The JIBS (see http://submerged-landscapes.wordpress.com/ for further details).

North America

In North America the Bureau of Ocean Energy Management (BOEM, formerly the Minerals Management Service) is the federal agency responsible for managing marine and energy development on the US Outer Continental Shelf (OCS) (www.boem.gov). Federal law requires that BOEM considers the effects of any marine development upon archaeological resources present within the area of potential effect. In discharging its responsibilities BOEM must ensure that any marine development meets the requirements of the National Historic Preservation Act (NHPA) of 1966 (as amended), the National Environmental Policy Act (NEPA) of 1969 and the Outer Continental Shelf Lands Act (OCSLA) of 1978. To enable this, BOEM funds research in the marine historic environment through their Environmental Studies Programme; this ensures that the most up-to-date scientific information is available to support their management decisions (www.boem.gov). 'Examining and Testing Potential Prehistoric Archaeological Features on the Gulf of Mexico, Offshore Continental Shelf' (GM-92-42-136) is one such project funded by BOEM in collaboration with the Coastal Marine Institute at Louisiana State University. This project has collected a number of cores on the Gulf of Mexico OCS, and these cores are being used to ground truth potential prehistoric sites and features previously identified through interpretation of remote sensing data. The results of this project will enhance the baseline information for prehistoric sites in the OCS, and improve survey methodologies and archaeological interpretations of geophysical data (www.boem.gov/OEP/). It is the results of projects such as this that are also used by BOEM to update guidance provided to marine developers called 'Notices to Lessees and Operators'. These documents include guidance on survey requirements for marine heritage sites, features and landscapes and detail of relevant regulations (see Flatman and Doeser 2010).

The National Oceanic and Atmospheric Administration is another US federal organisation that funds research in the marine environment through the Office of Ocean Exploration and Research. A number of NOAA-funded projects have sought to identify evidence of early human occupation of the North American continent. In 2007 the Institute of Maritime History and the University of New Hampshire received a grant from NOAA to undertake a 2-year submerged landscape survey in Blue Hill Bay, Maine. This project was initiated after the discovery of prehistoric artefacts in the Gulf of Maine by local fishermen (Fig. 9.6). The survey tested the effectiveness of a variety of survey techniques and methodologies, and a number of relict submerged landforms were identified (www.maritimehistory.org). In 2008 a research group from Mercyhurst College, Erie, Pennsylvania also gained funding from NOAA for a project to identify and map a number of submerged prehistoric river channels on the continental shelf of the Gulf of Mexico off Florida's coast. The research potential of this area was identified after a number of finds washed up on the Gulf coast or were retrieved during dredging. Subsequent work in 2009 sought to gather further evidence of these submerged river systems using side scan sonar and sub-bottom profiling techniques (Mercyhurst College 2009). In addition to funding from NOAA support was provided by a range of multidisciplinary institutions including; universities, archaeological research institutions and geological surveys (http://mai.mercyhurst.edu/research/anthropologyarchaeology-research/noaa-exploration/).

Fig. 9.6 A prehistoric stone biface estimated to be c. 9,000 years old, part of an assemblage of prehistoric artefacts found by scallop fishermen in the Gulf of Maine in the 1990's. A two-year submerged landscape survey in Blue Hill Bay, Maine was subsequently undertaken by the Institute of Maritime History and the University of New Hampshire with funding from NOAA. (Photo copyright of Stefan Claesson, 2007)

The Practicalities of International Collaboration

What happens in practice when the heritage agencies of adjacent nations begin collaborating over the submerged prehistoric landscapes beneath their seas? The following account might prove instructive, as a 'lessons learned' exercise. It illustrates the very marked 'cultural' differences that can exist between neighbouring countries, the ways in which the availability of funding sources can influence the direction of research and highlights potential difficulties that might be experienced in the future.

English Heritage originated as an organisation focused on the terrestrial dryland historic environment. Although it and its predecessor the HBMCE funded coastal surveys and excavations as far back as the1980s (see Fulford et al. 1997; Wilkinson and Murphy 1995), coastal and maritime archaeology was only one amongst many of its concerns. Wetland areas, now drained but formerly submerged at times, were also investigated and their prehistoric archaeology related to Holocene stratigraphy and paleo-ecology, as part of a wider EH wetlands programme in the 1980s and later (e.g. Waller 1994). The developing perception of submerged prehistoric landscapes in the North Sea by academic prehistorians, initiated by Coles (1998), was certainly understood and appreciated by some people within the organisation, but in the absence of either techniques or funding which might advance their investigation, this seemed of no practical application at that time. The publication of the influential paper 'Taking to the Water' (Roberts and Trow 2002), and the establishment of a Maritime Archaeology Team (MAT) in the same year initiated a new direction.

The development of prehistoric studies in the Netherlands was influenced by the geology and geography of the country, being focused around the major estuaries of the Scheldt, Meuse, Rhine, IJssel and Ems, where prehistoric and later sites are stratified within deep Holocene sediment sequences. From 1920 onwards, following the establishment of the Biologisch-Archaeologisch Instituut (BAI) under the direction of A.E. van Giffen at the University of Groningen, integration of prehistoric and natural scientific studies, especially at wetland sites, was seen as essential

(Waterbolk 1981). As Waterbolk notes, a 'concern with the relation of early man to his aquatic environment' and 'close association with Holocene geology…appear to be the main characteristic feature[s] of Dutch archaeology'. Jelgersma's (1961) pioneering sea-level curve, based on radiocarbon-dated peats, was one outcome, unsurprisingly in a country where sea level is a key concern. The strong link between archaeology and the environmental and biological sciences was maintained in the establishment of the National Service for Archaeological Investigations, (ROB), now National Heritage Service (RCE). Nevertheless, as in the UK, most interest focused on the onshore heritage, especially the wetland environments of the western Netherlands and there was initially little active interest in submerged prehistory. This appears to have resulted from the assumption that it would be impossible to investigate or preserve offshore prehistoric remains, if not a misconception that sites underwater would have been destroyed. This perspective has only recently begun to change (Maarleveld and Peeters 2004; Peeters et al. 2009; Peeters. 2011). In both countries, university departments have been involved in research related to submerged prehistory, but in the Netherlands the museums sector—for which there is strong regional tradition—has taken a much more prominent role than in the UK, notably in terms of establishing working relationships with fishermen to ensure recording of artefacts and faunal remains immediately after their recovery by trawling (Glimmerveen et al. 2004). Several of the contributors to the North Sea Prehistory Research and Management Framework 2009 were based at the Rotterdam Natural History Museum, but no British museums were represented at all. Both countries also have a tradition of amateur involvement, through the activities of individual collectors, the Council for British Archaeology and the Dutch Werkgroep Pleistocene Zoogdieren and this has on occasions produced significant results: for example, the finding of hand axes dredged from Area 240 at a Dutch aggregate wharf by the amateur palaeontologist Jan Meulmeester (Holden 2008) and the prehistoric artefact collection from the Solent, UK assembled by the fisherman Michael White (Wessex Archaeology 2004). On the whole, however, the Dutch tradition of amateur involvement was stronger.

Besides the differing traditions of the two countries, one key UK initiative, begun in 2002, has been the development of the Aggregates Levy Sustainability Fund (ALSF: see above). This has resulted in numerous maritime archaeological studies spanning almost a decade, many related to submerged prehistory, and some of which have been referred to above. Although collections of prehistoric artefacts from marine contexts have certainly not been neglected, it seems fair to say that the objectives of the ALSF have encouraged strategic and contextual investigations, often based primarily on geophysics, such as those mentioned in the introductory paragraph of this chapter. By contrast, in the Netherlands, where no comparable fund existed, most research could fairly be summarised as artefact and ecofact-based, often focusing on material recovered by the fishing industry (e.g. Glimmerveen et al. 2004; van Kolfschoten and van Essen 2004). However, in recent years growing awareness about the significance of submerged prehistory amongst heritage professionals in the Netherlands has led to funding of research projects consistent with legislative requirements. In contrast to ALSF-funded projects, the research in the Netherlands so far has been directly related to specific offshore developments, but there is a strong emphasis on strategic and contextual investigations (Peeters, in press), as in the UK.

The first serious attempt at coordinating prehistoric research on the north-west European shelf followed the production of Nic Flemming's SEA reports (Flemming 2002–2005), and culminated in a workshop, instigated and funded by EH and attended by archaeologists from Norway, Denmark, Germany, the Netherlands and the UK in London in 2003 (Flemming 2004). The volume arising presented a 'state of the art' account of recent research and made recommendations for future research and management, but there was no subsequent advance in implementing these proposals. In October 2006, in an attempt to take things further, two meetings were held at Amersfoort and Rotterdam, involving a small group from the UK and Netherlands. One outcome was the initiation of an electronic newsletter on North Sea Prehistory in early 2007. This was well-received initially but eventually the supply of 'copy' diminished to the extent that the newsletter had to be discontinued after its third issue.

Another venture followed another international workshop at the RCE, Amersfoort in March 2008 that led, eventually, to the publication of the North Sea Prehistory Research and Management Framework (NSPRMF) 2009 (Peeters et al. 2009). The existence of this document marks a degree of progress, but it remains to be seen how influential and useful it will be in the longer term. After all, such a framework is little more than a vehicle to draw attention to the importance of the subject. Critically, its success depends on the actions that follow. The NSPRMF is still 'young' and maybe it is somewhat optimistic to expect major advances at short notice. For the Netherlands, however, the NSPRMF serves as the key document in developing initiatives for heritage management, as in the case of the extension of Rotterdam harbour (Peeters in press), as well as for academic research (Fig. 9.7). Larger-scale research projects are currently in preparation.

Despite obvious advances, there has been a history of initiatives that began positively and optimistically, and certainly achieved some useful outcomes, but eventually proved difficult to sustain. There were several reasons for this. First, these initiatives often depended on impetus and motivation from a few individuals. This made coordination and driving the process highly vulnerable to any changes related to those people. Moreover, no one had the authority to direct overseas colleagues towards achieving desired ends, as would be the case with internally generated nationally based projects. There are several obvious messages to be learned here. First, for historical, 'cultural', organisational and resource reasons, heritage agencies and researchers based in universities and museums in different countries start from divergent positions. This need not present intrinsic difficulties, but it is essential that all parties in future ventures should attempt to understand where their colleagues in other countries are coming from, especially where collaboration between researchers and agencies widely separated by geography are involved. To avoid unrealistic expectations of what can be delivered, some mutual appreciation of 'cultural' backgrounds and funding limitations, at the very least, is needed. As demonstrated earlier in this chapter, it is far too simplistic to assume that the national

Fig. 9.7 Sample residues from the Yangtze harbour excavation are being inspected for the presence of archeological remains. Amongst the finds are charred and uncharred bone, flint, and charred plant remains and charcoal. The materials belong to a phase of occupation that can be dated to the Early Mesolithic. (Photo by D. Schiltmans, Bureau Oudheidkundig Onderzoek Rotterdam, courtesy of the Port of Rotterdam)

heritage agency of another country will be more-or-less like one's own. Secondly, it seems likely that in many organisations there will prove to be rather few people with specific interests in submerged prehistory. In the case of the North Sea initiative, this left the process (which was always under-resourced) vulnerable to changes of personnel. Consequently, a formally constituted organising Secretariat is needed to ensure continuity.

Finally, a reliable source of funding is required. The ending of UK ALSF funding from the end of March 2011 has been noted above. Offshore investigations will continue in north-west Europe, relying principally on the developer funding required by EIA. However it is instructive to read the contractor's comment regarding the work undertaken as part of the ALSF-funded study of North Sea Aggregate Extraction Area 240, discussed above: 'This project has afforded the time and development such that a much more detailed interpretation of Area 240 has been accomplished in comparison to the interpretation typically conducted during the course of an Environmental Impact Assessment (EIA) for an aggregate assessment' (Wessex Archaeology 2011). At a time of economic stringency, it is unlikely that anything comparable to the ALSF could be developed now. International collaboration will be dependent on securing funding from whatever sources are available.

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Chapter 10
Geoarchaeological Research Strategies in the Baltic Sea Area: Environmental Changes, Shoreline-Displacement and Settlement Strategies

Hauke Jöns and Jan Harff

Introduction

Sea level curves and shore-displacement models are traditionally based on geological and palynological investigations of dated sediments from different deposits in the coastal area, which are analysed and interpreted. However, in some cases, data from drowned forests and archaeological sites are also integrated—or at least referred to—usually in order to prove the quality of the models. Their validity is highly dependent on the quality of the data they are based on.

The continuous displacement of the shoreline as a result of the changing sea level and isostatic rebound, forced the people in the past to leave their coastal settlements and move to other sites that presumably offered better conditions for the future. Most of the abandoned sites fell into oblivion and were never occupied again because the specific attractiveness that originally led to their utilization was lost as a result of the changing environment. Today, all the traces and remains of earlier activity on these deserted sites can be used as archaeological archives, full of information about a specific—locally and chronologically limited—part of the history of mankind and the environment.

In the last 20 years, there has been very intensive and fruitful interdisciplinary cooperation between archaeologists and geoscientists in many parts of the Baltic Sea area, allowing them to reconstruct large periods of the environmental and settlement history. An example to be mentioned here is the research unit SINCOS (Sinking Coasts—Geosphere, Ecosphere and Anthroposphere of the Holocene Southern Baltic Sea) funded from 1999 until 2009 by the German Research Foundation. The SINCOS research aimed to obtain new data on the changes in the coastal landscape

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over the last 8,000 years in the German part of the southwestern Baltic coast by close cooperation between geologists, geophysicists, geographers, geodesists, botanists, zoologists, dendrochronologists and archaeologists (Harff and Lüth 2007). A similar scientific approach forms the base of the project Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf (SPLASHCOS)—funded by the European Commission within the Cost-Program—aiming to establish a network for multidisciplinary research on the submerged landscapes and archaeological sites of the European continental shelf (Fischer 2010).

This article has to be considered in front of the background of this new approach. It presents some general reflections on methodological preconditions and several case studies from different time periods that show how the multidisciplinary studies have improved our knowledge of the continuous displacement of the shoreline and the development of settlement in the shadow of such coastal changes of the Baltic Sea area.

To avoid any misunderstanding as far as chronology is concerned, it must be mentioned that all the dates discussed in this article should be understood as calendar years (calibrated ^{14}C years BC/AD), calibrated using the Calpal program by O. Jöris and B. Weninger (2004).

Geological Development and Environmental History

Due to the melting of the continental ice masses, the global sea level started to rise rapidly at the end of the Weichselian glaciation. During this process, the shape of the present Baltic Sea became subject to constant change, with regional differences in the dynamics and extent of this change.

The Baltic Sea has to be considered as a semi-enclosed marginal sea. It is surrounded by the Scandinavian Caledonides and the Fennoscandian Shield in the north, the Russian Plate in the southeast and the northeast-German Depression in the south and southwest (Šliaupa and Hoth 2011). The type of coasts around the Baltic Sea depends on the geological structures and the geotectonic setting. Fjord-like coasts and sea bottom coasts (Gulf of Bothnia) as well as archipelagos (northern Gulf of Finland, East Sweden) prevail at the Fennoscandian Shield built by Proterozoic crystalline bedrock. At the southern Gulf of Finland and the Estonian coast cliffs can be found, built from Palaeozoic sediments, whereas in the southern Baltic Sea morain cliffs and sandy Holocene spits and lowland coasts are dominating.

The Baltic area including the sea basin was shaped by the Quaternary glacial cycles. The inland ice abraded the Baltic Sea Basin, but also filled it with its morainic products so that the average water depth is 55 m today. The glaciers carved several separate sub-basins—e. g. the Mecklenburgian Bight, the Arkona Basin, the Bornholm Basin, and the Gotland Basin separated from each other by shallower sills. Within the Baltic Basin and along its southern coastlines Weichselian glacial deposits form the main sources for the Late Pleistocene and Holocene sediment accumulation. Today, the Baltic Sea is connected with the North Sea through the

Belts and the Sound which serve as a "bottle neck" for the water exchange with the world ocean (summarizing Harff et al. 2011).

Today the Baltic Sea is regarded as a brackish water reservoir, but its salinity has changed frequently during the Holocene. The postglacial paleogeographic history of the Baltic Basin is determined by both the eustatic rise and glacio-isostatic adjustment. Figure 10.1 shows, as a map, the vertical crustal movement of the Baltic for the last century (after Harff and Meyer 2011). Scandinavia is continuously uplifting since the end of the last glaciation so that even today rates of 9 cm/century uplift are measured at the Swedish coast of the Gulf of Bothnia. Here, the rate of uplift exceeds the eustatic sea level rise so that the northern Baltic coasts are continuously advancing.

The land uplift in the eastern Baltic area is lesser and has recently averaged only 1–2 cm/century so that it is more or less balanced by the eustatic rise of the sea level. Conversely, the southern Baltic is dominated by neotectonic stability or weak subsidence, respectively (Fig. 10.1). Superimposed with the climatically controlled eustatic sea level rise of 1.0 cm/century (Harff and Meyer 2011), continuous transgression causes a permanent retreat of the coast of 45 m/century on average here.

The initial stages of the Baltic Sea are closely linked to the last deglaciation of the Baltic area. This was a long drawn-out process, reaching the various regions along the Baltic rim at different times. While its southwestern and southeastern parts were already ice-free around 15,000 cal. BC (Clausen 1997; Eriksen 2002) and 12,000–10,000 cal. BC (Zagorska 1999; Ukkonen et al. 2006) respectively, the central and northern Baltic areas became ice-free not earlier than 8,500 cal. BC (Linden et al. 2006; Berglund 2008). Deglaciation was connected with a remarkable rise in temperature that permitted the emergence of tundra vegetation characterised by bushes, low dwarf-birches and pine trees.

The landscape changed considerably during the Allerød interstadial when the temperature again rose remarkably by a total of more than 5 °C (Clausen 1997). This change in climate permitted the growth of birch, aspen, rowan and pine trees in the southern Baltic area. The area provided a habitat for elk as well as giant deer and wild horses—there is evidence of the existence of open woodland that lasted for 1,200 years, from 11,900 to 10,700 cal. BC (Eriksen 2002; Terberger 2006a).

Throughout this whole period, the Baltic basin was gradually filling up with meltwater as a consequence of deglaciation (Fig. 10.2). A constantly expanding freshwater lake developed—the Baltic Ice Lake (Andrén et al. 2011). For more than 4,000 years (14,000–9700 cal. BC), this lake remained covered by ice for most of the year. Around 15,000, the Baltic Ice Lake became dammed in the West due to the strong uplift in today's central Sweden, so that its water level rose continually to more than 25 m above the paleo-sea water level (Fig. 10.2a). While the shoreline of the southwestern part of the Baltic ice lake was still far to the north and east of the present shore, large parts of what are today the territories of the Baltic States were submerged (Zagorska 1999). This phase ended around 9700 cal. BC, when a rapid drop of the level of the Baltic Ice Lake took place; the drainage tracks of the Baltic Ice Lake have been localised in the Central Swedish Depression (Andrén et al. 2011, p. 83 et sqq.). But this strait closed again during the Younger Dryas period due

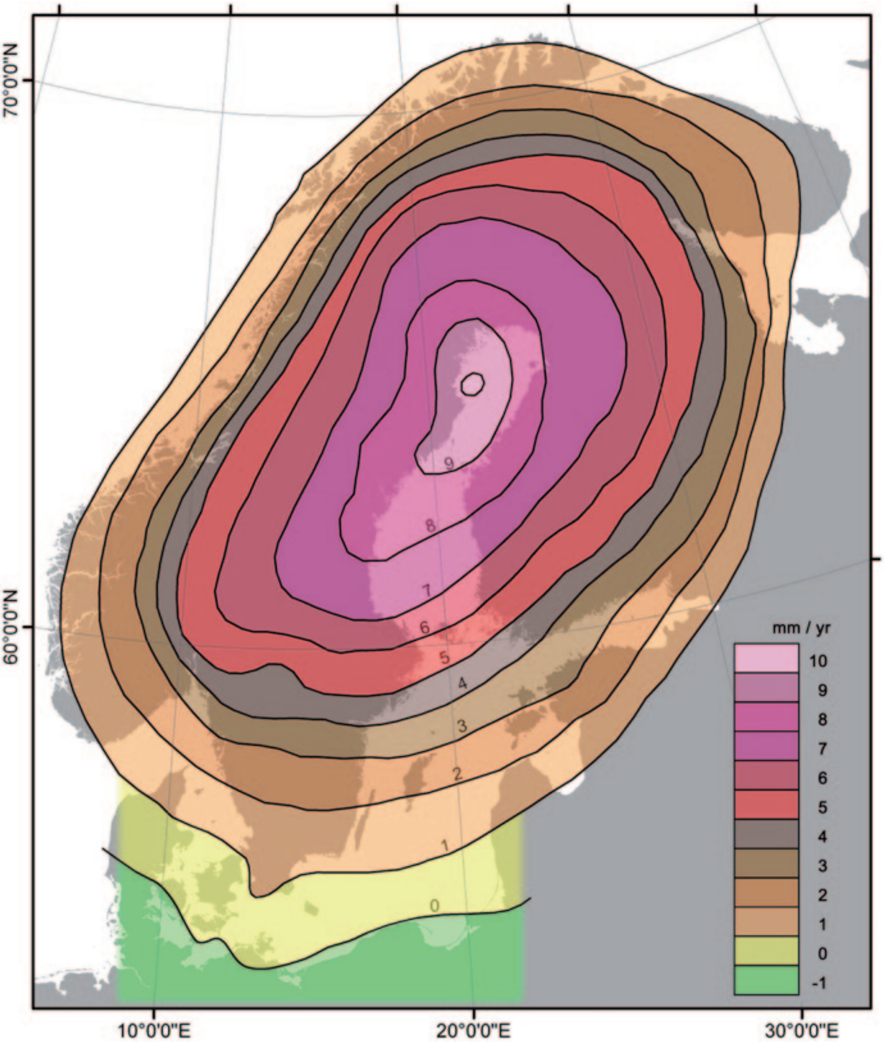

Fig. 10.1 Vertical crustal displacement (mm/year) for the central Baltic and for the western Baltic Sea for the twentieth century. (Harff and Meyer 2011, Fig. 7.6)

to the increase in Fennoscandian's uplift, and the level of the Baltic Ice Lake again rose rapidly, causing a transgression in large areas along the southwestern shore of the lake. As a result of the isostatic uplift in the eastern part of the Baltic area, a regression of the Baltic Ice Lake occurred here.

The transition from the Baltic Ice Lake to the succeeding stage—the Yoldia Sea (9700–8700 cal. BC)—was marked by a rapid fall in the water level of about 25 m, caused by an outflow of the Baltic Ice Lake water to the Kattegatt following again the Central Swedish lowland. Sediments from the south-central Swedish lowlands

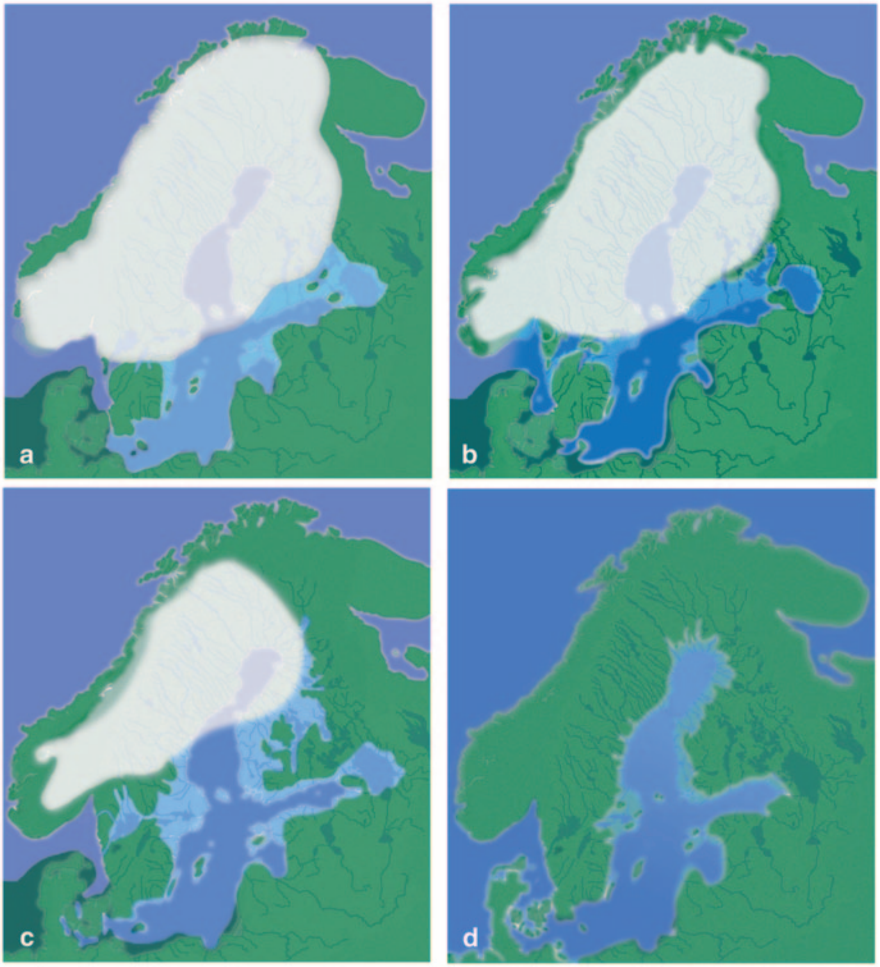

Fig. 10.2 Paleogeographic maps of the Baltic Sea: **a** The Baltic Ice Lake just prior to the maximum extension and final drainage at 9700 cal. BC; **b** the Yoldia Sea at the end of the brackish phase ca. 9100 cal. BC; **c** the Ancylus Lake during the maximum transgression at ca. 8500 cal. BC; and **d** the Littorina Sea during the most saline phase at ca. 4500 cal. BC. (Andrén et al. 2011, Figs. 4.4, 4.6, 4.7 and 4.8)

indicate that this outflow took place 300 years before—due to global sea level rise—saline water could penetrate from the west through the same fairly narrow straits into the Baltic Basin. As a consequence the freshwater environment was converted to a brackish one that lasted for 150–350 years (Andrén et al. 2011, p. 84). As a result of the Baltic Ice Lake regression the environmental conditions changed rapidly, especially in the southern and western parts of the Baltic. The extension of land bridges between central and northern Europe formed migration paths of prehistoric populations.

The transition from the Baltic Ice Lake to the Yoldia Sea occurred during the Preboreal, which was characterised by a rapid increase in the average annual temperature throughout the whole southern Baltic area. The environmental conditions—climate, vegetation and landscape—changed considerably (Schmölcke et al. 2006). Forests dominated by Scots pine and birch trees expanded more and more. Hazel quickly spread into the southern Baltic area and, finally, the elm and oak arrived. These forests became the habitat of red and roe deer as well as wild boar, moose and aurochs. Brown bears, the European otter, beavers and foxes were also present.

The changing climate of the Preboreal led to a fast retreat of the ice margin, so that around 9000 cal. BC most of the Baltic Sea basin was deglaciated (Andrén et al. 2011, p. 84). The swift retreat of the Weichselian ice mass during this phase led to extremely dynamic and short-lived environments with a particularly high sea level. Large parts of the present landscape became inundated during this period. However, due to the rapid isostatic land uplift of the Fennoscandian Shield following the deglaciation, the highest points of the moraines in western Sweden and southeastern Norway emerged from the sea and formed a fast-growing archipelago.

The exchange of water between the Baltic and the North Sea Basins was severely reduced, which led to a change of the Baltic water salinity from brackish to freshwater. In addition, the water level rose as a result of the damming of the so-called Ancylus Lake (8700–7800 cal. BC). While the containment of this lake only influenced the shoreline in the northern part of the Baltic to a small extent, due to the on-going uplift compensated for the rising water level, the “Ancylus transgression” of the southern Baltic area became dramatic (Fig. 10.2c). According to Björk (1995), the water level here rose up to 10 m/century, so that vast areas were successively inundated. A slight change from freshwater to a brackish environment has been detected for some areas of the Ancylus Lake, indicating that salt water from the North Sea had started to flow into the Baltic basin (Lemke 2004). Due to the rate of uplift in central Sweden Andrén et al. (2011, p. 88) argue, that a river system in the southwestern Baltic Basin enabled a water exchange between the Ancylus Lake and the Paleo-Kattegat.

The following phase, from 7800 to 4000 cal. BC, was characterised by constant uplift in the northern part of the Baltic area and a strong salt-water transgression in its southern part (Lemke 2004; Andrén et al. 2011, p. 88 et sqq.) According to Rößler (2006) the central part of the Mecklenburgian Bight was not earlier affected by this development as 6100 cal. BC. The marine ingression was caused by a rapid rise in the level of the North Sea which led first to the inundation of the Danish Belts and the Øresund and thus to a new connection between the Baltic and the North Sea (Fig. 10.2d). This was the beginning of the so called the Littorina Sea phase of the Baltic Sea, which was characterised by a brackish environment.

For the southwestern Baltic coastal area, Kliewe and Janke (1982) estimated for the Littorina transgression a sea level rise of 2.5 cm/year. This development formed a more structured coastline with a constantly changing topography consisting of numerous small islands and sea inlets. Not earlier than around 4000 cal. BC, when the sea level had already reached a level only 1 m lower than today, the sea level rise was decelerated to 0.3 cm/century. The coastal landscape was consolidated and the first compensatory processes began (Schmölcke et al. 2006). Lime and ash trees arrived in the southern Baltic area to complete the deciduous forests of oak, elm, hazel and birches.

Settlement History and Sea Level Change

The settlement of the Baltic Sea area started a few centuries after the end of the last glaciation 15,000 years ago and has continued without any notable interruption until today. Our knowledge of the settlement development in this area is almost entirely based on the archaeological remains of earlier cultures because contemporary written sources are—regionally differing—not available before the period between the ninth and the thirteenth centuries AD.

Based on the remains of the past human communities it is possible to obtain spatially and chronologically differentiated information about the cultural characteristics of former societies as expressed, for example, in house-building traditions, costume fashions or burial customs. However, if one also wants to analyze more general living conditions, such as the climatic and environmental conditions or the available resources, archaeological research must be supplemented by the scientific information provided by disciplines such as botany, zoology and the geosciences. The results of these investigations permit the reconstruction of the biosphere and geosphere that gave rise to the environment of the former settlement area and they are, therefore, essential for understanding settlement behaviour and thus, the anthroposphere. This applies in principle to all landscapes that are used as a source of food or are occupied, settled and even modified by humans, but it is especially applicable to the coastal area of the Baltic Sea. The communities living there since deglaciation not only had to constantly adapt to the ever-changing composition of the flora and fauna—both on shore and in the sea—but also, in some periods, had to face and react to dramatic changes in the shoreline caused by isostatic rebound and land uplift on the one hand and the constant eustatic rise in sea level on the other. The removal of inundated settlements to more secure spots, the abandonment of graveyards in flooded areas and the relocation of silted-up landing and harbour sites or dried-out fishing fences in areas of land uplift are all evidence of the reaction of ancient communities to the changing environmental and living conditions.

To sum up, the people living on the Baltic rim in the past were continually forced to adapt their economic strategies to a changing environment. Consequently, their remains—preserved in the soil ever since they abandoned their homes—are, today, not only considered to be an important record of settlement history but also of coastal development. Especially since the beginning of the 1990s, when absolute-chronological classification by ^{14}C dating was supplemented by the AMS method, which also enabled the dating of very small samples of organic material, an increasing number of archaeological sites that were originally on the coast have been investigated not only to answer archaeological questions but also to obtain data about the sea level at the time of their occupation (Fischer 1996; Åkerlund et al. 1997).

Fig. 10.3 An artist's view of a typical Mesolithic costal settlement at the Baitic Sea. (Graphic: F. Bau, Århus; after Jöns 2011, Fig. 2)

Changes in coastline and landscape developed the contact zone between land and water around the Baltic Sea that has consistently been an area of special importance for human communities. Only this ecosystem provides access to marine resources such as fish, mussels and oysters and an opportunity to hunt brants and ducks, walruses and seals as well as other sea birds and mammals (Fig. 10.3). Together with lakes and rivers, the sea was the most important transportation system up until the Middle Ages, so the maritime landscape was also of great importance for travelers, migration, communication, and the exchange of goods (Westerdahl 2000).

Even though the reasons for and the intensity of the use of the landscape and settlements in the coastal zone changed through the ages, it was common for all the communities living there to modify the utilized or occupied parts of the landscape, e.g. by building houses, fishing fences or boat-landing facilities—and also by leaving their refuse and rubbish on the sites (Jöns 2002).

Many of the deserted coastal settlements from the past have been eroded through the ages, by currents in the case of inundated sites or by wind, frost, sun, and rain in the case of sites on dry land. In particular, structures, tools and refuse of organic material such as wood, bone, antler and leather have often disappeared completely so that the archaeological record of these sites consists almost entirely of inorganic finds made of stone or ceramics. Especially in those parts of the Baltic Sea area, where the glacio-isostatic rebound has led to permanent land uplift, the information available on changes in the sea level has traditionally been used by archaeologists to date sites that had not produced diagnostic artifacts and to assign them to the archaeological cultures to be expected (Ling 2004 with further references). Especially

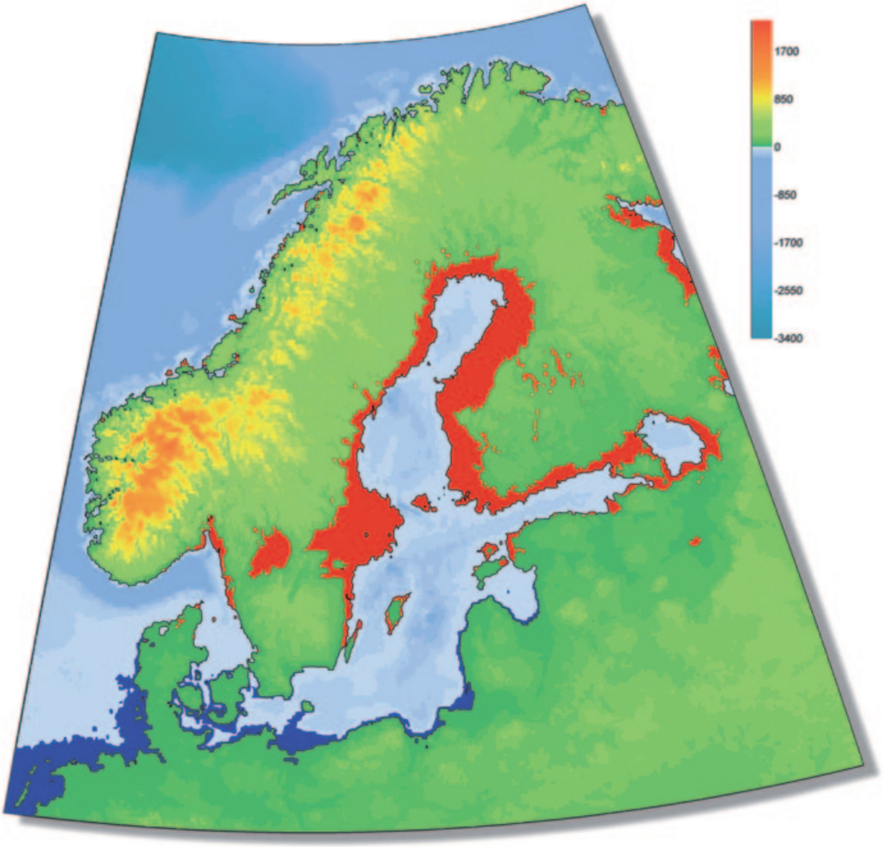

Fig. 10.4 The Baltic Sea and the change of coastlines since the onset of the Littorina Transgression about 6500 BC. *Red colours* mark areas of regression and *blue colours* mark areas of transgression. (Harff and Meyer 2011, Fig. 7.2)

in central and northern Sweden (Linden et al. 2006; Berglund 2004, 2008), Norway (Fuglestvedt 2008; Grimm 2006; Gustafson 1999) and Finland (Siiriäinen 1982; Jussila 1995) analyses of sea level curves and shore-displacement models are of great importance for the dating of archaeological sites: the rule of thumb especially in the northernmost parts of these countries is 'the higher the level and the farther off the coast, the older the site' (Fig. 10.4).

The remains of settlements can be used as fossil sea level index points, provided that the relevant parts of these sites were originally situated near the shore or constructed with specific reference to sea level (for a summary see Jöns 2011). In such cases, it can be assumed that the settlement facilities on the site, e.g. houses, hearths and pits, were above the mean sea level and, in general, secure from inundation by storm surges. In these cases it has to be ensured that the dated material represents the lowest parts of the site (Olsson and Risberg 1995). Therefore, features and struc-

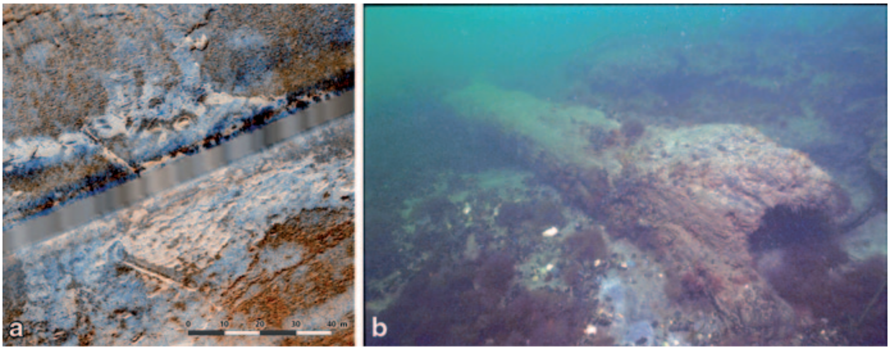

Fig. 10.5 **a** Result of sidescan sonar survey in the Wismar Bight (Germany). Some tree trunks with close connection to a peat layer are detectable in the lower and left centre of the plot (Tauber 2007, Fig. 7). **b** A tree trunk in situ on the sea floor at the Jäckelberg, Wismar Bight (Germany). (Photograph courtesy of the IOW)

tures of high significance are especially fish traps, fishing fences or the foundations of piers and other harbour facilities that originally must have been installed near the coastline. Thus, the reliable dating of these settlement remains can help us to reconstruct the sea level at a specific point in time. This is especially valid in the case of archaeological sites that were flooded during storm surges, when their remains were covered with sediments that preserved them from erosion and conserved them in some fortunate cases for thousands of years, until today. Almost without exception, such favourable conditions only exist on sites that were inundated immediately after they were abandoned or while they were still occupied. Most of these are still under water today. This is first and foremost true of those areas in the south-western part of the Baltic Sea that were rapidly inundated during the Littorina transgression and were not or only minimally affected by the glacio-isostatic uplift so that the drowned landscapes and sites remained below sea level. These sites are of great scientific value because they not only offer an opportunity to recover artifacts made of organic material but also enable information to be obtained on the dynamics of rising sea levels. In these areas, shore-displacement models can be used to obtain an initial idea of the chronological classification of the submerged sites, here, the rule of thumb is "the deeper the site below sea level and the farther located offshore of the present shoreline, the older the site".

This rule of thumb is not only valid for archaeological sites but also for "sunken" or "drowned" forests, that were systematically detected and investigated in the southern part of the Baltic Sea during the last 15 years, although the phenomenon of tree stumps on the sea floor has raised peoples' awareness since the nineteenth century (summarising Uścinowicz et al. 2011). Tree stumps rooted in the sea bed were until recently known only from the coastal waters of Denmark and Germany in water depths between 1 and 14 m below present sea level (e.g. Christensen 1995; Lampe 2005; Lampe et al. 2005; Curry 2006). Most of them were found with the help of sidescan sonar equipment (Fig. 10.5a, b; Tauber 2007). During the last several years, systematic surveys led also to the documentation of some offshore tree-trunk sites in Lithuanian and Polish waters. They were positioned in water depths between 14.5 and 27 m (Damusyte et al. 2004; Damusyte 2006) and 16–17 m respectively (Uścinowicz et al. 2011). These remains may not only be used for dating the storm surges that led to the inundation of these forests but may also deliver data about the respective climate and environmental conditions.

Case Studies

The increasing amount of relevant data obtained from new investigations over the last few decades, especially in Norway, Sweden and Germany, has led to a large number of regionally valid sea level curves (Fig. 10.6), which permit the generation of shoreline-displacement models of increasingly high quality (Rosentau et al. 2007). This new information about shoreline developments has, in some cases, already had important consequences for the archaeology-based reconstruction of the settlement history and led to changes in the research strategy. The history of Stone Age settlement in northern Sweden is one such example (Hörnberg et al. 2005). The glacio-isostatic land uplift there created a dynamic landscape that experienced a great deal of substantial environmental change during the Holocene such as the relocation of lake shorelines and modifications of the water flow in rivers. Consequently, the present landscape is completely different from that in the past. For a long while, only a few Stone Age sites were known from the inland parts of northern Sweden so that, until the 1970s, the region was thought to be more or less unsettled and thus of little archaeological significance. The situation changed recently when a model simulating early Holocene land uplift was created. This meant that the positions of contemporaneous lake shorelines could be reconstructed. These were used on archaeological field surveys and finally led to the discovery of a large number of Mesolithic settlements (Olofsson 2003; Bergmann et al. 2003).

The development of sea level models has had widespread implications for Swedish archaeology. A new reconstruction of sea level development by T. Påsse (2003) changed the historical interpretation of the famous Bronze Age ship carvings from Bohuslän in western Sweden. The shore-displacement model based on this research indicate that the clay-soil plains surrounding most of the well-known Bronze Age rock-art sites could not have been dry land—as had been assumed before the study—but were, in fact, at the bottom of the sea in shallow bays. Consequently, it is hypothesized that at least some of the ship carvings were originally done on or near the contemporary shore, which itself could have been a ritual landscape with special locations for maritime inspired cult activities (Ling 2004).

Even more remarkable results could be gained for the period from the 7th to the 4th millennium BC. From the culture science and historical point of view this period is of special scientific interest, because in that time the transformation from the extremely flexible and mobile Mesolithic hunter-gatherer and fishermen communities to the land occupying and landscape shaping Neolithic farmer societies

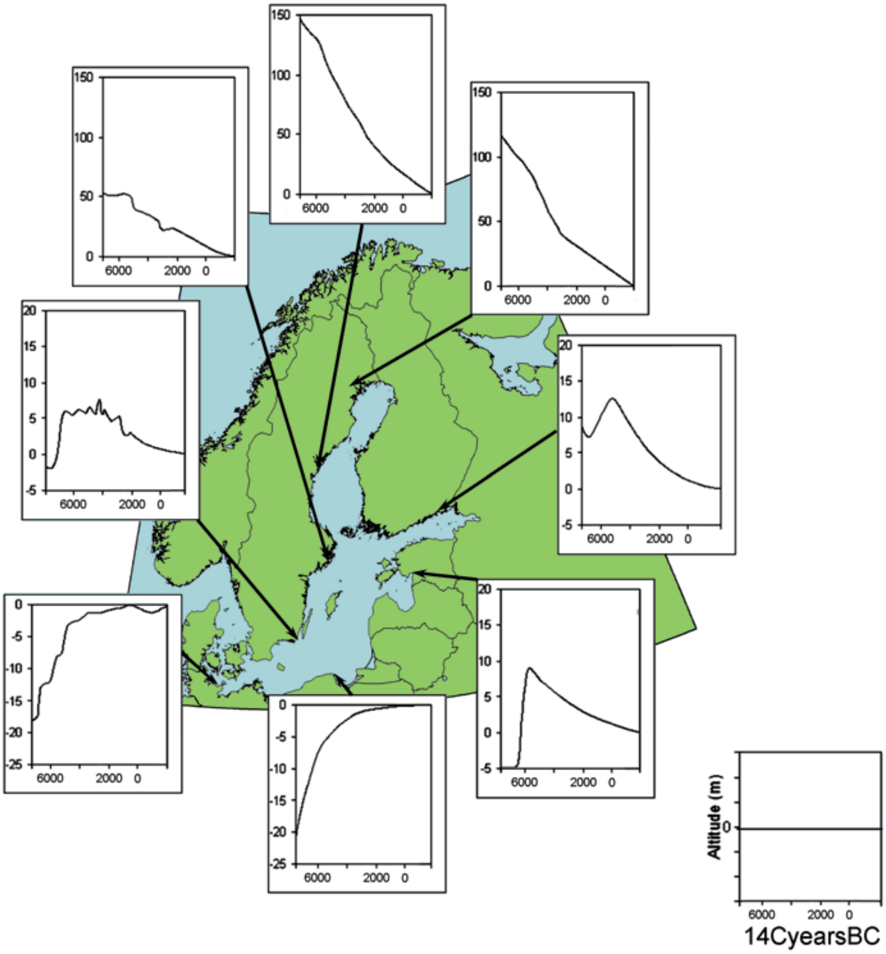

Fig. 10.6 An assortment of relative sea level curves around the Baltic Sea during the Phase of the Littorina Sea. (7000 BC, after Rosentau et al. 2007, Fig. 4)

took place (Terberger 2006b). So the coastal zone experienced a changing of the economic strategies, which commonly is known as "Neolithic revolution" according to the cultural model of Vere Gordon Childe (1936, pp. 66–104).

This transverse took place during the younger part of the Littorina transgression, The dynamic rise in sea level during this phase led in the areas without land uplift to the flooding of whole landscapes since the late 7th millennium: this makes especially the southwestern part of the Baltic rim an extraordinarily interesting area of research as far as the relationship between the geo-system, eco-system, climate and socioeconomic system is concerned (Harff et al. 2007). This was also the reason for the establishment of the multi-disciplinary research project SINCOS (Sinking Coasts: Geosphere, Ecosphere and Anthroposphere of the Holocene Southern Baltic

Sea), which aims to reconstruct the coastal morphogenesis, the palaeoclimatic and ecological conditions as well as the settlement history of the area between the Oldenburger Graben and the Oder estuary during the Littorina transgression. Within this project, archaeological investigations were undertaken to obtain information on whether and how the ancient human communities reacted in the face of coastal decline and the enormous changes in their natural environment. A special focus is on whether they adapted their economic systems, social structures and/or their communication networks in reaction to these changes. The SINCOS research was concentrated in two areas, to the west and east of the Darss Sill: the Wismar Bight as part of the Mecklenburgian Bight in the west and Rügen Island in the east (Jöns et al. 2007).

In the discussion of the suitability of archaeological sites as sea level index points, particular attention is paid to a group of more than 20 submerged settlements, today 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 geophysical and Hyball surveys and, in a second step, partly excavated underwater. As well as seeking answers to several questions about the settlement pattern and chronology of the respective sites, a further aim is to gather data about ancient coastlines and the dynamics of the rise in sea levels.

Of special importance is the Jäckelberg-Huk site, located on the edge of the Jäckelberg at a depth of 8.5 m below the present sea level, because it is one of the oldest known submarine sites in the waters of the Wismar Bight. Radiocarbon analyses date the site to the period between 6400 and 6000 cal. BC. The fish remains found on the site consist only of pike, perch and eel, which indicate a freshwater environment; the settlement must therefore have been situated in immediate proximity to a freshwater environment (Fig. 10.7a). The salvaged artifacts include trapezes, rhombic arrowheads and also a few very small longish triangular microliths, which prove that the people from this settlement were closely related to the initial phase of the southern Scandinavian Kongemose culture (Sørensen 1996).

Of supra-regional importance is then the Timmendorf-Nordmole II site (Fig. 10.7b). Here, parts of a fishing fence were excavated at a depth of 5 m below the present sea level, which had blocked the end of a small brook. The preservation conditions for organic material on the site were excellent; wooden artifacts such as several leister prongs and parts of a fish trap were recovered. Analysis of the find material indicated that the site belongs to an aceramic phase of the Ertebølle culture; a series of ^{14}C dates places the site in the period between 5100 and 4800 cal. BC (Hartz and Lübke 2006).

The neighbouring site, Timmendorf-Nordmole I, is also of great scientific value. There, settlement remains of the late Ertebølle culture were investigated at a depth of 2.5–3.5 m below the present sea level. They were radiocarbon dated to the period between 4400 and 4100 cal. BC. On this site, a pit was excavated that was covered with a number of long logs and poles that could originally have been a roof or covering for some structure. In the heterogeneous sediment that filled the pit, a truncated blade was found with a well-preserved handle made of hazel wood and lime-paste binding (Lübke 2003, 2005).

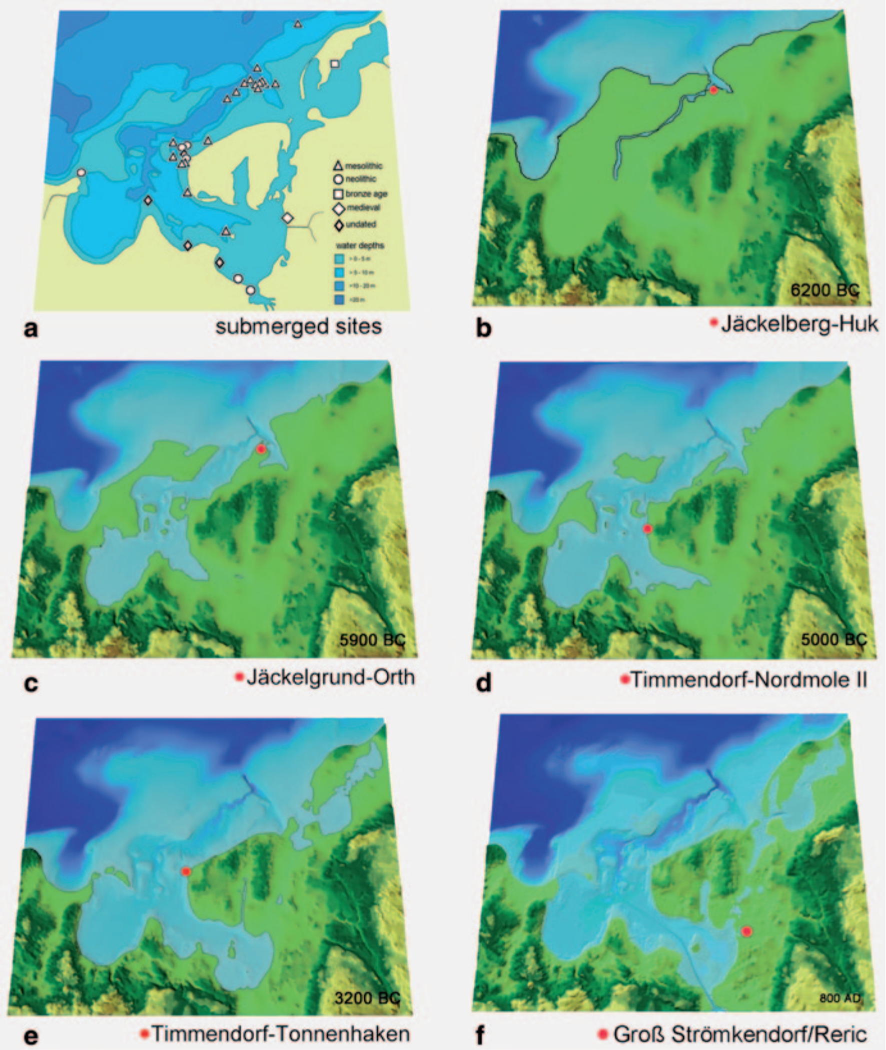

Fig. 10.7 Submerged archaeological sites and scenarios of different stages of the Wismar Bight (Germany) from the late 7th millennium BC to the 1st millennium AD. **a** Distribution of submerged sites. **b–f** Scenarios. **a** designed by H. Lübke, Schleswig; **b** designed by the author; **c–f** designed by M. Meyer, Warnemünde. (After Jöns 2011, Figs. 15.9, 15.10 and 15.16)

The sequence of Stone Age sites around the island of Poel is closed by the site Timmendorf-Tonnenhaken, where settlement remains were identified in a depth of 2 m below the present sea level (Lübke 2002). The site is situated on a former peninsula and has a cultural layer with well-preserved artifacts made of stone, bone and antler (Fig. 10.7d). Potsherds were also found here, which prove that this site was occupied by people of the Neolithic Funnel Beaker culture. This chronology is confirmed by ^{14}C dates between 3200 and 2700 cal. BC and by the fact that all the bone material is from domesticated animals, e.g. cattle or pigs.

That the transgression did not stop in the area of the Wismar Bay with the end of the Littorina transgression can not only be seen by recent measurements of the coastline but also by the remains of a trading centre from the early medieval period, that were investigated near Groß Strömkendorf on the shore of the Wismar Bight (Fig. 10.7e). This site is located only a few kilometers south-east of the above-mentioned Mesolithic and Neolithic sites of the coast of Poel island. It was occupied from the early eighth until the beginning of the ninth century AD and is presumably identical with the *emporium reric* mentioned in the Frankish annals (Jöns 1999). The site's waterfront is of special interest in the discussion of shore displacement in the area of the Wismar Bight. Geological and geophysical investigations have proved that the harbour was located in a long stretched-out bay that had been washed out by meltwater in the deglaciation phase. During the phase of occupation, the bay was still separated from the Wismar Bight by the remains of a ground moraine that formed a natural barrier. Meltwater had only cut the moraine through by just a small inlet, thus connecting the Wismar Bight with the bay. So geology created outstanding conditions for the use of this small bay as a natural harbour. Given the above-mentioned rising sea level in the Wismar Bight, the ground moraine was gradually completely eroded over the last 1,200 years and the shoreline of the harbour bay displaced by about 80 m towards the coast so that the former waterfront area and harbour basin are now completely submerged. Observations made on the site indicate that the sea level in the eighth century AD was 80–100 cm lower than the present sea level. It seems possible that the gradual erosion of the ground moraine as a result of the rising sea level finally led to the loss of the harbour's natural protection, which could also be a reason for abandoning the trading centre already at the beginning of the ninth century AD.

Within the SINCOS project the shortly reported archaeological information were used together with geological and palynological data for the calculation of a new sea level curve for the Wismar bay (Lampe et al. 2005). When all these data are plotted on this curve, there is a high degree of concordance between the different sources, which emphasises the significance of archaeology-based data from sites that were occupied for only a short time (Fig. 10.8).

Summary

After the Fennoscandian ice sheet had melted, the new landscape around the Baltic Sea basin began to be settled by human communities. Due to the eustatic sea level change and the strong isostatic land uplift, the coastal zone was an unstable habitat; in particular, it was subject to a continuous displacement of the shore that forced the people living along the coastal zone to move their settlements, either because they were flooded in submerged areas or because they no longer had direct access to the sea in uplifting zones. Given the fact that these people were highly depen-

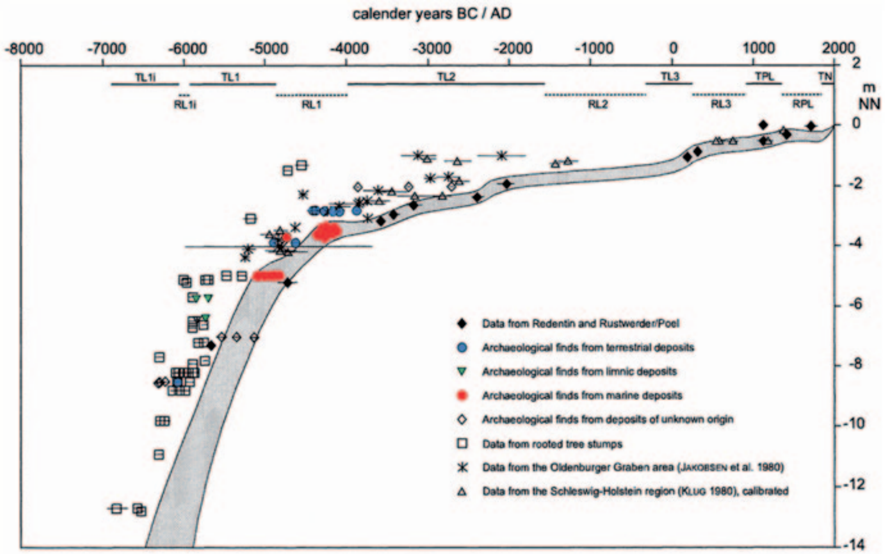

Fig. 10.8 Relative sea level curve for the Wismar Bight as reflected by AMS-14C data from peats, rooted tree trunks, archaeological finds and published data. *T* transgression, *R* regression. (After Lampe et al. 2005, Fig. 9)

dent on changes in the sea level, sea level curves and shore-displacement models can be used to determine the chronology of prehistoric sites if they were originally located on the shore. Similarly, well-preserved coastal sites can be regarded as a record of the sea level at the time of their occupation and thus used as sea level tie points. During every phase in the development of the Baltic Sea, the people living in coastal areas were—to a large extent—forced to adapt their respective economic systems to the prevailing environmental conditions as well in sea level height as in the salinity of the aquatic environment. The first who reached the Baltic area were groups of hunter-gatherers who migrated to the late-glacial landscape. In the following Mesolithic and early Neolithic periods, the coastal environment provided favourable conditions not only for hunting game but also for marine food resources. While the communities inhabiting the central and northern parts of the Baltic rim experienced the continuous emergence of new land and ever-larger islands in the archipelago, a rising sea level reduced the amount of land available for habitation by the communities along the southern shore. Here, the prehistoric humans were apparently forced to move their settlements to higher elevations following the sea level rise. After agriculture and animal husbandry were introduced in the Neolithic period, the importance of marine food resources as a source of nutrition decreased. At the same time, the changes in sea level became less dramatic, although shore displacement continued. Most of these sites can provide information on sea levels at the time of their occupation and can therefore be dated by reference to shore-displacement models.

Acknowledgements This chapter was initiated by the multidisciplinary research unit SINCOS (Sinking Coasts—Geosphere, Ecosphere and Antroposphere of the Holocene Southern Baltic Sea; http://www2008.io-warnemuende.de/projects/sincos/) and the European research network SPLASHCOS (Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf; http://php.york.ac.uk/projects/splashcos/), that are funded by the German Research Foundation and the EU as a COST action. We wish to thank the SINCOS and the Splashcos-communities for fruitful cooperation. We have to thank especially Friedrich Lüth from the German Archaeological Institute (Berlin/Germany), Anders Fischer, Heritage Agency of Denmark (Copenhagen/Denmark) and Geoff Bailey (University of York/UK) for discussions and important advises. Finally we have to thank Michael Meyer, Institute for Baltic Research, Warnemünde, for providing us with shore-displacement models and scenarios for the Baltic area and especially for the Wismar Bight.

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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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Bathymetry and topography derived from ESRI Ocean Basemap, version: March 2013

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

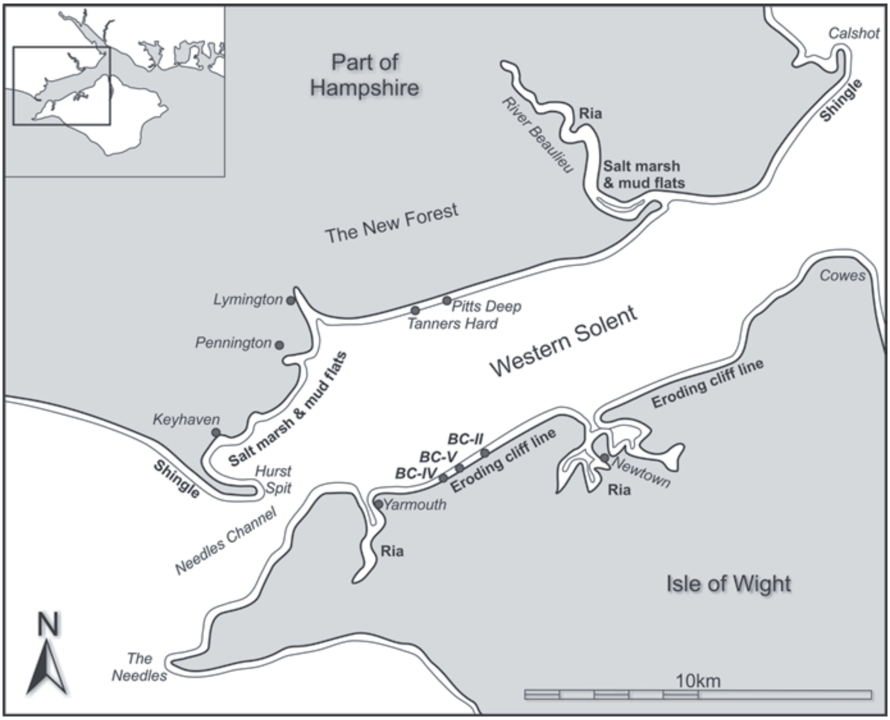

Fig. 11.2 Map of local Bouldnor Cliff area with geomorphological, archaeological and palaeolandscape features highlighted. Bouldnor Cliff sites are represented by *BC-II*, *BC-IV* and *BC-V*. Submerged landscapes have also been recorded at Pitt's Deep and Tanner's Hard (Julian Whitewright after Garry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

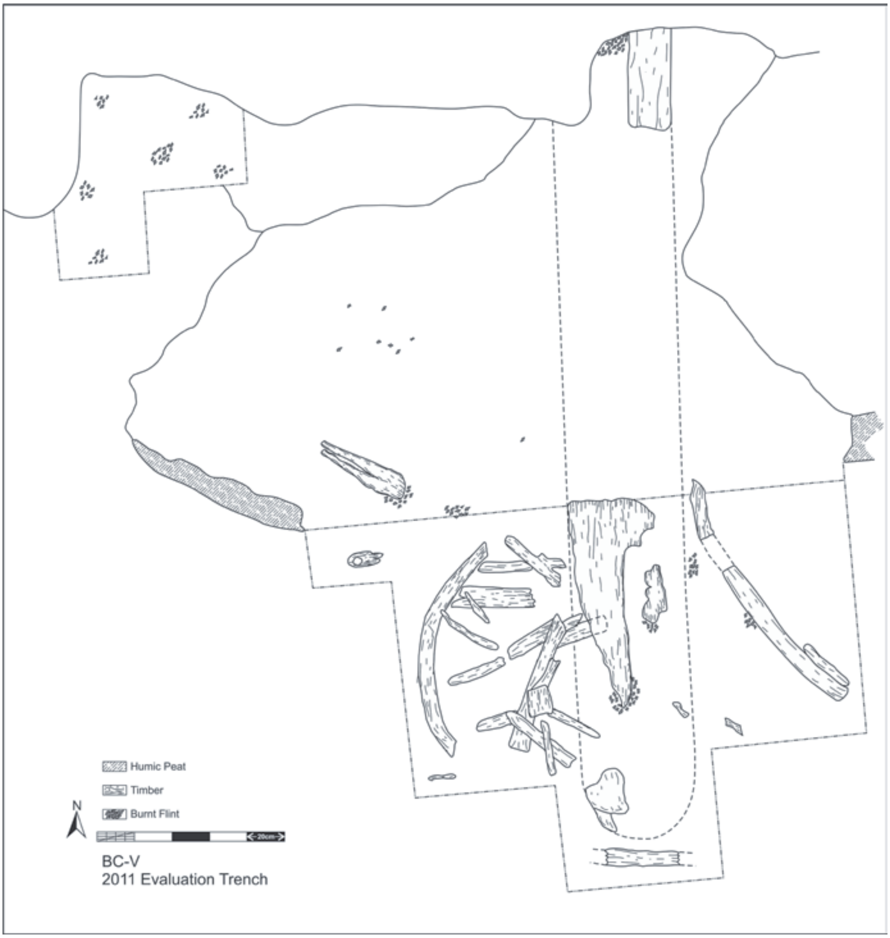

Fig. 11.3 Plan of trench excavated at BC-V showing the assemblage of worked timbers with interpretation suggesting the construction of a log boat/dug-out canoe. (Julian Whitewright after Garry Momber)

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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Chapter 12
Heritage Management and Submerged Prehistory in the United Kingdom

Andrew Bicket, Antony Firth, Louise Tizzard and Jonathan Benjamin

Introduction

Knowledge of (at least partially) submerged prehistoric sites in the UK has existed since at least the early nineteenth century (e.g. Dawkins 1870); however, recent decades have yielded considerable advancement in the study of submerged prehistory in the UK. One of the major drivers of research in submerged prehistory in the UK has been the Marine component of the Aggregates Levy Sustainability Fund (ALSF, referred to as MALSF below), which ran between 2002 and 2011 (Bicket 2011). The Aggregates Levy is the tax on aggregates (sand and gravel) extracted from the many offshore licence areas (owned in the UK by The Crown Estate) that are concentrated mainly in the east, south and west coasts of England and Wales (Fig. 12.1). A proportion of the levy was redistributed as funding for research into the impact of aggregate dredging upon the environment. Conducted primarily as a form of mitigation, funded research topics included oceanography, hydrography, ecology, maritime and aviation archaeology and submerged prehistory. As a consequence, much of the existing large-scale research in submerged prehistory has

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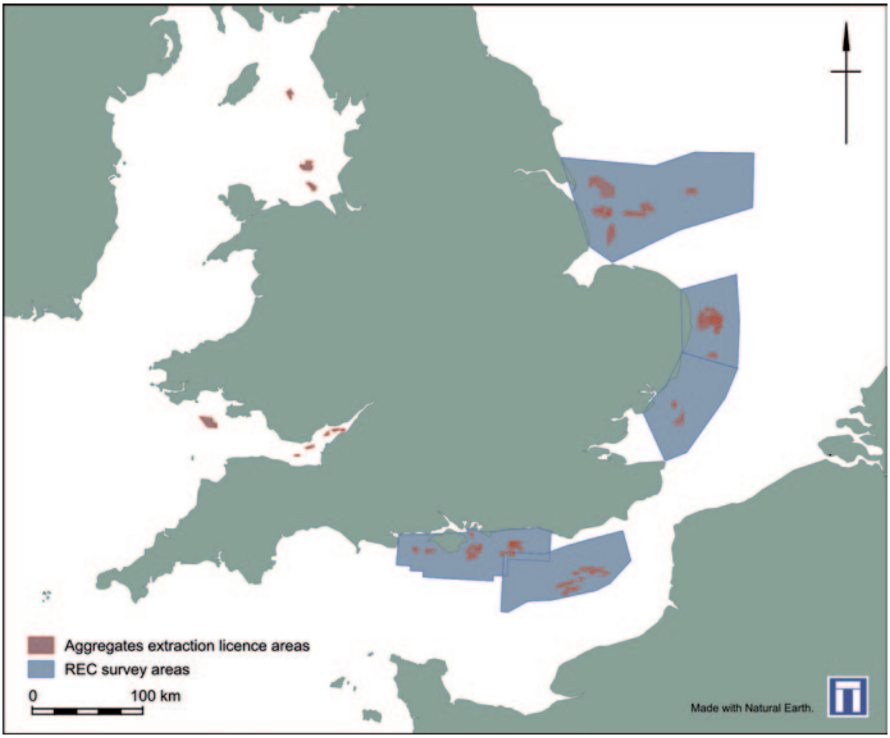

Fig. 12.1 Composite licence area, seabed prehistory and REC (Regional Environmental Characterisation) data. Much of the existing large-scale research on submerged prehistory has focused on areas near aggregate extraction in England and Wales

focused on areas near aggregate extraction in England and Wales (Fig. 12.1). By the end of the MALSF early in 2011, around £3 million had been distributed for cultural heritage research to recipients across the UK including universities, charities and commercial companies. A significant proportion of the fund has supported the investigation of submerged prehistory and offshore paleolandscapes.

A principle finding of the MALSF research projects was that submerged paleolandscapes are preserved beneath the seabed and over considerable areas (Gaffney et al. 2007, 2009; Emu Ltd. 2009; James et al. 2010). Depending upon the severity of glacial scour and other processes of erosion and degradation during the Quaternary, the potential exists for Paleolithic (c. 900,000–10,000 BP) and Mesolithic (10,000–6,000 BP) archaeology to survive in marine contexts. This potential has been demonstrated by MALSF research projects, but as yet the widespread presence of prehistoric remains, in particularly, discrete sites have remained elusive. For example, several of the Regional Environmental Characterisation (REC) projects have highlighted the presence of submerged sedimentary facies across very large areas of seabed that were once dry land which have the potential to contain in situ Lower Paleolithic archaeological materials; from periods dating to around 720,000 BP in the Outer Thames (Emu Ltd. 2009), 500,000 BP in the South Coast region (James et al. 2010) and 700,000 BP in the central and southern North Sea (Limpenny et al. 2011; Tappin et al. 2011) (Fig. 12.1).

Geophysical survey and paleoenvironmental analyses enable researchers to create large-scale reconstructions of paleolandscapes. Nonetheless, the reconciliation of conceptualised paleolandscapes (as context) and physical sites has not yet been fully realised. There are few known submerged sites in UK waters but significant reports of chance finds of artefacts and Pleistocene megafaunal remains provide undeniable evidence of the potential for discrete deposits of prehistoric material, such as those examined within Area 240 (discussed in further detail below). The contribution that geoarchaeological investigation of landsurfaces and deposits can make to understanding 'conventional' archaeological material such as artefacts and structures is considerable, especially for earlier prehistoric periods when such artefacts and structures are relatively ephemeral, widely dispersed and often reworked into secondary contexts (Hosfield and Chambers 2004). Where artefacts or structures are present, it is likely that the surfaces and deposits in which they are embedded will provide integral context to their understanding and interest.

The integrated methodologies and primary data produced thus far have informed fundamentally our view of the archaeological potential of our coasts and offshore areas. Currently, research undertaken through development-led archaeology, collaborative research projects and consultation with a broad cross section of marine stakeholders is likely to produce further results and significant discoveries. This will result in a continued realisation and improved understanding of submerged archaeological material. In turn, this will also support the seamless approach to heritage management of prehistoric sites and landscapes, both above and beneath the sea.

The Paleogeography of the United Kingdom

Great Britain as an island is the paleogeographical exception rather than the rule (Fig. 12.2). A peninsula for most of the last 1 million years, Great Britain has only relatively briefly been separated from Eurasia during the recent geological time. Large areas of now submerged, potentially inhabitable land in the central and southern North Sea, Irish Sea and a significant coastal band around the majority of the rest of the British Isles coastline have, for example, been inundated since the last ice age as the global sea level rose by around 120 m to their present levels (Fairbanks 1989; Bailey and Flemming 2008).

These now submerged paleolandscapes may have provided ideal conditions for hominins, their prey species and exploitable fauna and flora. The ability to investigate these potential archaeological resources following the last ice age (or previous Pleistocene glacial–interglacial cycles) is complicated in the UK by the complex interplay of several global-, continental- and regional-scale variables, i.e. eustatic sea level change (Shennan and Horton 2002; Shennan et al. 2006), glacio-isostatic tectonic readjustment (Lambeck 1995; Bradley et al. 2009), and the development of coastal geomorphology driven partially by these larger-scale processes (e.g. Smith et al. 2010). Moreover, the preservation of submerged and intertidal archaeological

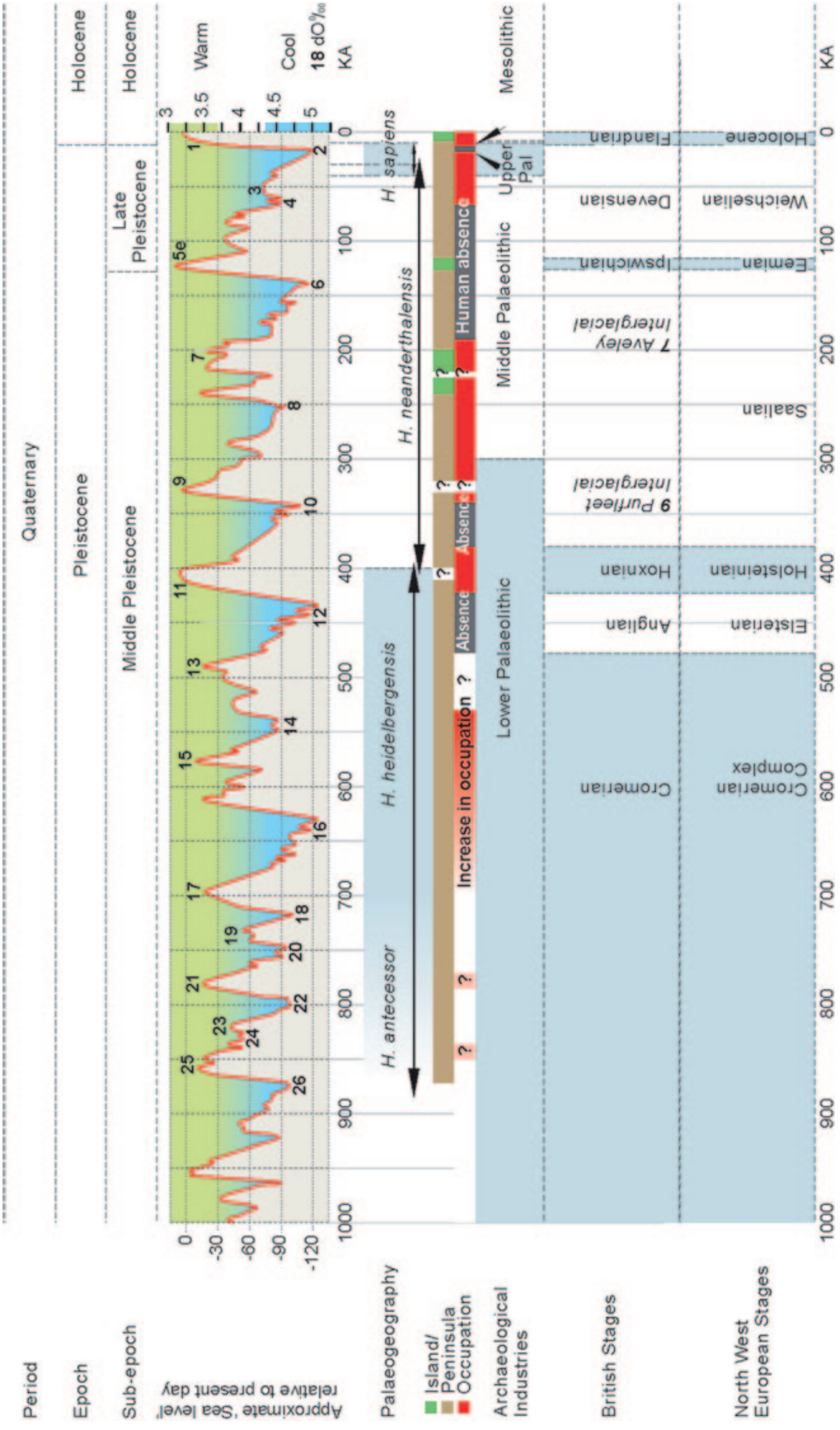

Fig. 12.2 Great Britain as an island is the palaeogeographical exception rather than the rule

material is influenced by high-energy processes such as glacial erosion (either directly by ice scour or subsequently by meltwater), tidal and wave action, and storms. It is also assumed that the high-energy Atlantic and North Sea coasts of the UK compared to more sheltered regions such as the south westBaltic (Fischer 1995; Lübke 2011) induce a further level of complexity for our investigations, suggesting that the preservation of archaeological material and sediments of paleoenvironmental interest is at worst removed, and at best fragmentary and problematic to investigate. Realistically, this may be so in many cases, but as it stands this assumption has not been proved. The corpus of submerged prehistory investigations is far from comprehensive around UK shores. The necessarily sparse spatial and temporal scale at which existing MALSF paleolandscapes projects like the North Sea Palaeolandscapes Project (Gaffney et al. 2007, 2009), RECs (Emu Ltd. 2009; James et al. 2010, 2011; Limpenny et al. 2011; Tappin et al. 2011) and The Relict Palaeolandscapes of the Thames Estuary Project (Dix and Sturt 2011) is also not sensitive to detecting discrete sites except by chance. Where large-scale research has taken place, a wealth of paleolandscape data has been retrieved but with very few sites being added to the catalogue. More focused investigations such as at Bouldner Cliff (Momber et al. 2011) and Area 240 (Tizzard et al. 2011) are clearly more suitable for examining a particular deposit of archaeological interest but not to a broader prospection for unknown sites across a region. Clearly, a balance must be struck between the regional identification of archaeological potential and the detection of smaller-scale sites to specifically define the archaeological significance and importance of in situ submerged offshore sedimentary deposits undisturbed by millennia of degradation by coastal-, glacial- and human-induced processes.

Directly through the MALSF, the commissioning of Regional Environmental Characterisation surveys (RECs) over large study areas surrounding the main clusters of aggregates extraction areas in the South Coast, East English Channel, East Coast, Outer Thames and Humber regions (Emu Ltd. 2009; James et al. 2010, 2011; Limpenny et al. 2011; Tappin et al. 2011) has led to a greater understanding of the level of preservation of submerged sediments of archaeological interest and the development of best-practice for identifying their traces from both geophysical and geotechnical survey datasets. The methods that underpin the examination of buried landscapes within the RECs were initially developed for the management of cultural heritage that may have been impacted by port dredging and aggregates extractions (Firth 2000). These integrated methods were then scaled up during earlier MALSF projects, particularly Seabed Prehistory, undertaken by Wessex Archaeology and others between 2004 and 2008 including investigations of the palaeo-Arun river (Gupta et al. 2004; Wessex Archaeology 2009).

Post-MALSF, this best-practice methodology continues to inform the examination of submerged prehistory through various offshore sectors including aggregates extraction and renewable energy schemes. Research such as that done under the auspices of the MALSF and RECs has produced high-quality deliverables that provide new insight for interpreting the terrestrial archaeological record in a continuum from land to sea (James et al. 2010). For example, during the South Coast REC survey, seamless 3D palaeogeography models of internationally important archaeological landscapes such as the south coast of England were developed and analysed for a period of 500,000 years through the integration of substantial spatial datasets such as the SRTM digital elevation model (James et al. 2010) and offshore geophysical survey data (James et al. 2010). This research reinforces the regional context of key Paleolithic sites such as Boxgrove within a scientifically based interpretation of the regional paleolandscape at various periods during the last 500,000 years (James et al. 2010). By understanding the configuration of the coastline, the land during a given period of time becomes a much more holistic and robust paleogeography in which to interpret the archaeological and paleoenvironmental records.

As has been shown by the Seabed Prehistory project, published in eight volumes (Wessex Archaeology 2009), the subsequent RECs and other significant MALSF-supported paleolandscape reconstruction projects, e.g. North Sea Palaeolandscapes Project (NSPP) (Gaffney et al. 2009), West Coast Palaeolandscapes Project (Fitch and Gaffney 2009), these offshore, buried landscapes are characterised by familiar features such as river systems (e.g. the paleo-Arun river investigated by Gupta et al. 2004), marshes, estuaries, hills and lakes that could have supported a rich and diverse array of species including early hominins when climatic conditions were suitable. There is, therefore, potential for these submerged landscapes to preserve archaeologically significant Paleolithic and Mesolithic archaeology (Wenban-Smith 2002; Westley et al. 2004). In addition, tantalising potential for as-yet unpopulated phases of the Pleistocene, predominantly the Ipswichian interglacial (MIS 5e, 130–110,000 BP), have also been suggested by palaeogeographic reconstructions of the English South Coast and East English Channel (James et al. 2010; Arnott et al. 2011). If colonised by humans, a significant reassessment of this period would be required hinting at the potential for offshore locations to provide insights that have so far eluded terrestrial-based investigation.

With sufficient resources in time, data and industry collaboration, this kind of enlightening and progressive paleolandscape research provides real context for making informed and effective decisions when managing cultural heritage offshore over large areas of the seabed.

Developing the Management of Submerged Prehistoric Archaeology

The MALSF had a major and positive impact on the ability of the marine aggregate industry to deliver sustainable development for the historic environment, in line with the high-level marine objectives of the UK[1]. Before the MALSF, which first came on-stream in 2002, the aggregates industry was making major strides in assessing the possible impacts on the archaeological heritage of individual licence proposals, through licence-specific Environmental Impact Assessment (EIA) and small strategic projects. The process of applying for individual aggregate dredging licences, accompanied by EIA, provided the basic structure for the sorts of archaeological work that were being carried out. From the mid-1990s onwards, EIAs were typically

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[1] http://archive.defra.gov.uk/environment/marine/documents/ourseas-2009update.pdf.

accompanied by detailed desk-based studies of what archaeological resources were known—or might be expected—to be present in the vicinity of the proposed licence area. Geophysical data, acquired for assessing the aggregate resource, were being made available to archaeologists to help identify possible sites (Firth 2011). Provision was starting to be made for fieldwork to test conclusions from desk-based or geophysical studies (e.g. RECs, NSPP). Where issues were identified, exclusion zones were being introduced and fieldwork undertaken (Wessex Archaeology 2006) to mitigate possible impacts to features of archaeological interest such as paleochannels (Wessex Archaeology 2002). The results of individual desk-based assessments/technical reports and EIAs were clearly of interest to archaeologists, because they presented some of the first development-led area-based investigations in UK waters (Firth 2000). The results were of interest to industry and government, because they gave practical meaning to a previously unfamiliar and nebulous requirement of EIA regulations stemming from EU directives. The results were of interest to the general public, which has a widespread fascination with underwater archaeology. The elements of the EIA process—desk-based studies, geophysics and evaluation to test conclusions, mitigation strategies and dissemination to a variety of audiences—have heavily influenced the types of projects funded through the MALSF. This is unsurprising, because the key advances that were being made were simultaneously highlighting major gaps in knowledge and capability that could not be addressed within the scope of investigating an individual licence application.

Given the results of research conducted from 2002 to 2011, it has to be recognised that sustainable development of marine aggregates has not been the only beneficiary. Other sectors of marine development have also gained from the progress made in investigating submerged prehistory through the MALSF, including capital dredging for ports and offshore renewables. Heritage agencies have also benefited in relation to their statutory obligations and powers, as knowledge created by the MALSF and methodologies that have been developed have been transferred sideways. The "business of archaeology" has benefited too, with a diverse range of organisations—charities, universities and commercial companies—engaging in MALSF projects, and marine archaeology having a much higher profile than previously, both within terrestrial archaeology and amongst other marine disciplines. The MALSF contributed in a significant way to submerged prehistory being both vibrant, more effective and helping to deliver sustainable development whilst safeguarding the UK's marine heritage through innovation and the definition of 'best-practice'.

Case Study: Area 240

Between December 2007 and February 2008, lithic artefacts, including handaxes, flakes and cores, as well as faunal remains were discovered by Mr. Jan Meulmeester in stockpiles of gravel at the SBV Flushing Wharf, near Antwerp, Belgium (Fig. 12.3).

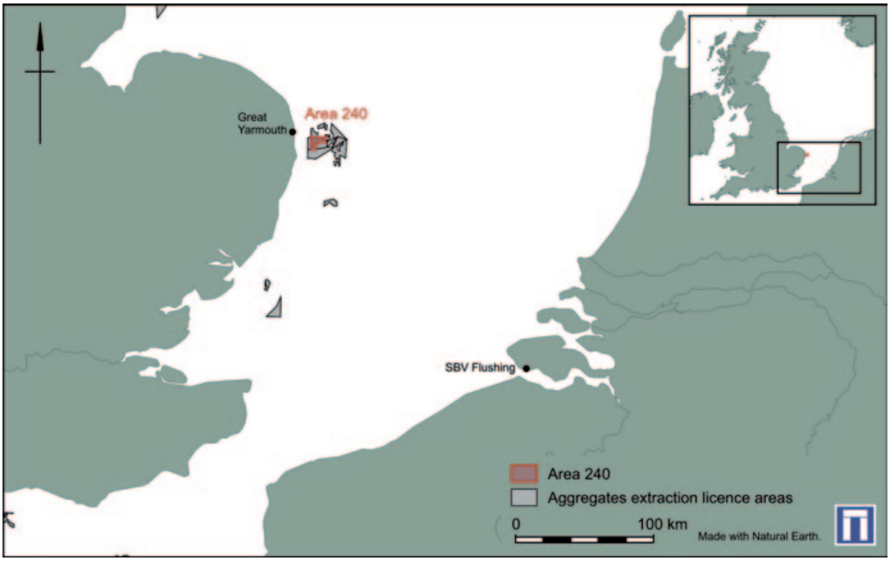

Fig. 12.3 Lithic artefacts, including handaxes, flakes and cores, as well as faunal remains were discovered by Mr. Jan Meulmeester in stockpiles of gravel at the SBV Flushing Wharf, near Antwerp, Belgium

They were recovered from a discrete locale within Area 240; a marine aggregate licence area situated approximately 11 km off the coast of East Anglia (south-east Britain) in water depths of between −16.7 and −33.5 m Chart datum (CD) (18.2 and 35.0 m below Ordnance Datum (OD)). The handaxes were dredged from a discrete 3.5 × 1.1 km area in water depths of −20 to −33.5 m CD (21.5 and 35 m below OD), which is situated within the active dredging area. Following the discovery, a voluntary exclusion zone was put in place by Hanson Aggregate Marine Limited (HAML), the licensee. The discovery has shown that significant and rare archaeological material can be present in deposits targeted for marine aggregate extraction in British waters; however, archaeologists have limited capacity to identify and localize such deposits in the marine environment. In light of the discovery at Area 240, a project concerning the application of geophysical, geotechnical and seabed sampling of those deposits was funded through the MALSF and administered by English Heritage (Wessex Archaeology 2011). Diving methodologies were considered during the project design; however, it was ultimately decided that this site in Area 240 was not conducive to diving; water depths approaching 30 m, the strong currents in the area and notoriously poor visibility all hindered potential diving operations. The prospect of locating flints, particularly in an area of 3 km^2 without a more precise location for the find-spot is remote and would require a major commitment of time and money. Due to cost effectiveness, it was decided that the chance of failure to find artefacts was too high and therefore, geophysical, geotechnical and seabed sampling was favoured over archaeological diver survey. The project was

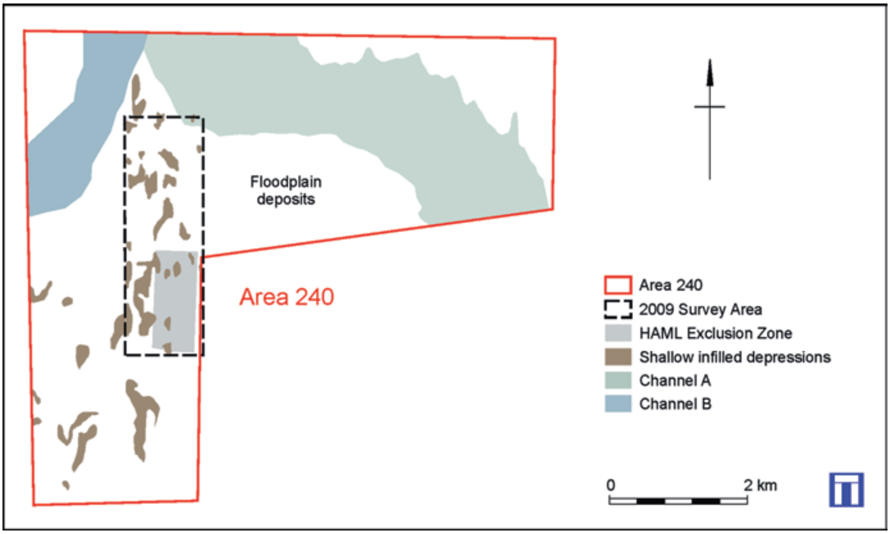

Fig. 12.4 A series of sediment units dating from >500 ka to the last marine transgression, c. 7200 BP/6100 cal. BC. Two channel features, Channel A and Channel B, dominate the area

divided into a series of stages allowing the work to be developed on an iterative, judgement-led basis. The investigations included:

- Detailed re-examination of geophysical data (multibeam echo-sounder and sub-bottom profiler) originally acquired in 2005 for the assessment of aggregate reserves across the whole of Area 240, and 158 geotechnical (vibrocore) logs acquired between 1999 and 2007
- Intensive geophysical survey of the 3.5 × 1.1 km area, acquiring a range of data including sub-bottom profiler data acquired using four different methods of sub-bottom profiling, undertaken in 2009
- Adaptation of ecological seabed sampling methods (photography, trawling and clamshell grabbing) to recover further worked flint and faunal remains from the seabed
- Targeted coring to obtain complete samples of the sedimentary sequence from ten locations in the vicinity of the site
- Paleoenvironmental assessment and analysis, and scientific dating using radiocarbon and Optically Stimulated Luminescence (OSL)

This process enabled the development of an overarching synthesis and interpretation. The results revealed a complex history of deposition and erosion in Area 240. Dredging operations over the last 20 years have further complicated the interpretation of this area. A series of sediment units dating from >500 ka to the last marine transgression c. 7200 BP/6100 cal. BC (Behre 2007) were interpreted, although not as a complete sequence. Two channel features, Channel A and Channel B, dominate the area (Fig. 12.4).

Channel A is observed to the north of where the artefacts were dredged, orientated north-west to south-east. The southern edge of the channel is prominent and is observed as a deep cut of 5 m. The northern edge of the channel is less obvious and is observed as gently shoaling, rather than being a steep cut. The sediment infilling this buried channel varies in composition and is indicative of a changing flow regime with periods of high-energy and low-energy sediment deposition. The high-energy depositional sediments comprise sands and gravels; fine-grained sediment units, indicative of lower-energy depositional environments are observed infilling broad shallow depressions or forming small bank structures up to 3 m high. The floodplain of Channel A is extensive, encompassing the majority of Area 240 and comprising sands and gravels. It is likely that the cut of the channel and the development of te floodplain occurred during the Anglian period, developing as the ice sheet retreated and glacial meltwater carved broad channels across the region as part of a braided plain system. It is possible that the system was more extensive both laterally and vertically and that much of the sediments deposited with this early development of the system were subsequently removed or reworked during the sea-level rise in the early Hoxnian.

The major development of the floodplain and the initial infilling of Channel A has been attributed to Saalian age, with OSL dates indicating deposition of outer estuarine sediments during MIS 8. Studies carried out to the north of Area 240 (Wessex Archaeology 2009) indicate that the coarse-grained fill may have been deposited during the Saalian (MIS 8, 7, 6) with overlying finer-grained sediments deposited at the onset of the Ipswichian Interglacial (c. 130,000–110,000 BP). Furthermore, sediments from a bank structure situated to the west of Area 240 were dated to MIS 7/6 (Limpenny et al. 2011). Within Channel A, the Saalian sediments were further cut, probably at the onset of the Devensian (MIS 5d), with fine-grained infill sediments deposited in a brackish or estuarine environment. These sediments returned OSL dates of 109±11 ka (GL 10037) and 96±11 ka (GL 10041), both correlating to the Early-Devensian. Further features observed in Area 240 include slight depressions cutting into the Saalian floodplain deposits. These depressions are predominantly situated in the central and southern areas and are infilled with sediments of variable composition. Vibrocores indicate generally finer-grained deposits (clays and fine-grained sands) and suggest an outer estuarine or near coastal depositional environment. To the south, a sand-gravel infill is observed and appears to be deposited in a fluvioglacial environment of mid-Devensian (MIS 3) age (36±3 ka, GL 10044). This age of sediment was unexpected in this area with no previously documented sediments of similar date in the offshore region. OSL dating of vibrocores in the wider East Coast region, however, indicate that the upper fill deposits of channels have dates of similar MIS 3 age (Limpenny et al. 2011). The channel and floodplain system are thought to be the remnants of an extension of the onshore Yare Valley.

Channel B is shallow and meandering, situated in the north-western corner of the survey area and orientated north-east to south-west. This forms part of a larger feature, which is observed in regional datasets to flow southwards through adjacent aggregate areas and beyond. Channel-fill deposits are observed on the sub-bottom profiler data and a topographic trace of the channel is also observed on the bathymetric data. The topographic trace indicates a broad feature, approximately 1 km wide and up to 4 m high. Sub-bottom profiler data indicate that the infill sediments are up to 6.5 m thick and the vibrocore data indicate a fill sequence including peats and other organic sediments, which are indicative of low-energy deposition in a fluvial or marshland environment. The intertidal mudflat/saltmarsh sediments are observed between 32.06 m below OD and 31.57 m below OD. Radiocarbon dating for the bottom and top of this unit returned dates of 7,710–7,560 cal. BC (8,595 ± 35 BP, SUERC-32234) and 6,730–6,590 cal. BC (7,820 ± 30 BP, SUERC-32233). These are comparable to previous dating undertaken within the area. Independent dating of four peat samples from a vibrocore situated within Channel B deposits dates the peat between 10,140 ± 35 BP (10,040–9,660 cal. BC, SUERC-11978) and 8,355 ± 35 (7,530–7,330 cal. BC, SUERC-11975) (Hazell, pers. comm. 2010).

Based on the Early Mesolithic date of these sediments, Channel B may also be an offshore extension of the River Yare and the peats comparable to those of the Breydon Formation (Arthurton et al. 1994; Bellamy 1998). Onshore, the basal peat of the Breydon Formation dated to c. 7,580 ± 90 BP and is observed at 23 m below OD. Around 6 km offshore Great Yarmouth, clays of the Breydon Formation are observed at a depth of 27 m below OD. These are comparable depths to the Early Mesolithic peats and clays between 30–32 m below OD in Channel B. The basal peat of the Breydon Formation is overlain by the Lower Clay composed of soft silty clay which becomes firmer with depth (Arthurton et al. 1994), and which may be comparable with the thin unit of sandy, shelly clay observed overlying the peats in the vibrocores from Channel B. Although not directly associated with the flint and faunal remains the preservation of Mesolithic sediments are important as relatively few have been documented off the East Coast.

Seabed sampling in the area from which the handaxes were dredged led to the recovery of further flints and faunal remains (Tizzard et al. 2011). The flint tools and bone already recovered by aggregate dredging in Area 240 and the flint flakes recovered during these investigations indicate that the area is significant in terms of its artefact content and preservation conditions. The methodologies used within this sampling survey, which included clamshell grab sampling, 2 m beam trawling and visual inspection have shown that debitage from the production of flint tools and hand axes exist at least within the localised area. Continued investigation of this material has led to an updated interpretation of the ages of this material (cf. Tizzard et al. 2011). The prehistoric characterisation indicated that the flint and faunal remains are likely associated with three particular units/ages. A proportion of the older (fossilised) faunal remains are likely to have been dredged from the older shallow marine unit dating to > 500 ka. The hand axes and some of the flints dredged in 2007/2008 and the flint flakes sampled during this project are most likely associated with the deposits dated to the early Middle Paleolithic (Wolstonian, 350–200 ka). Some artefacts may have been deposited in the mid-Devensian, in the fills of shallow depressions dating to c. 30,000–40,000 BP. In these two latter cases, Area 240 would have been a cold outer estuary environment.

The investigations demonstrate that it is possible to relate unstratified archaeological material to submerged and buried landsurfaces that, although complex, can be examined in detail using a variety of fieldwork and analytical methods. This work has also confirmed the likely provenance of the assemblage (discovered by Mr. Meulmeester in 2007–2008) and the entire assemblage can now be related to particular deposits. Furthermore, this work provided a detailed, factual basis for discussions of future management of the potential effects of aggregate dredging on the marine historic environment. The importance of linking artefacts to specific sedimentary contexts is a critical step for bolstering confidence in the regional assessments of submerged prehistory potential in submerged locations. The assessment of importance of prehistoric remains is based upon the specific qualities of a given deposit or remains; however, the rarity of Paleolithic (and Mesolithic) remains in the UK and the critical information they provide on the colonisation of early hominins in the UK during the Pleistocene and Holocene (even if degraded and limited at a given location) means that such materials are considered of national (and potentially international) importance (English Heritage 1998).

Archaeological, Geoarchaeological and Natural Deposits: Questions and Considerations for Heritage Management

Firth (2004) outlined three thematic issues regarding the submerged prehistory of the North Sea region: terrestrial versus marine; natural versus cultural; and sites versus context. Since the 2003 conference on the submarine prehistory of the North Sea (Flemming 2004), considerable advances and discoveries have been made in the field of submerged prehistory. In the same volume, Bailey (2004, p. 7) outlined the justification for researching submerged prehistoric coastlines. Furthermore, and importantly, greater focus has been paid by respected terrestrial archaeologists now willing to work collaboratively with marine sciences, and it seems that more and more terrestrial prehistorians are open to looking offshore (see various contributions in Benjamin et al. 2011). The question then shifts to that posed by Maarlevald and Peeters (2004), ‘Can we manage?’ Or perhaps put slightly more optimistically, ‘How can we manage?’ As suggested by Firth’s (2004) themes in submarine archaeology there is both cultural and purely environmental significance that paleolandscape and paleolandsurface research lends directly to prehistoric archaeology. Simply put: are preserved paleoenvironments or -landsurfaces found in today’s submarine environments significant to archaeology, heritage management, oceanography and the earth sciences? From the perspective of the archaeologist, it is easy to say that when there are obvious cultural deposits and features with identifiable material that these deposits are significant. It follows that the absence of such archaeological markers might lead to the suggestion that whilst preserved paleolandscapes or -landsurfaces may exist in situ, they may not be relevant to archaeologists if they do not contain what we would traditionally refer to as an archaeological *site*. Nonetheless, there are some cases when the paleoenvironmental data inform archaeological theory and questions in ways that prehistorians simply cannot ignore; distinguishing the culturally significant from the purely environmental remains challenging. There are perhaps geoarchaeological questions (or answers) stemming from the study of landscapes, context and paleoenvironments. We must, therefore, take the opportunity to describe the importance of natural deposits that provide context for individual sites and/or the wider paleoenvironment/landscape. We must also take a realistic approach that not *all* submerged landsurfaces are necessarily significant to archaeologists or heritage managers who may have real-world decisions to make based on limited financial resources and the on-going desire for socio-economic benefit and human progress. Therefore, a great deal of care should be taken to assess the cultural significance of these preserved natural deposits.

There are a number of reasons for prehistoric landsurfaces and deposits to be subject to special measures if they fall within development (or extraction) areas for not only 'archaeological' reasons. The following section summarises a previous ALSF report by Wessex Archaeology for English Heritage (2008) on the presence and importance of submarine paleolandsurfaces and deposits. For over a century, antiquarians and archaeologists have recognised that layers of peat are the remains of the previous surface of the land, in which prehistoric objects and structures can be found. These peaty layers are made up of earlier vegetation that has been preserved by being waterlogged; the same conditions that have preserved vegetation have also caused other organic material to survive which leads to their status as important paleoenvironmental archives. Although prehistoric landsurfaces and deposits can be characterised, for example, as layers of peat, sedimentary facies relating to coastal, estuarine and delta formations and paleoriver gravels, the range of circumstances in which special (archaeological) interest can arise is very wide. Also, our knowledge and understanding of the processes that are involved is still poor on the small scale (i.e. up to tens of metres). Paleolandscape reconstructions have thus far been on necessarily large spatial scales (i.e. hundreds of square kilometres). Reconciling this with the potential scale of prehistoric sites (sometimes only a few square metres in total size) is a conceptual and practical issue that must be overcome if we are to work at, and understand, the archaeological scale. Where diver (human-scale) investigation can be used this issue is overcome (cf. various chapters in Benjamin et al. 2011). In the increasingly challenging working environments of deeper water (>30 m), we are currently restricted to remote sensing, ROV/AUV, and extrapolation of geotechnical and paleoenvironmental analyses. Therefore, all generalisations about the presence or absence of interesting prehistoric landsurfaces or deposits have to be treated cautiously and with consideration of the spatial (and temporal) scale at which they can be interpreted and synthesised with other archaeological researches.

The term 'landsurface' is used here intentionally, and is distinct from 'landscape' in the sense of 'submerged landscapes' to which they are often referred. Landscapes exist in the perceptions of their inhabitants; they are as much a cultural construction as physical. Archaeologists might, at some point, be able to infer now-submerged landscapes in the way that our predecessors might have perceived them. However, there are currently too many difficult variables to address in delineating former

Table 12.1 Factors that make prehistoric landsurfaces of special interest to archaeologists and cultural heritage managers

Factor	Relevance
Narrative	A prehistoric landsurface or deposit will be of special interest where it makes a distinct contribution to understanding overall historical processes relating to a region (or country), to the early prehistory of a larger region or continent, or to the global understanding of humanity's origins
Associations	Generally, historic assets have special interest where they present a distinct, tangible link to a person or event, especially known, named historical people and events. Prehistoric deposits are unlikely to generate such interest as although there is no doubt that the lives of our predecessors were punctuated by significant characters and episodes, they are now lost in time
Respect	Some prehistoric landsurfaces and deposits have been found with human remains directly associated with them. In some cases, there are burials. In other cases, relatively small fragments of apparently isolated bone—including bits of skull—have been found, the meaning of which is uncertain. The presence of large quantities of human remains in a prehistoric landsurface or deposit may generate special interest by virtue of the need for respect
Aesthetic	The scope for a prehistoric landsurface or deposit to give rise to aesthetic special interest is probably limited to circumstances where early art—such as a cave painting—is preserved. Monumental structures such as Seahenge (Pryor 2001) might also be regarded as having special interest in aesthetic terms
Current relevance	A prehistoric landsurface or deposit will be of special interest on account of its current relevance if it presents a direct parallel with a topic of public debate today. Specifically, direct evidence of the relation between human activity and environmental change—including sea-level change—is likely to give rise to special interest on account of its current relevance. Special interest will arise not only where there is clear evidence of people responding to environmental change, but also where prehistoric people can be seen to have caused or modified environmental change

(currently low-resolution) topographies and adorning them with flora and fauna, and such slight understanding of the behaviours of the people that lived there, that attempts to discern 'landscapes' at anything but very regional scales are likely to remain highly speculative for some time to come. In the meantime, reference is made here to 'landsurfaces' as the physical evidence upon which landscape interpretations might subsequently be built. Not all prehistoric landsurfaces and deposits that have special interest will need to be managed in situ. Many important prehistoric landsurfaces and deposits have been found in the course of development, and have been managed (often through recording and analysis) in such a way that development has been able to proceed without restriction through the application of mitigation strategies. For a prehistoric landsurface or deposit to be of special interest, the remains must be capable of making such a distinctive contribution to our understanding or awareness of people's actions or environment in the past that the remains themselves should be protected from unmitigated damage. In these terms, prehistoric landsurfaces can be important because of what they can say about the environment that people lived in at the time they formed (e.g. factors outlined in Table 12.1), about the people themselves when they lived on and around these surfaces and deposits, and about the circumstances and processes that caused them to become uninhabitable. The scope for high levels of preservation within fine-grained deposits means that in some cases, material that gives a detailed and direct insight into the activities of a single individual or a small group, millennia ago, will survive (e.g. the factors informing prioritisation outlined in Table 12.2). In many cases, however, the study of early prehistory involves looking at far broader aggregations of evidence, to pick up patterns that hint at processes that affect whole populations of hominins, or overall human development.

Discussion

The consideration and analysis of submerged prehistoric archaeology, landsurfaces and their conceptual landscapes should be standard practice within development-led archaeology and heritage management. Like researchers in the fields of prehistoric and marine archaeology, organisations like Wessex Archaeology rely on baseline data from various interdisciplinary sources, and also create and interpret new data—primarily marine geophysics and geotechnical—with reference to marine archaeology of all types and ages. When possible, development-led archaeology aims to disseminate the reports generated into the public domain, to be accessed by students, researchers and the general public. Whilst heritage management and research communities may feel segregated at times, there is an important role each plays in the field of submerged prehistory. The importance of heritage management and cooperation is noted in Flemming's (2004) volume *Submerged Prehistoric Archaeology of the North Sea: Research Priorities and Collaboration with Industry*. The subtitle can be interpreted to mean research cooperation (cf. Gaffney et al. 2007), but also includes day-to-day work on marine development activities such as sub-sea cables, offshore renewable energy, pipelines, etc.[2] In the UK, where development projects in coastal and marine environments are a major growth industry, particular attention is now paid to the assessment of impacts on cultural heritage, including submerged prehistory. Discoveries and advances will continue to come not only from academic institutions but also from the developing field of highly specialised practitioners who have access to data and new techniques that are being developed by various sectors working offshore.

In order to be able to improve confidence in smaller-scale development-led submerged prehistory assessments, the regional picture must ideally be in place first. MALSF research was able to show the regional potential but was not able to assess the site—Area 240 being an exception, linking sedimentary units to artefacts. Regional projects such as the NSPP and Humber REC showed development towards a focused analysis and ground-truthing, producing a relatively coherent 8,000-year-

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[2] For a discussion of development-led archaeology in the US see Faught, Chapter 3, and Pearson et al. Chapter 4.

Table 12.2 Prioritization and prehistoric landsurfaces

Factor	Rationale for prioritisation
Rarity	In principle, the absence of comparable landsurfaces or deposits will add to special interest on account of rarity. This will depend on the amount and quality of local knowledge in any given region or location. Thus, in the UK, as current knowledge of landsurfaces or deposits with direct artefactual evidence of prehistoric activity is currently limited; any such landsurface or deposit will be considered 'rare', at least for the time being. Equally, prehistoric structural remains are currently very rare, and will add considerably to the special interest of a landsurface or deposit
Representativity	The special interest of a landsurface or deposit is likely to be greater where it comprehensively represents the attributes from which the special interest arises, rather than a single facet. Representativity may be greater, for example, where a deposit covers an extensive stratigraphic sequence (i.e. potentially multiple phases 'landscape') rather than a single horizon, or where a surface encompasses a range of topographies
Diversity	Prehistoric landsurfaces and deposits have formed in a range of environmental circumstances. Even comparable, contemporary environments may have been inhabited in different ways depending on the cultural disposition of the people at the time
Potential	The special interest of a prehistoric landsurface or deposit will be enhanced where there is demonstrable potential for yet greater interest to develop. Potential may arise in respect of greater understanding through investigation and research, or for greater awareness and appreciation where the surface/deposit lends itself to wider access. Potential may arise from paleoenvironmental indicators, artefactual assemblages or even structural material that is exposed or can be reasonably assumed to be buried
Survival	The special interest of a prehistoric landsurface or deposit will be affected by the degree to which the physical remains have survived, gauged in terms of completeness. A surface or deposit is likely to be of greater special interest where its sequence or extent is complete, rather than fragmentary or interrupted
Documentation	The special interest of a prehistoric landsurface or deposit may be increased by the availability of documents, map, images, oral testimony or other evidence that enhances understanding or appreciation of the asset
Grouping	The special interest of a prehistoric landsurface or deposit may be greater where several surfaces/deposits are grouped together. Grouping is likely to add to special interest where the individual assets, taken collectively, enable greater understanding or appreciation of a range of environments, activities or types of inhabitation, or provide a chronological sequence, for example
Setting and context	The special interest of a prehistoric surface or deposit may be increased by its situation in a place that adds to its understanding or appreciation
Associated collections	The special interest of a prehistoric landsurface or deposit may be increased by the presence of an associated collection of artefacts in a museum or other archive. An associated collection may have been recovered from the surface/deposit in the course of previous investigations or activity, by trawling, or by antiquarian collecting at the coast, for example. Where the collection has accrued indirectly, care will be needed to establish the degree of association between the collection and the surface/deposit

old paleolandscape but the spatial limitations of offshore sampling strategies mean that the human smaller-scale is still obscure. Ideally, archaeologists would have greater control over sampling locations in order to produce feasible research questions which are not necessarily appropriate for development-led mitigation strategies. Indeed, collaboration is advisable when the particular juxtaposing goals of development-led archaeology and academic-led research are compared. Development-led mitigation is based around the tenet of reasonable and cost-effective mitigation where practicable, whilst academic studies are focussed around particular research questions and sets of objectives for the purpose of advancing scientific knowledge. Clearly the spatial distribution of development-led archaeology in licence areas across the UK territorial waters has considerable potential for advancing our knowledge of submerged prehistory. Important industry-led initiatives such as the Marine Aggregates Regional Environmental Assessments (MAREA) have provided detailed integrated baseline data gathering and environmental impact assessment for the aggregates dredging associations at a regional scale.[3] The ability of development-led mitigation strategies to fully examine particular questions is, however, tempered by important economic and practical factors.

Collaboration has an obvious role here. For example, COWRIE Guidance for offshore development now includes the recovery of duplicate geotechnical cores, with one set of cores purely for archaeological purposes (Gribble and Leather 2011). Various factors including time and cost limit the scope to which these cores can be analysed within development-led projects. The cost for academic research projects to recover the same offshore core samples would be prohibitive except for large, well-funded projects. Standardised or regular collaboration with universities or institutions such as the British Geological Survey on the analysis of these cores to extract detailed paleoenvironmental and paleogeographical datasets focused upon particular research goals (e.g. IPCC or national and/or regional research priorities and frameworks) would provide a considerable and cumulative resource that could be undertaken over the course of a PhD or research project as well as providing training and skills for the next generation of offshore specialists in geoarchaeology, paleoecology and geosciences. Further benefits include more cost-effective access to laboratory instruments and equipment, shared technical experience of technicians and researchers (in both commercial companies, universities and other institutions) and wider sources of additional funding in addition to the contributions from coastal and offshore developers required by curators.

An often-discussed factor that limits the dissemination of development-led research is moratorium periods, due to commercial sensitivity, on the release of project-specific information. The length of a collaborative research project would occupy much of a moratorium period (in addition to the analysis, compilation of research papers and relatively lengthy publication times of major journals). For all parties, including developers, this kind of collaboration would provide considerable *added value* at national and international levels whilst defining more clearly

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[3] http://www.marine-aggregate-rea.info/.

the archaeological importance of offshore deposits and therefore the most suitable strategies for cultural heritage management and sustainable development.

Examining offshore paleolandsurfaces is challenging and can be expensive. Collaboration may have considerable benefits. A further challenge is the integration of terrestrial and intertidal prehistoric archaeology to the understanding of offshore-submerged prehistory in a continuum. In areas where submerged prehistory may be restricted to a relatively narrow coastal shelf (as is the case for much of Scotland), intertidal archaeology may be directly linked to submerged sites. In these cases, smaller-scale, near-shore surveys may be much more feasible for the prospection of submerged sites.

Conclusion

Reconstructing paleoenvironments through the identification of submerged terrestrial landsurfaces will enhance the archaeological record indirectly by providing context for existing sites—including those now coastal sites that were once hinterland locations. Such knowledge of existing paleolandsurfaces also provides direct information for the potential for archaeological material to be discovered—i.e. direct evidence of prehistoric human occupation on the now submerged continental shelf. However, management of submerged landsurfaces (or landscapes) will require greater understanding if we are to effectively establish archaeological significance. Until such a level of comprehension is established, a precautionary approach is advisable. Due to the increased financial and research resources that would have to be assigned to investigate the archaeological value/importance/significance of a given area of sub-seabed this may conflict with real-world issues of socio-economic benefit and offshore development. In such cases, offsetting mitigation, such as that provided to archaeologists through the MALSF, can be seen as an effective corpus of case studies whereby economic benefit is maximised and scientific progress is also made. Given the variety of techniques that can be used to explore continental shelves from around the world (cf. Benjamin et al. 2011), we should encourage our partners in industry to develop a similarly proactive approach to offshore development such as those presented through the Area 240 case study. This will not only provide a positive contribution for heritage and science, but can also be considered economically sensible from the perspective of developers who often seek to find added value through public relations and community engagement.

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Chapter 13
Recent Developments in African Offshore Prehistoric Archaeological Research, with an Emphasis on South Africa

Bruno Werz, Hayley Cawthra and John Compton

African Coastal and Sub-Sea Prehistoric Archaeology

Offshore, submarine, undersea or sub-sea prehistoric archaeology represents a relatively unexplored and small part of marine and maritime archaeology since these specialisations started to develop during the second half of the last century. With the emphasis mostly on historical shipwrecks and their contents, very little attention was paid to other types of submerged finds, and certainly not those dating to prehistoric times. This is especially the case in Africa (Werz 1999, 2007). This lack of interest stands in stark contrast to that shown for terrestrial coastal archaeology, as evidenced by the substantial number of projects that have been undertaken here over the years, and in particular in South Africa.[1] South African coastal archaeology

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[1] See for example Avery 1975; Avery 1987; Avery et al. 1997, 2008; Bartram and Marean 1999; Berger and Parkington 1995; Brink and Deacon 1982; Cohen et al. 1992; Deacon et al. 1986; Grine 1998; Grine et al. 2000; Henshilwood 2008; Henshilwood et al. 1994; Hewitt 1921; Horwitz et al. 1991; Jerardino 1998, 2007; Klein 1975; Lombard 2007; Marean et al. 2007; Parkington et al. 1987, 2009; Poggenpoel and Robertshaw 1981; Schwarcz and Rink 2000; Singer and Wymer 1982; Smith 1993; Smith et al. 1992; Thackeray 1988; Thompson and Marean 2008; Van Andel 1989; Van Noten 1974; Volman 1978; Wilson 1996.

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is important as several caves and rock shelters are present along the country's west and south coast containing deposits dating from the late Middle Pleistocene to the Holocene. Over the years, these have provided many geological, archaeological and paleoenvironmental data sets that assist in a better understanding of the development of modern humans (Deacon and Lancaster 1988; Fisher et al. 2010; Grine 1998; Henshilwood et al. 2002, 2004; Marean et al. 2004, 2007; Rightmere et al. 2006). Nevertheless, the thought that the offshore region may also contain traces of the prehistoric past was entertained by few. This view only changed relatively recently, when evidence emerged that proves that submerged prehistoric material of considerable age can survive multiple marine transgressions.

The Oldest Prehistoric Finds from Under the Sea

During the late 1980s, two shipwrecks were discovered by amateur divers in Table Bay near Cape Town, South Africa. The wrecks were identified as those of the Dutch East India Company (VOC) ships *Oosterland* and *Waddinxveen* that sank in close proximity of each other on Friday 24 May 1697 CE. A maritime archaeological project followed during the period 1990–1996 (Werz 1992, 1993, 1999, 2009). During fieldwork, the stratigraphy of sediments underlying and surrounding the wrecks was recorded. This included excavating test holes, one of which was sunk 3.5 m deep into the seabed at a water depth of 7–8 m and about 150 m seawards from the high-water mark on the wreck site of the *Waddinxveen*. At the bottom of this test hole and immediately overlaying Malmesbury Group metasediment bedrock was a compact layer of red-brown sand. This distinct layer was some distance below and isolated from the layers containing shipwreck material. Upon excavating this approximately 0.20 m thick layer that was later identified as an old land surface or paleosol, an Acheulean hand axe was found *in situ* by one of the authors (Bruno Werz), together with some fossilized bone in breccias cemented to the bedrock (Fig. 13.1). The hand axe, accessioned as WV 95-2-4/TH3, measures 201 × 116 mm, with a thickness of 55 mm, and weighs 1,104 g. It was made from a flat quartzite cobble and still has some traces of cortex on the back. The artefact shows no signs of wind or water abrasion and has extremely sharp edges, indicating that it was deposited soon after use at the location where it was found (Werz 1999, 2009; Werz and Flemming 2001).

Some other similar finds were excavated in the period following, also at a water depth of 7–8 m (Fig. 13.2). They consist of another Acheulean hand axe and a bifacial hand axe-like artefact, together with some smaller lithic fragments. The second hand axe was found 280 m from the high-water mark close to the wreck of the *Oosterland*, which is situated some 750 m north of the wreck of the *Waddinxveen*. It was accessioned as OS 95-3-13/11-12S and measures 205 × 101 mm, with a thickness of 52 mm and a weight of 856 g. This hand axe is smoother and more regular in appearance than WV 95-2-4/TH3. The bifacial tool found 200 m offshore also near the wreck of the *Oosterland* is probably an unfinished hand axe and measures 193 × 124 mm, with a thickness of 54 mm and a weight of 997 g. This artefact,

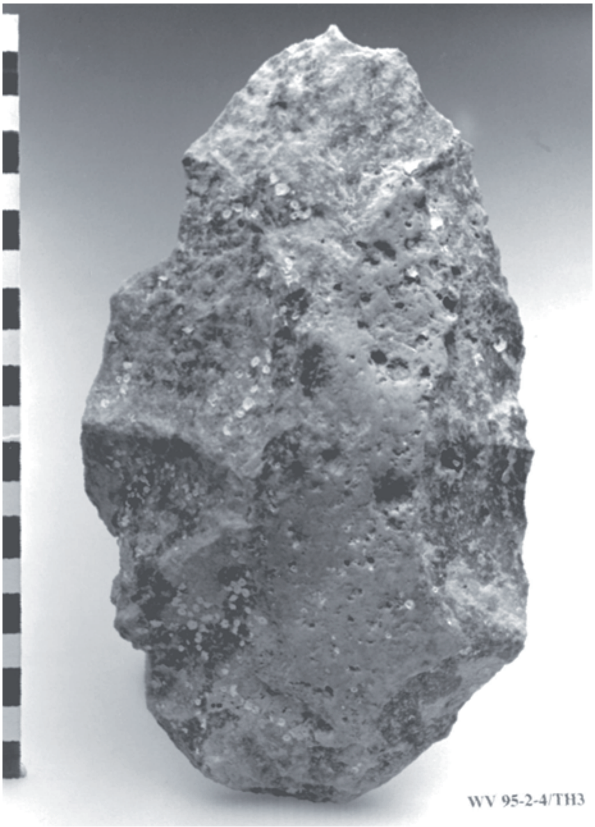

Fig. 13.1 The Acheulean hand axe that was found *in situ* near the wreck site of the *Waddinxveen*. (Photo by Bruno Werz)

which was recorded as OS 96-4-29/PDP 33SE, is made of a large quartzite flake that has been worked on both sides. It is less regular than the two hand axes, possibly due to its unfinished stage, and still shows some cortex on one side (Fig. 13.3). Both finds from the *Oosterland* site were recovered from deposits approximately 1 m thick containing stone, varying in size from pebbles (4–64 mm) to boulders (>255 mm). This layer was overlain by a deposit of pale-yellow coarse sand that was in excess of 2 m thickness at places (Werz and Flemming 2001).

Dating of the implements was based on typology, indicating their approximate age as between 300,000 and 1.4–1.5 million years. The fact that they were produced from locally occurring quartzite, which is visually indistinguishable from the ubiquitous Table Mountain sandstone, confirms their regional origin. Both the hand axe and the hand axe-like tool that were found in the gravel deposit show relatively sharp edges, with limited signs of sand or water abrasion. This confirms that the implements were deposited at approximately the same location and not transported over significant distances. Local circumstances that explain why these finds were preserved in such a pristine condition include: a combination of their rapid burial by beach and aeolian sediments, the low seabed gradient, as well as constructive

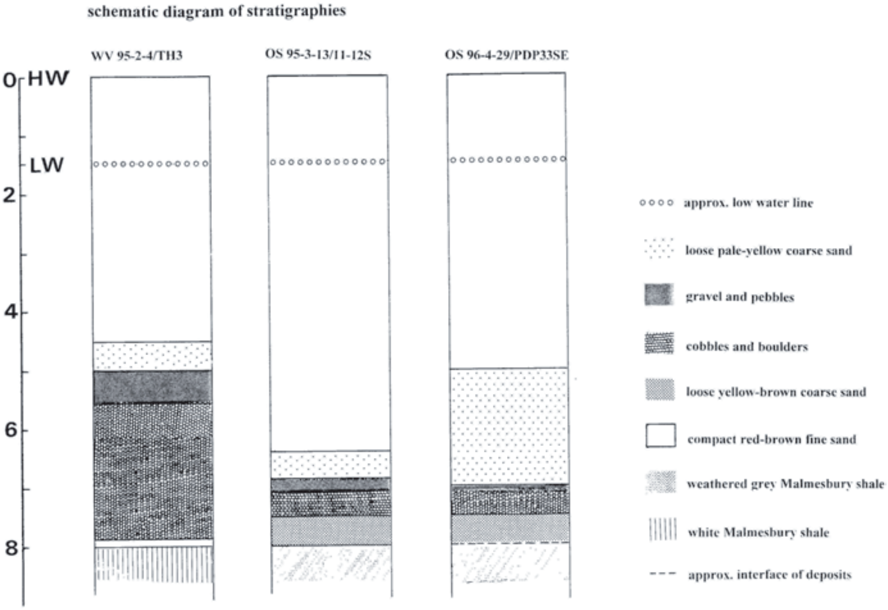

Fig. 13.2 Stratigraphies on the locations where the Acheulean tools were found. (Werz and Flemming 2001, p. 185)

wave action. The location where the finds were made is well protected from dominant swells and the most common winds, while the beach gradient is approximately 1/400. This contributed in a positive way to their preservation when the hand axes were most likely to be exposed at the waterline. The moderate wave action on the sea floor, as well as additional sediment input from adjacent rivers contributed to the further build up of protective sediments (Werz and Flemming 2001).

One of the important aspects of this discovery is that it proves that prehistoric material can be found in and survive *in situ* under the sea. The finds from Table Bay have further confirmed that this even relates to Early Stone Age (ESA) artefacts, which must have witnessed several marine transgressions and regressions over many millennia. In fact, these Acheulean tools represent the oldest artefacts ever found under the sea in the world (Flemming 1998). Realizing this, a research programme was started in 2002, now guided by the African Institute for Marine and Underwater Research, Exploration and Education (AIMURE), which aims at locating, identifying and studying prehistoric sites underwater around the coasts of southern Africa. As part of this programme, known as Operation 'Zembe' or 'axe' in the local Nguni languages, offshore searches are undertaken at designated areas that have been earmarked as promising find locations, based on the study of the adjacent landscape and local bathymetry. Searches are undertaken at depths between 0 and −50 m by members of AIMURE's Dive Unit, whereas survey data have been supplied by the Hydrographic Office of the South African Navy. Operation 'Zembe' is thus a logical progression from the various coastal archaeology projects already referred to.

Fig. 13.3 The three Acheulean stone tools from Table Bay (from *left* to *right*): OS 95-3-13/11-12S and OS 96-4-29/PDP33 SE, *below*, the first find: WV 95-2-4/TH3. (Werz 2009, p. 112)

The Significance of the Continental Shelf to Archaeology

There is a rich archaeological record of human evolution in Africa spanning millions of years. Of particular interest is the last 1 million years when the genus *Homo* underwent many changes leading up to the emergence of modern humans. One possible driving force in this evolution is climate change. Earth experienced major fluctuations in climate over the last million years, alternating between cold glacial periods and relatively warm interglacial periods such as today. The changes in climate may have resulted in large fluctuations in rainfall and vegetation to which early humans had to adapt. Contraction and isolation of environments in which humans could live may have separated human populations for long enough periods of time (tens of thousands of years) to allow divergent populations to develop (Lahr and Foley 1998; Basell 2008). These large scale glacial to interglacial climate fluctuations resulted in the buildup of continental ice sheets in the northern hemisphere and the removal of water from ocean basins as ice lowered sea level by as much as 120 m during glacial maxima (Clarke et al. 2009). The lowering of sea level exposed areas of the present-day submerged shelf. The extent to which the coastal plain expands with lowering of sea level depends on the offshore bathymetry. Where the shallow shelf is expansive, the coastal plain is much enlarged and therefore provided newly exposed terrain for animals and humans to occupy. The continental margin surrounding Africa has several areas with expansive shelf areas onto which animals and humans may have moved to during glacial periods (Fig. 13.4). Two of these areas, the shelf off North Africa and that off South Africa are of particular interest because they are adjacent to coastal cave sites having rich archaeological records which document some of the earliest evidence of modern human behaviour (Henshilwood et al. 2002; Hublin 2001; Marean et al. 2007). In addition, both of these expanded shelf areas are bounded by interior barriers: the Atlas Mountains and Sahara Desert in the case of North Africa, and the Cape Fold Belt in the case of South Africa. These mountain and desert barriers limited the movement out of the coastal plain at the end of glacial periods (glacial terminations) when the ice sheets melted and sea level rose rapidly to flood the coastal plains.

It has been proposed that some events in human evolution may correspond to the periodic isolation of groups on the coastal plain of South Africa as it expanded and contracted in response to the large amplitude (120 m) variations in sea level and climate over glacial–interglacial cycles (Compton 2011). The southern coastal plain of South Africa expands five-fold during glacial maxima (Fig. 13.5) and may have served as a refuge for animals as the interior became increasingly arid (Mitchell 1990; Morris 2002; Marean 2010). The expansive glacial coastal plain rapidly contracts by as much as one-third in 300 years as sea level rises during glacial terminations. Rapid flooding may have increased population density on the contracted coastal plain and increased selection pressures for expanded diets to include marine resources and the hunting of large animals. Groups isolated by climate during glacial periods and by the Cape Fold Belt during interglacial periods for up to tens of thousands of years may have diverged from populations elsewhere on the African continent (Compton 2011).

For most of the past 1 million years, sea level has been lower than today, and if the exposed shelf did serve as a refuge for humans living in southern Africa during glacial periods then much of the relevant archaeological record is currently submerged offshore. Although it is generally acknowledged that the now submerged shelf may have been an important area occupied by humans during glacial periods, the shelf remains poorly documented in terms of bathymetry, geological substrates and other features useful in understanding these paleolandscapes during periods of exposure. In the case of North Africa, the large coastal plain off Tunisia on the Mediterranean Coast would be a key area to explore, with preservation enhanced by the relatively low energy waves of the Mediterranean in comparison to Atlantic Ocean waves off the Moroccan Coast. In the case of South Africa, the greatest coastal plain expansion occurs on the Agulhas Bank offshore of the rich Middle Stone Age (MSA) sites at Blombos Cave (Henshilwood et al. 2002) and Pinnacle Point (Marean et al. 2007). The observation that coastal caves near present-day

Fig. 13.4 Elevation of the African continent and surrounding ocean basins showing the southern African plateau, shelf area (shaded in *white*) exposed during glacial maxima (−120 m) and the location of key archaeological sites. (ngdc.noaa.gov)

sea level rarely preserve archaeological material has discouraged most people from exploring offshore. Offshore exploration is expensive and requires geophysical expertise and has perhaps appeared not worth pursuing given the unlikelihood that archaeological material could survive a single, let alone multiple strand line migration with the high-energy waves typical of the South African coast. Nevertheless, there are two important reasons for developing offshore exploration. The first is to better document the environments at the time when the shelf was exposed in order to understand how humans inhabited and interacted with emergent glacial period landscapes. The second reason is that the offshore potential for archaeological material will only be known after the shelf has been explored and sampled.

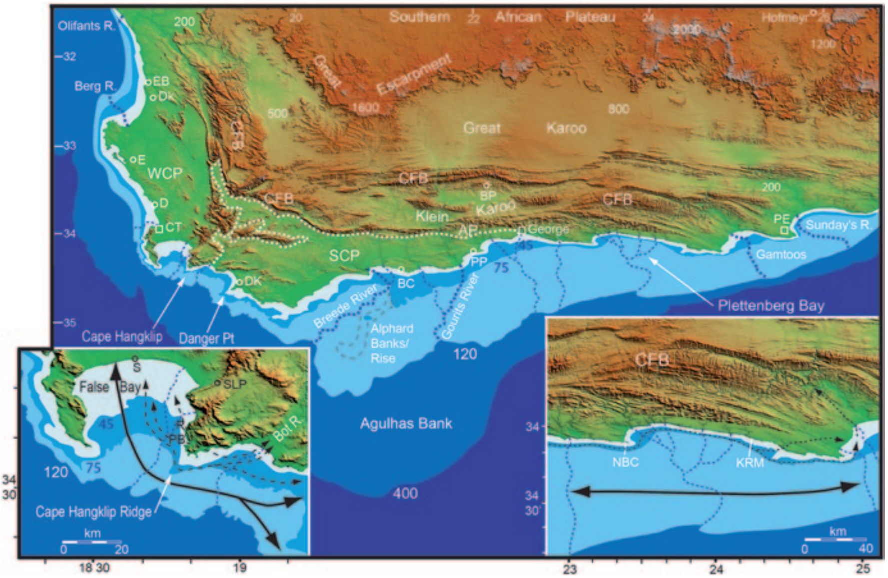

Fig. 13.5 Bathymetry (45, 75, 120 and 400 m contours; Van Andel 1989) and topography of southern Africa (*numbers* represent spot elevations) showing the extent (dashed *line*) of the southern coastal plain (*SCP*) separated from the interior and from the western coastal plain (*WCP*) by the Cape Fold Belt (*CFB*) mountains. The Cape Hangklip and Plettenberg Bay portals are enlarged to show possible migratory pathways during glacial lowerings of sea level. Key fossil and archeological sites indicated are: Blombos Cave (*BC*), Bloomplaas (*BP*), Die Kelders (*DK*), Diepkloof (*Dk*), Duinefontein (*D*), Elandsfontein (*E*), Elands Bay (*EB*), Klasies River main (*KRM*), Nelson's Bay Cave (*NBC*), Peers Cave (*PC*), Pinnacle Point (*PP*), and Swartklip (*S*). Also shown are: Sir Lowry's Pass (*SLP*), Attaquas Pass (*AP*), Pringle Bay (*PB*), Rooielsbaai (*R*) and the cities of Cape Town (*CT*), George and Port Elizabeth (*PE*). (Map by John Compton)

Developing a Strategy for Offshore Exploration

In walking over the landscape of the present-day coastal plain, it is not difficult to find scattered on the surface stone artefacts ranging from ESA hand axes to MSA and Late Stone Age (LSA) lithic fragments. These artefacts are not everywhere on the landscape and the limited number of studies to date suggest they tend to be focused within certain environments, especially those near bodies of water or along the coastal shore zone (Kandel et al. 2003; Compton and Franceschini 2005). Artefacts are also more commonly observed on non-depositional to erosional surfaces upon which artefacts can accumulate. Marginal to non-depositional surfaces have thin sediment covers susceptible to surface exposure and weathering as well as mixing by animal activity (bioturbation) such as burrowing moles. For example, the large Cape dune mole rat (*Bathyergus suillus*) is common on the coastal plain and a prodigious digger, constantly turning over the soil and bringing rocks including stone artefacts to the surface. These scattered and reworked lithics are not as easily interpreted as *in situ* stratified deposits of caves and some open air sites, but they do provide valuable information on how humans inhabited the landscape. Archaeological studies which include scattered artefacts on the broader landscape are rare in comparison with cave and open air sites, but they provide insights from which an offshore exploration strategy can be developed.

The amount of recent, Holocene sediment deposition on the continental shelf is highly variable and can be up to tens of metres thick, for example, in areas near river mouths with thick sand accumulation near the coast or mud accumulation further offshore in the inner-to-middle shelf transition, at water depths of 80 to 140 m (Birch 1980). Offshore areas with significant sediment deposition would make them off limits for exploration because, although the sediment may bury and preserve artefacts resting on the Pleistocene flooded surface, the required removal of the overlying sediment would make recovery of these artefacts impractical. The South African western and southern margins are largely starved of sediment or are too energy dispersive to allow for fine-grained sediment (mud) accumulation and, as a result, large areas of the shelf seafloor have relict, erosional or non-depositional surfaces (Birch 1980). These surfaces commonly have a thin gravel or sand layer resting directly on bedrock. It is from these erosional surfaces, as well as the overlying sediment drape, that Pleistocene age material including artefacts may be recovered if present. The large areas of the shelf which are erosional or non-depositional can be further selected for features that are similar to those identified from onshore studies and suggest that human occupation is more likely to have occurred. Possible target features on the shelf may include river channels and their banks, local depressions that may have served as lakes or water holes, and local highs or resistant ridges which may have provided rock shelters or strategic lookouts. The other region of the shelf predicted by the sea-level hypothesis to have more likely focused animal and human occupation would be the portals on either end of the Cape Fold Belt barrier connecting the Southern Coastal Plain to the western and eastern coastal plains, as well as in the vicinity of the highstand position of major perennial river systems where animal and human populations may have been focused during flooding of the coastal plain at glacial terminations (Compton 2011).

One of the key data sets for understanding offshore glacial landscapes is bathymetry. Because sediment deposition since sea level has flooded the shelf has been relatively minor and localized in this region, the offshore bathymetry is a generally good indication of the exposed topography during lowstands. The bathymetry combined with seismic stratigraphy can clearly define paleoriver channels and local depressions most likely to have been wetland environments favourable to human occupation. Large dune cordons now submerged can also be delineated by high resolution bathymetry. Vegetation and soils are largely obliterated by sea level as it floods the coastal plain, but the geological bedrock exposed at or near the surface can provide a useful guide to the type of soils and vegetation biomes that most likely existed at times of exposure by analogy to the onshore, where the bedrock geology has a strong influence on the distribution of vegetation biomes (Mucina and Rutherford 2006).

Based on the observation that most caves near present-day sea level (<3 m elevation) have been washed out, it is unlikely that in-place cave deposits will be preserved in currently submerged offshore caves. Exceptions may occur where the orientation of the cave opening is opposite to the incoming wave energy, or where cave deposits have become cemented in place prior to inundation by the sea or sealed by cemented dune deposits. For example, caves located near sea level at De Hoop Nature Reserve have calcite-cemented fill deposits preserved as conglomerate attached to the cave walls, and temporary sealing of cave entrances by aeolian dune sand is documented at some Pinnacle Point sites (Marean et al. 2007). Outside of these rare preservational settings, the majority of cave-fill deposits and open-air sites are predicted to be extensively reworked and redistributed by migration of the high-energy strandline over the coastal plain as it flooded. The flooding of the glacial coastal plain occurred rapidly during deglaciation with sea level rising from −120 to −80 m within 5,000 years and thereby limiting the time available for the destruction of artefacts in the high-energy surf zone. The most likely artefacts to be preserved after passing through the migrating strandline are stone artefacts made of hard, resistant quartz sandstone, quartzite, silcrete or vein quartz. Many quartz artefacts may survive the surf zone, although sharp edges may be rounded and surfaces dulled by abrasion. For example, a study in the Elands Bay area near present-day sea level on the West Coast found a mixture of older, waterworn and fresh stone artefacts (Orton and Compton 2006). Although somewhat blurred, the morphology and features of the waterworn artefacts could still be clearly identified. Therefore, although reworked and redistributed by wave action as the strandline migrated over the landscape, the recovery of stone artefacts from the shelf would provide direct evidence of human occupation during glacial lowstands and allow comparison of the relative abundance and type of stone artefacts from onshore deposits**.**

Preservation potential of artefacts is predicted to be greatest at previously exposed glacial shelf sites which were most rapidly flooded and which are dominated by sandy sediments, as opposed to areas exposed to abrasive wave action over longer periods of time along rocky gravel shores. In general, shelf sites accessible by scuba diving using air (up to −50 m) are within rocky substrates with relatively long periods of high-energy wave abrasion and are more likely than deeper water sites to have had stone artefacts destroyed. Therefore, if artefacts are recoverable from near-shore dive sites then it would suggest that sites further offshore should have good potential for stone artefact recovery. Recovery of bottom sediment at water depths of the middle-to-outer shelf between −80 and −120 m would require submersible or shipboard sampling by coring or dredging.

Offshore Prehistoric Archaeological Potential of the South African Coastal Plain

As recently as 27,000–18,000 years ago during the Last Glacial Maximum, when the northern hemisphere ice sheets were at their maximum extent and sea level was 120 m lower than today, the waters of False Bay had receded to expose an extensive valley (Fig. 13.5). The steep and rugged Cape Fold Belt whose mountains today

Fig. 13.6 AIMURE diver exploring an overhang in False Bay as part of Operation '*Zembe*'. (Photo by Bruno Werz)

form a barrier to movement between the western and southern coastal plains fell away and the False Bay Valley merged with the Bot River Valley to the east allowing for the movement of animals on a much expanded and interconnected coastal plain (Compton 2011). The only obstruction to movement was the Hangklip Ridge, a resistant sandstone rocky ridge with escarpments of 1 to 10 m that extends in a south-westerly direction from Cape Hangklip (Rogers 1985; Van Andel 1989). The fossil record indicates that there were large migratory herds of wildebeest and springbok on the coastal plain of southern Africa not present in historical times. Drying out of the continental interior during glacial periods may have compelled animals and humans to move onto the expanded coastal plain as a refuge. There are several key MSA archaeological sites along the southern and western coast with some of the earliest records of modern humans adapting a marine diet (Marean et al. 2007) and making symbolic items such as shell jewellery and engraved ochre and ostrich eggshell (Henshilwood et al. 2004; Texier et al. 2010). But our understanding of the coastal plain habitat is hindered by the fact that sea level has only been as high as it is today for around 5 % of the last 900,000 years. This means that much, if not most, of the occupied coastal plain of South Africa is now out of reach, with all the potential archaeological and fossil records submerged on the shelf. Submerged bedrock overhangs are known in False Bay (Fig. 13.6), and these may have been occupied by humans during glacial periods when False Bay was exposed by lowered sea levels. To date, the shelf has received little study which reflects the difficulties and expense of doing submarine geology and archaeology, as well as the general belief that high-energy waves would have likely destroyed whatever records may exist offshore.

Offshore Cape Hangklip, the southeast perimeter of False Bay, has been selected as an initial dive site to document the underwater features of the area, as well as to assess the potential of recovering stone artefacts. Cape Hangklip was selected in part because the Hangklip Ridge, a resistant quartz sandstone submarine ridge, extends offshore southwest of Cape Hangklip. The Hangklip Ridge may have provided rock shelters, which are not resolved by the available bathymetry and difficult to observe by remote sensing methods, such as side scan sonar. Divers will be able to explore any cave and overhang sites along the ridge and collect samples of sediment from within and adjacent to the cave or overhang features. Onshore Cape Hangklip has archaeological sites that have yielded stone hand axes of the ESA and Still Bay points of the MSA within 30 m elevation of present-day sea level (Gatehouse 1955). The bathymetry of False Bay and to the east offshore of the Bot River Valley shows that Cape Hangklip was a potentially key lowstand site for human occupation, as it is situated at the junction of what would have been the False Bay Valley and Bot River Valley. These valleys were exposed during glacial maxima and together formed a major conduit for animal migration between the western and southern coastal plains. The Hangklip Ridge sits strategically at the top of this narrow valley portal connecting the western and southern coastal plains (see Fig. 13.5). Diving on the Hangklip Ridge is a collaborative project and involves the University of Cape Town, the Marine Unit of the Council for Geoscience, and the AIMURE. In addition to Cape Hangklip, other possible future dive sites on the shelf include the Alphard Banks, a submarine hill rising above the extensive and relatively flat surrounding coastal plain when exposed during a glacial maximum. The strategic position of an elevated hill may have attracted humans to it for observing the landscape, in search of game animals, for example.

Scuba diving is useful in documenting details of the shelf, such as the composition of bottom sediment and the nature of rocky ridges. The limitation to diving is the time available to make observations, the visibility of waters during diving and the water depths accessible to divers (Fig. 13.7). The preservation potential in rocky shore environments such as Hangklip Ridge appears to be very low owing to the high wave energy and presence of quartzite gravel. The continual movement of hard, quartz gravel over quartzite bedrock surfaces by the high-energy surf makes preservation of any stone artefacts highly unlikely. Sea level reached the working limit of scuba diving on air from −35 to −40 m by 12,000 years ago, and since then the bottom sediment has been influenced by storm base wave energy to −40 m water depth, making the inner shelf in areas with rocky substrates highly abrasive and unlikely to preserve artefacts. The more likely areas where artefacts may be preserved are the middle and outer shelf with low gradients and few rocky substrates and where the strandline migrated quickly over the terrain as it was flooded. At these greater water depths of between −80 and −120 m, the challenge will be in finding scattered and reworked artefacts partially buried by more recent muddy sand deposits.

Geophysical Surveys

Besides the work that is currently being undertaken in the Cape Town area, a start has been made with offshore data collecting for a major coastal archaeology project at Pinnacle Point near Mossel Bay on the Cape South Coast. One of the authors (Hayley Cawthra) is currently doing offshore remote sensing of the sea bed in an area

Fig. 13.7 Searches for prehistoric material on the sea bed are not only hampered by limited dive times, depth restrictions or bad visibility. The abundance of sea life around the Cape coast, such as virtual forests of giant sea bamboo (*Ecklonia maxima*) and a variety of bottom dwellers, often obscure any artefacts that may be present. (Photo by Bruno Werz)

bordering on a series of coastal caves. These caves at Pinnacle Point, as those at Die Kelders, Blombos and others, have provided some of the earliest evidence of modern human behaviour. The genetic and fossil record suggests that biologically modern humans first appear at about 200,000 years ago (McBrearty and Brooks 2000; Gibbons 2007). Major outstanding questions from this time period concern the driving forces and timing of modern cognition and behavioural modernity. During much of this period, Earth's climate was colder than at present with sea levels falling as much as 130 m below present datum (Waelbroeck et al. 2002). As a result, a substantial coastal plain on the shallow Agulhas Bank off the southern Cape coast was exposed, as was explained above. The implications of this exposed landscape have been documented by Van Andel (1989), Fisher et al. (2010), Jerardino and Marean (2010) and Compton (2011), as the shoreline migrated rapidly in response to sea-level fluctuations. Interest has been initiated in coastlines and marine resources as a potentially significant factor influencing the dispersal of modern humans, as submerged coastal landscapes are recognised to be important as refugia for animal and human populations (Bailey et al. 2007; Bailey and Flemming 2008; Compton 2011).

A pressing question, therefore, is the nature of this environment; how it fluctuated through time and how it may have influenced human occupation. It is with the recent archaeological results from the Pinnacle Point site (Marean et al. 2007; Brown et al. 2009; Marean 2010) and the obvious need to extend the research offshore, that geological and geophysical interest in the southern Cape has been initiated. The acquisition of offshore geophysical data, when allied with geological modelling, presents a unique opportunity to complement the large onshore body of knowledge concerning human origins, and how this links with fluctuations in past ecosystems. A multidisciplinary program to understand the palaeoenvironment as early humans occupied the area includes a large marine geoscience programme, aimed at investigating the marine geology of the continental shelf in the vicinity of the coastal caves. The aim of this pending work is to conduct marine geophysical and sampling surveys using the most advanced current technologies available, and consequently to develop a high-resolution geophysical, geomorphic or palaeoenvironmental database for a sector of the shelf off Mossel Bay as an initial locality. High-resolution shallow seismic, surficial geophysical and hydrographic surveys are being undertaken. The data collected in this way will be integrated with geological modelling to reconstruct past ecosystems, with a focus on critical climate or sea-level intervals associated with important events in human evolution. Examples of these are the earliest as yet recorded use of marine resources ~ 164,000 years ago at Pinnacle Point (Marean et al. 2007), and the appearance of symbolic artefacts and innovative stone tools throughout southern Africa ~ 60,000–70,000 years ago (Henshilwood et al. 2002, 2004), suggesting modern human behaviour. The results of the study will be integrated with onshore data from key archaeological sites on the Cape South Coast, including Pinnacle Point, Blombos and Nelson Bay Cave, to generate more holistic models of changing ecosystems and their influence on human evolution. The well-known close correlation between plant biomes and the underlying geology implies that geological modelling will provide direct insight into the floral and faunal resources available for humans occupying the shelf. These models will be integrated with the hard offshore palaeodata and existing onshore information to create a holistic picture of fluctuating ecosystems through time, which can be correlated to known developments in human behaviour.

Multibeam Bathymetry

Multibeam bathymetry provides a high-resolution digital elevation model of the surveyed seafloor. The bathymetric data are used to define relief of submerged reef complexes and provide insight into the gradient of the continental shelf. Acquisition of sonar swath bathymetry using a multibeam echosounder encompasses the principle of a three-dimensional fan shape of acoustic energy, subjected to pitch, roll, yaw and vessel oscillation (Parkinson 2001). The array transmits pulses triggered at known intervals to insonify an area of seafloor normal to the ship's track. High-resolution motion reference units negate for the inherent, or erroneous, motion in the data acquired (Jones 1999). Multibeam surveys are conducted using an ultra-high resolution multibeam echosounder with an operating frequency of 400 kHz. A series of parallel survey lines are acquired prior to the multibeam survey to conduct a ‘patch test’ on the data. A ‘patch test’ is used to calibrate multibeam echosounder installations for bias in time, roll, pitch and heading (Hughes-Clarke 1997; Parkinson 2001) to measure and correct for the inherent misalignments. Sound velocity profiles are collected daily within the survey area to correct the multibeam echosounder data for changes in the velocity of sound through the water column. The probe measures the velocity at half-metre intervals from the water surface to the seafloor.

Side-Scan Sonar

With the acoustic textures derived from side-scan sonar, surficial areas of reef, sediment and gravel pavements are delineated. Shadows cast from submerged overhangs yield evidence of submerged cave systems on the continental shelf. The side-scan sonar system comprises a top-side processing unit (TPU), an underwater tow-fish containing a port and starboard transceiver as well as housing most of the electronics, and a cable to provide power to the tow-fish and transfer the acoustic data received to the TPU (McQuillin and Ardus 1976; Blondel and Murton 1997). The acoustic beam produced by the linear piezoelectric elements is vertically wide (40–50°) but relatively narrow (1–2 °) horizontally and transmits in a transverse direction (McQuillin and Ardus 1976; Jones 1999). The majority of the acoustic beam is reflected away from the seafloor, a portion of the acoustic pulse is absorbed by the seafloor medium, and a small portion is reflected back towards the acoustic source, referred to as backscatter (Belderson et al. 1972; McQuillin and Ardus 1976; Blondel and Murton 1997; Jones 1999). The tow-fish transducers record the strength of the backscatter signal, and this is what is used to make up the sonograph image. Strong returns are represented as dark areas on the sonograph image, whereas weak returns are lighter. Post-processing of the sonograph image can enhance the image by enhancing the signals proportionally to the distance the beam has had to travel—time-varied gain (TVG; Blondel and Murton 1997).

Sub-Bottom Profiling by Boomer Seismics

Sub-bottom profiling allows mapping of the unconsolidated Holocene marine sediment wedge and underlying lithologies. The application of principles of seismic stratigraphy (Catuneanu et al. 2009) elucidates rates of change in sea level as well as the geometry of underlying compacted horizons. Boomers are low-frequency seismic profilers, characterised by broadband frequency spectrum and high-peak intensity (Parkinson 2001). Seismic energy is derived from a bank of capacitors, discharged into an electromagnetic coil, providing a clear pulse and resolvability of seismic return as a repulsion induces cavitation volume in the water column. The compression wave travels into the sub-seafloor where some of the energy is reflected from the different sedimentary-layer interfaces to arrive at the surface where it is received by a hydrophone. Hydrophones convert high-intensity acoustic pressure into electrical energy (de Moustier 2008), though this exchange is low when compared to sonar transducers (Parkinson 2001). As with side-scan sonar data, seismic imagery produced from the boomer data indicates the strength of the returned signal, with darker areas representing denser, or more consolidated, sediments, and lighter areas representing less consolidated sediments.

Geological Mapping

Following acquisition and interpretation of the geophysical data, the surveyed area will be mapped and sampled by scuba diving, targeting mostly submerged outcrops of Table Mountain Sandstone and calcrete horizons that may be conducive to cave formation. Pockets of gravelly sediment associated with submerged caves will be important in the search for archaeological artefacts. Analytical techniques applied include stratigraphic or sedimentological (transmitted light- and scanning electron microscopy) and geochronological analysis by Optically Stimulated Luminescence. Identification of *in situ* molluscs preserved in lithified aeolianites and beach rocks will be used as palaeoenvironmental markers.

Geological Modelling

For critical phases of climate and sea-level change, the behaviour of geological systems can be reconstructed quantitatively by computerised geological modelling. For example, during sea-level fall fluvial systems will incise, creating deeper and straighter channels with minimal development of associated wetlands (Cawthra et al. 2012). Abundant sediment will be supplied to the marine environment, nurturing the growth of larger dune systems. Conversely, during sea-level rise fluvial systems will aggrade, creating meandering channel systems with extensive development of wetlands. Erosion of pre-existing geomorphic features such as dunes would predominate. This distinction is important because in quantifying the palaeoenvironment in which early modern humans lived, sites with likely preservation of archaeological material in a southern African context can be identified and sampled. In addition to gaining a clearer understanding of the palaeoenvironment, preservation potential of seafloor-archaeological deposits is more clearly understood by modelling sedimentological processes.

Conclusion

Offshore or sub-sea prehistoric archaeology is a growing branch of marine archaeology but little work has been done to date in the African region. Nevertheless, some recent South African programmes have already indicated the potential for and the importance of this type of research. Supported by the discovery of the world's oldest artefacts from under the sea in Table Bay, it is now accepted that even ESA material can be found in that environment *in situ*. Together with Stone Age finds and other evidence deposited in coastal caves that border a huge and relatively accessible offshore region off the south coast of South Africa, this indicates the possibility that critically important information can be obtained from the offshore coastal plain in the future. This has opened the way for further planning and cooperation between different specialists and institutions in the fields of archaeology, geology, palaeoenvironments and others. By using the results obtained to date, in conjunction with future efforts to acquire more information from marine archaeological, geophysical and sampling surveys, it is hoped that the database can be extended. Further information on the bathymetry and geology of the South African shelf is essential to better understand lowstand coastal plain geomorphology and to identify future areas for archaeological exploration.

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Chapter 14
Inundated Site Studies in Australia

David Nutley

Introduction

The ancient beach where the first Ancestral Australian stepped ashore is now almost certainly about 100–130 m below sea level and between 50 and 500 km out to sea. The sand in which that footprint was made has been subjected to tens of thousands of years of wave action, storms, tsunamis, tidal currents, and the vigorous burrowing of countless generations of marine life. In many areas, Australia's coastline is marked by rugged, towering cliffs where tens of metres of earth have been carved off through the onslaught of the three great oceans to Australia's west, south and east—the Indian Ocean, the Great Southern Ocean, and the Pacific Ocean (Figs. 14.1, 14.2, and 14.3). Each of these generates huge seas across a fetch of thousands of kilometres. It is little wonder that the challenge of finding remnants of inundated Australian Aboriginal sites seems nothing less than daunting.

The difficulties are compounded by the nature of Aboriginal Australian material culture. In a land with large areas of perishing heat and long seasons with little water, Aboriginal culture evolved to be light weight, highly transportable by individuals and finely tuned to the cycle of resource availability. Remaining in one area too long would result in disaster. Resource availability and resource usage had to be finely balanced. This required a sophisticated knowledge of geography and natural history and a high degree of individual, family, and clan mobility. Even in tropical or coastal areas, considerable distances were travelled throughout the year. In remote, inland areas, these distances could extend to hundreds of kilometres.

Habitation sites and accommodation structures were, of necessity, entirely abandoned for lengthy periods. Permanent constructions were generally impractical as they could not be maintained. As a result, the material culture that eventuated was organic in nature and often ephemeral. Temporary shelters (popularly referred to as gunyahs—but each language group had its own term), spears, boomerangs, and various containers were made from wood, bark, leaves, or other fibres. Offsetting

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Fig. 14.1 South Head, at Sydney, New South Wales showing the effects where 4–5 m seas from across the Pacific Ocean regularly pound against the shore line. (Photo by David Nutley)

Fig. 14.2 Cape Spencer on Australia's southern coastline with sedimentary rocks overlaid with light sand and susceptible to wind, rain, bioturbation, and wave erosion. (Photo by David Nutley)

Fig. 14.3 A typical section of the Great Australian Bight where the Southern Ocean has attacked the shoreline with unrelenting ferocity. (Photo by David Nutley)

this material culture, underpinned by mobility was the practice of repeated use of habitation sites. Over time, these sites could build up a deep deposit of artefacts, including stone tools and the by-products of cooking—including the baked soils of hearths, shells from shell fish, fish, and bone fragments. The depth and consolidation of the deposits was a factor of the length of repeated use of a sites. During long periods of stable sea levels, sites could be used for tens of thousands of years. During rapid sea level rises when people had to regularly retreat from the transgressing sea, the depth of deposit was lighter and more prone to the impacts of wind, rain, waves, currents, and bioturbation.

Stone artefacts, quarry sites, and, in some areas, stone fish traps are relatively durable items of Australian Aboriginal material culture in an inundated environment. Rock shelters are items that are quite likely to remain in situ if they are not worn away by wave action. Structurally, however, these are natural formations and indistinguishable from rock overhangs that were not used as shelters if artworks on the walls or material culture deposits on the floors are washed away. Finding a rock overhang underwater is an indicator that the location may have been used for shelter and would encourage further investigation in the area but without in situ deposits is not in itself an indication of actual habitation.

During inundation much of Australia's shoreline was sculptured and reshaped by ferocious waves travelling unimpeded across the mighty Pacific Ocean, Indian Ocean, or Southern Ocean. It is, therefore, perhaps not surprising that so little work has been done to date in investigating inundated sites of Aboriginal Australia. What chance do fragile gunyahs, bark canoes, wooden spears, boomerangs, woven baskets, ochre paintings on rock shelters, carved trees, shell middens, or hearths have against these forces? At many locations, there is perhaps little or no likelihood of preservation.

Studies of cyclonic impacts on known coastal midden sites in North Queensland have further highlighted the impacts of these seasonal events, even behind the relatively protective barrier of the Great Barrier Reef (Bird 1992, pp. 75–86, 1995, 40:57–58). At other locations, protected and sheltered from the worst of the encroaching seas, the likelihood for site survival is significantly increased (Fig. 14.4).

The need to understand the initial settlement of Australia and the potential for underwater archaeological sites to reveal valuable information about early occupation has been recognised by Australian archaeologists for a long time.

The earliest archaeological evidence of human occupation in Australia has been found at the site of a dry inland lake, Lake Mungo and is dated, amidst ongoing discussion, to around 60,000 years BP (Attenbrow 2002, p. 152). Ideas about how this occupation came about vary from Aboriginal belief in evolution within Australia (Attenbrow 2002, p. 152) to arrival from the sea (Flood 1983, pp. 29–39). As an island continent, Indigenous occupation of Australia was at any rate closely tied to the use of maritime and estuarine locations.

During maximum glaciation, 15,000–18,000 years BP, sea levels are estimated to have fallen up to 130 m below current levels (Inman 1983, p. 89). Shorelines shifted out onto the continental shelf and, in places, much closer to the commencement of the continental slope and the 200 m contour for a period of 10,000 years

Fig. 14.4 Australia's Bournda National Park illustrating an example of a protected, low-energy environment favourable to potentially surviving inundation. (Photo by David Nutley)

(Roy 1998, p. 368). A sea voyage in an undocumented form of raft or boat would then have involved an open-water crossing of some 50–90 km from Sunda (Indonesia) (White and O'Connell 1982, pp. 42–53; Flood 1983, p. 32).

Various theories have been devised to predict the pattern of settlement, most being a variation on an arrival from Sunda and/or via Papua New Guinea (e.g. Birdsell 1957, pp. 47–69; Bowdler 1977, pp. 205–246; Horton 1981, pp. 21–27). Except for Birdsell, who suggested a general, radiating spread across the continent from the northwest, most models suggest settlement patterns that follow the availability of resources, i.e. the coastal lands and rivers. With sea level rising coastal occupation would be driven back as the perimeter of Australia shrunk. This is postulated as causing an effect of coastal intensification as more people moved into less space (Megaw 1974; Hughes and Lampert 1982; Lampert and Hughes 1974; Beaton 1983, 1985; Lourandos 1980, 1983, 1985). A common element of much of the 1980s and of subsequent discussion (Dortch 1997; Head 2000; Rowland 1996) confirms a belief in the potential of coastal environments to reveal details of the demographics and spatial realignments of Indigenous populations. This potential exists where demographics and spatial realignments have been in response to the rise and fall of sea levels or to cultural and social evolution—or both. It is these areas of debate that underline the potential importance of finding and investigating inundated sites.

Proof that sites can survive inundation has been documented at many previously inundated sites across Australia. The dry water bed of Lake Mungo, the exposed shoreline of Lake Victoria in New South Wales (Hudson and Bowler 1997), Wyrie Swamp in South Australia, (Luebbers 1975), Wingecarribee Swamp in New South Wales (McDonald 2003) and the levees at Penrith Lakes (Comber 2007) all attest to this level of resilience. In addition, hearth sites recorded by the author on the regularly flooded banks of the Darling River (Fig. 14.5) attest to the resilience of such features to survive such events (Nutley and Smith 2003, pp. 25–26). These hearths had baked the earth below, forming deep, vertical cylinders of baked earth.

Fig. 14.5 Remains of two circular hearths (at either end of tape scale) on the flood-prone banks of the Darling River in central New South Wales. (Photo by David Nutley)

With depths of over a metre, such features, if located behind a coastal barrier, could survive relatively intact if the waters of one such flood did not dissipate—e.g. the coastal barrier broke through and the sea level permanently inundated the site.

While these are terrestrial archaeological sites, some formal work has also been conducted regarding the underwater context. This has varied from site specific investigations (Flemming 1982; Dortch et al. 1990; Nutley 2005; Coroneos et al. 2007) to predictive modelling (Nutley 2006; Steyne 2008). The following outline of these investigations provides a summary of the state of investigations to date and the potential direction for future investigations.

Site-Specific Investigations

Offshore: Cootamundra Shoals

A 1982 survey of Cootamundra Shoals in the Timor Sea about 200 km northwest of Darwin (Figs. 14.6 and 14.7) provided the impetus in Australia for inundated cultural landscapes to be considered as an area of archaeological investigation. Cootamundra Shoals was chosen due to its proximity to a potential point of initial migration from Southeast Asia and due to its broad and relatively shallow continental shelf. During the survey, divers searched for underwater features such as cliffs, terraces and submerged reefs, and fossil beach ridges (Flemming 1982a, b; Flemming 1984 and 1986). At Cootamundra Shoals, the shallowest surface of the reef plateau is about 30 m below sea level. The shoals feature many intersecting deep karstic valleys down to 60–90 m. At times of low sea level, these valleys would have been perhaps 1–2 km wide, and tens of kilometres in length. This topography would have provided protection from the worst of the waves from the open sea and from oceanic currents.

Fig. 14.6 Locality map, Cootamundra Shoals

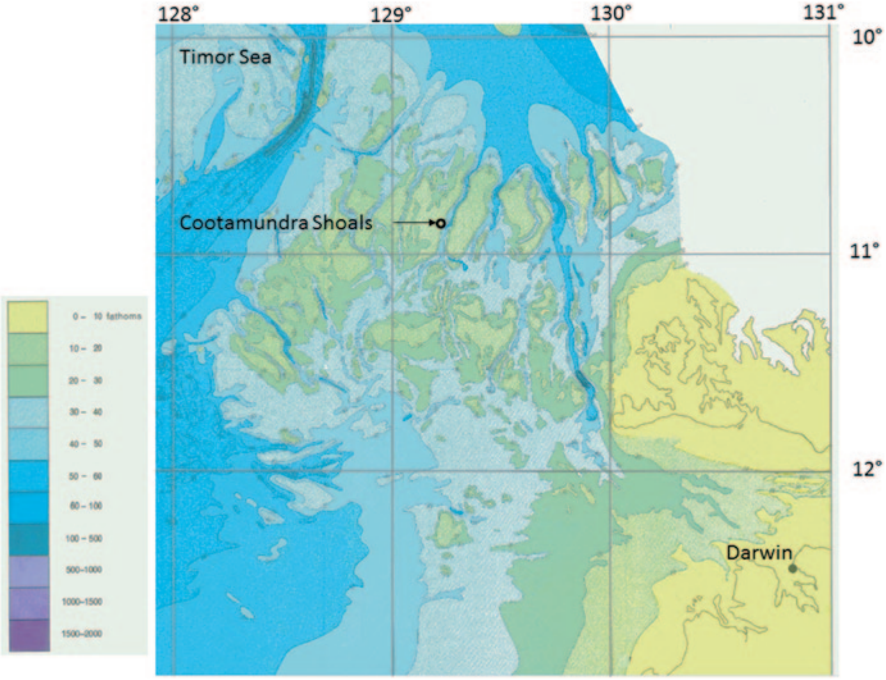

Fig. 14.7 Bathymetry surrounding Cootamundra Shoals. Depths are shown at 10 fathom intervals as shaded contours. Map modified from Veevers and van Andel (1967; Plate 1). Image is courtesy of the Commonwealth of Australia (Geoscience Australia) 2014. This product is released under the Creative Commons Attribution 3.0 Australia License. http://creativecommons.org/licenses/by/3.0/au/deed.en

No rock shelters and stone tools or other evidence of prior human occupation were found during the Cootamundra Shoals survey. To date, this is the only offshore search for Australian Indigenous sites and has the potential for further investigation.

Rock overhangs, terraces, and fossil beaches that may have been used for habitation could certainly be observed in this area but given the depth and time limitations on divers, remote technologies that were not available to this expedition may be required to adequately cover the depth and sufficient area to examine these features. Actual artefacts are unlikely to be observed due to natural sedimentation and bioturbation. These factors are almost certain to bury artefactual material.

Lakes: Lake Jasper (Western Australia) and Lake Victoria (New South Wales)

The dating of Australian lake shorelines indicates that current lake levels are similar to those that existed 40,000 BP, but that they have not been stable over the entire period. Glacial period aridity caused these lake levels to lower from about 25,000 BP and again during the Last Glacial Maximum (LGM) from 18,000–22,000 BP (Dortch 2004, pp. 26–27). Post-glacial warming from around 15,000 BP to 10,500 BP caused these lake levels, in both mountainous and arid regions, to return to their previous levels. It can be presumed that retreating shorelines would have been followed by Indigenous populations and suggests that many shorelines that were inhabited between 25,000 BP and 10,500 BP are now submerged. This provides Australia's lake systems with the potential to have preserved and recorded, in an inundated environment, thousands of years of Indigenous occupation during the LGM.

Archaeological work at Lake Victoria in New South Wales recorded a large number of sites, and artefact deposits were found on the lake bed where the waters had retreated (Figs. 14.8 and 14.9) (Hudson and Bowler 1997). An underwater survey of Lake Jasper (Dortch et al. 1990; Dortch 1997) in southwest western Australia (Fig. 14.10) also illustrated this potential.

As with Lake Victoria, the initial survey of Lake Jasper (Figs. 14.10 and 14.11) was undertaken when the lake was at a low level. Scattered stone artefacts were located in association with stumps of trees and grass trees (*Xanthorrhoea preissii*). The grass trees were in their growth position, leading to the conclusion that they had been part of a pre-inundation environment (Dortch et al. 1990, p. 43). The following year, a diving survey (Dortch et al. 1990, p. 44) collected about 100 stone artefacts from four sites. This was in addition to approximately 60 artefacts previously collected from three exposed sites when the lake level was lower.

The significance of the Lake Jasper survey was to confirm the potential for undertaking archaeological investigation of inundated Indigenous sites. It began the process of linking the underwater investigations with known terrestrial and tidal sites. In addition, it raised the prospect for further work on inundated Aboriginal landscapes such as 'Warren Beach' in southwest western Australia (Fig. 14.10). At Warren Beach, tree stumps dating to about 8,340 year BP, 'apparently in growth position', were reportedly lying submerged hundreds of metres out to sea (Merrilees

Fig. 14.8 Locality map, Lake Victoria

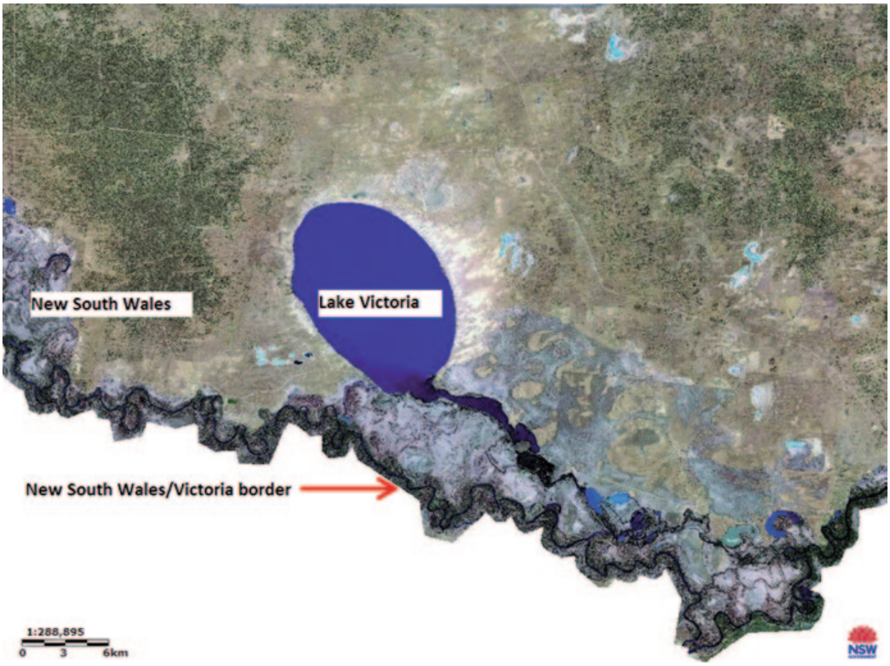

Fig. 14.9 Detail view of Lake Victoria. (SixMaps, Land and Property Information, NSW Government)

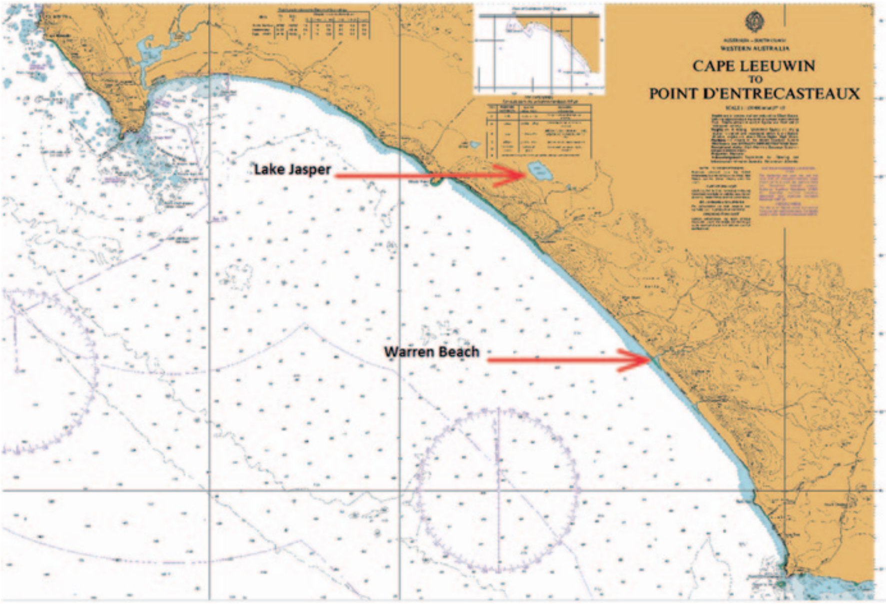

Fig. 14.10 Locality map, Lake Jasper. (Copyright RAN Australian Hydrographic Service)

Fig. 14.11 Detail view of Lake Jasper. (© Microsoft Corporation)

1979, p. 120). No subsequent work on Warren Beach has linked these tree stumps to submerged archaeological remains though this must still be considered as a site for future research.

Wetlands: Wyrie Swamp (South Australia) and Wingecarribee Swamp (New South Wales)

In 1973, wood and stone artefacts were recovered from peat deposits at Wyrie Swamp in South Australia. These included three complete boomerangs, one broken boomerang, a short spear, two types of digging stick, a carved wooden barbed javelin fragment, and chert tools and flakes that were found in a layer dated between 10,200+150 and 8,990+120 BP (Luebbers 1975, p. 39). Further confirmation of the potential of wetland peat deposits was recorded at Wingecarribee Swamp in New South Wales where artefact scatters were found extending into swamp and, in places, predating the onset of peat accumulation (McDonald 2003, p. 61).

This demonstrated ability of peat to preserve artefact material, including, in some contexts, organic material, means that peat beds in either freshwater or saline environments should be considered an important marker for archaeological site survival.

Stone Fish Traps

The extensive archaeological investigation of stone fish traps has been largely focused on their construction and functional characteristics. Consideration of their resistance to inundation has been addressed by Nutley (2006, pp. 18–22, 55–58) and their potential to survive inundation in an identifiable and in situ form is greater than most other forms of Australian Aboriginal material culture. Of the recorded non-estuarine, coastal fish traps, those at Hinchenbrook Island off the Queensland Coast are of prime importance as they provide indication of extending beyond the current low water mark. Mapping the full extent of these formations could provide valuable dating of coastal habitation prior to current sea levels. Archaeological analysis of land sites has established that Aboriginal use of the area began about 2,000 years ago. It is predicted that this date may well be extended following further research (Gray and Zann 1988, p. 3). Campbell (1982, p. 101) observed that the 'oldest system extends mostly below present low water'. Further investigation would provide additional evidence of the duration of human habitation in this area. The work would need to be done in an environment of thick mud, swarms of sandflies, deadly marine stingers, (Chironex fleckeri, the 'Box Jellyfish' and the Irukandji), and the potential for salt-water crocodiles. However, current archaeological work in which the author has been engaged in Darwin Harbour in similar conditions demonstrates that with appropriate personal protection equipment (PPE) and observer boats, such risks can be safely and successfully overcome. Probes and remote sensing techniques would also be valuable in this environment.

Fig. 14.12 Fish weirs in relation to the *Yowaka River*. *Site A* is at the upper limit of tidal waters and *Site B* is tidal but permanently underwater

The 2005 archaeological recording of two estuarine stone fish traps on the Yowaka River (Fig. 14.12) in New South Wales (Nutley 2006, pp. 47–51) has highlighted the ability of these structures to survive inundation. One of these structures is at the current limit of tidal waters, and the second structure is approximately 150 m downstream. The downstream structure is entirely underwater and may represent a time when the tidal limit was lower. The upstream fish trap is only covered in water during very high tides and floods and may represent a newer structure. Neither of the structures has been maintained for many years, and both structures are currently non-functional. Further significant disturbance, however, is unlikely—outside of any human intervention. The upstream structure is largely buried in gravel and accumulated silt as well as being overgrown by grass and shrubs. The downstream site is reduced primarily to its larger component rocks which have survived the major floods in this valley. These large rocks are, therefore, unlikely to be affected by future flooding. If the valley was to become more permanently flooded, these two traps would be very likely to survive intact beneath an accumulation of subsequent deposits of silt and gravel.

The significance of these findings is that inundated ancient river beds are potential sources for surviving records of these structures. Investigations of offshore sites should, therefore, not be limited to ridges or other areas that are primary indicators of terrestrial Aboriginal sites. In a submerged environment, in situ fish trap structures are likely to be located in the former river beds. There is potential to contribute to the predictions for offshore sites through further research on the potential for inundated fish traps further downstream on the Yowaka River and in similar estuarine systems in areas where stone fish trap technology is known to have been practiced.

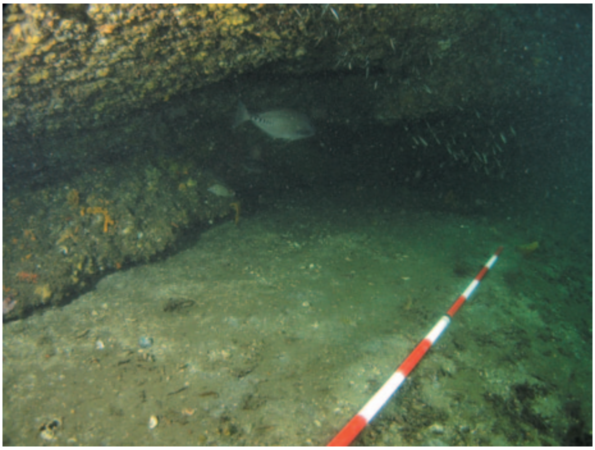

Fig. 14.13 Submerged rock overhang in Southwest Arm, Port Hacking, Australia. (Photo by David Nutley)

Rock Shelters

In 2007–2008, a preliminary archaeological survey of potential inundated rock shelters was conducted in South West Arm, an off-shoot of Port Hacking in New South Wales (Coroneos et al. 2007). The site was chosen due to the abundance of recorded rock shelters above the water line in this area and on the hypothesis that similar rock formations should exist below water. Conducted with the aid of volunteers from the Underwater Research Group, a New South Wales dive club, a number of rock overhangs with the potential of being rock shelters at times of lower sea levels were recorded (Fig. 14.13). While no coring or excavation has yet been conducted, the existence of these overhangs demonstrated that usable features have survived inundation. Given the use made of similar above water features in the same area, it was concluded that there was a high probability that these underwater rock overhangs were also used for shelter perhaps up to around 7,000 years before the present.

The Southwest Arm survey points to a potential for further work on inundated rock shelters around Australia. Currently, collaboration is being developed with the School of Biological, Earth, and Environmental Sciences, University of New South Wales and the Paleobiology Laboratory of the Department of Biological Sciences at Macquarie University. This collaboration seeks to increase understanding of the seabed morphology in the study area to better understand both the process of inundation and the potential for archaeological site survival. Examples of interrelated study areas of overlapping interest include the geochemistry of recent sediments and the study of benthic foraminifera (protozoa). Such studies can provide indicators of responses to human activities as well as the time frame of inundation events.

Predictive Modelling

Due to the nature of Australian Aboriginal material culture, inundated sites, or even displaced, isolated artefacts, are very difficult to find. In addition, Aboriginal clan structure meant that population numbers in any given area were typically small and the structural impacts on the environment were minimal.

Added to this, work in an underwater environment requires specialized equipment and specialized personnel. Non-disturbance dive inspections are likely to be of limited use—identifying rock overhangs in relatively shallow water being a notable exception. Elsewhere, casual or archaeological divers are highly unlikely to observe surface scatters of artefacts. Other investigations are likely to require detailed hydrographic survey and modelling, core extracting and analysis, or other forms of diver-based excavation or mechanical excavation. Any project aimed at locating surviving sites, particularly offshore or in any significant coastal estuarine environment will have a significant financial component. It is, therefore, critical that any such investigations are directed by well-informed, predictive modelling that maximises the chance of success. Two predictive studies of the Australian context have been produced to date. One is a predictive model for Australia as a whole, and the second is a predictive model for Port Phillip Bay in Victoria.

The first, 'Surviving Inundation' is 'an examination of environmental factors influencing the survival of inundated Indigenous sites in Australia within defined hydrodynamic and geological settings' (Nutley 2006a). This study has also been produced by Flinders University as the monograph 'The Last Global Warming?—Archaeological survival in Australian Waters' (Nutley 2006b). Underlying the investigations of this study have been existing ethnographic and archaeological records, physical geography, and environmental and hydrographic studies. The study shows how environmental factors and artefactual composition interact to determine site survival. This highlights opportunities for targeted, synthetic, multidisciplinary research. It suggests some key areas for initial investigation but, as an initial research priority, identifies the need to map areas of high and low probability for inundated site survival in Australia and a multidisciplinary, collaborative approach to research.

Perhaps one of the key outcomes of the direct observations made of shell midden sites at the land–water interface during the 'Surviving Inundation' study was the extreme vulnerability of unconsolidated shell deposit to even the most gentle wave action in relatively protected estuarine environments. The site observed at North Arm, Middle Cove, is a deeply recessed indentation formed within the Hawkesbury sandstone where there is a fetch of only 130 m across the estuary and a maximum fetch of less than 1,000 m. The cove is protected from oceanic storms but reflects the semi-diurnal, microtidal regime of this region including a maximum spring tide range of less than 2.0 m (Roy 1998, p. 367). Wind-generated waves are minimal and typically would not exceed a few centimetres in normal conditions or 150–200 mm in a gale (Nutley 2006b, p. 37). The cove is edged with rock shelters of sandstone and other sandstone outcrops and lined with an overlay of midden deposits for almost the full extent of the estuary. Aboriginal midden sites are among the most productive and informative archaeological site types in Australia as they can contain not only dietary evidence of shellfish, fish, and land animals but also stone tools, stone flakes, pollen samples, and even some human burials. The eroding edges of these deposits are clearly visible above the wind- and wave-swept sandstone. There was visible evidence of burrowing by small marsupials and insects. In spite of the protected nature of the cove, there was no evidence of this midden surviving below the current maximum level of tide and tidal surge. Even in this extremely protected setting, it can be concluded that unconsolidated shell midden deposits would not survive in situ during inundation. The material would very likely be swept into the estuarine waters and redeposited out of context.

This study underlines the vulnerability of Australian Aboriginal archaeological sites to inundation and cautions against a presumption that a relatively protected area will necessarily preserve those sites. Small, incremental erosive forces can be as effective at obliterating a site as large ocean swells. However, if a shell midden has been laid down over a very long period of time and is well consolidated and/or the site is behind a coastal barrier that suddenly collapses, then its chances of survival are greatly increased. If an archaeological site is situated behind mangroves, or similar vegetation, and not lying on exposed sandstone, the deposit may be more resilient to inundation.

'Surviving Inundation' therefore identifies a number of determinants for site and artefact survival (Nutley 2006a, pp. 59–60, 73–74). In a high energy, coastal or riverine environment even robust structures will eventually be levelled and stone tools waterworn until they are no longer recognisable.

Inland rivers, estuarine systems with backwaters, mud flats, swamp land, or marsh environments are much more favourable to site and artefact survival and are:

> …capable of trapping and protecting cultural materials in ever-increasing layers of sedimentation and organic materials. Artifacts that settle into an anaerobic environment, whether a layer of silt or in a deep water, low oxygen, low light environment, are likely to avoid the abrasive, chemical and biological attack otherwise endured during gradual inundation.(Nutley 2006b, p. 59)

The ability for consolidated sites to survive inundation has already been referred to through the observations on the flood-prone banks of the Darling River in western New South Wales (Nutley and Smith 2003, p. 23, pp. 25–26).

Based on the analysis of data in this study, 'Surviving Inundation' makes the following observations about conditions necessary for inundated Indigenous sites to survive and remain in situ:

- Shell middens: only likely to survive rapid, low-energy inundation unless deeply buried in consolidated sediments or peat prior to inundation within a high-energy environment.
- Carved trees: only likely to survive in conditions of rapid, low-energy inundation within a freshwater environment. To survive in a high-energy environment they would need to be deeply buried in consolidated sediments or peat prior to inundation.

- Bora rings: generally earthen and unlikely to survive even with rapid, low-energy inundation. Bora rings that are rock structures would have far greater resistance.
- Fish traps: Those made from organic materials such as saplings or woven materials are highly vulnerable to the processes of inundation and likely only to survive rapid, low-energy inundation unless deeply buried in consolidated sediments or peat prior to inundation within a high-energy environment. However, fish traps constructed from stone are moderately vulnerable to the processes of inundation but likely to survive relatively intact except within a high-energy environment.
- Stone artefacts: moderately vulnerable to abrasion and dislocation during slow inundation but likely to survive rapid, low-energy inundation.
- Rock outcrops quarried for stone artefact manufacture: highly resistant due to their intrinsic hardness. These sites are vulnerable only to slow inundation in a high-energy environment. Where they have survived, they would be 'visible' to remote sensing equipment such as side scan sonar. However, they would require close investigation to distinguish them from unquarried rock.
- Rock shelters: moderately resistant to the processes of inundation due to their bulk. Depositional material within the shelter is likely to survive only where the original depth of deposit was considerable or in those areas where the deposit is located in recessed floors, within fissures or trapped under fallen boulders. Even then, survival is only likely during relatively rapid inundation in a low-energy environment.
- Rock art sites: Engravings are unlikely to survive long on soft sandstone. Organic paints and charcoal within the shelter are likely to be vulnerable to marine organisms and chemical attack. Sandstone that absorbs red ochre may retain that stain but may equally be susceptible to absorbing additional masking colouration from waterborne minerals.(from Nutley 2006b, pp. 59–60)

The other predictive modelling study has been conducted in Port Phillip Bay in Victoria by Hanna Steyne through Heritage Victoria within the Department of Planning and Community Development (Steyne 2008; http://www.dpcd.vic.gov.au/heritage/maritime/submerged-landscapes-virtual-archaeology-project/submerged-landscapes). This project used existing published and unpublished data to predict the survival of ancient land surfaces beneath the bay. Sources included sub-bottom profile data, pollen data, archaeological and historical evidence, and then produced an animated reconstruction (available on the web site) of the area 10,000 years before the present—a time before sea levels rose and flooded the bay. A particularly interesting component of this study was the linking with three recorded Aboriginal oral histories, two from 1968 and one from 2004, which also recall the time when the bay was dry land. These oral histories are also available on the website.

Conclusions

In Australia, some important preliminary research has been undertaken into inundated sites but the research has been largely isolated and focused on terrestrial coastal sites or the banks of lakes, swamps, and estuaries rather than a direct focus on underwater settings. There is considerable scope for increased understanding of impacts occurring at the land–water interface and how this shapes the survival of different site types in different settings. It is also clear that rapid, low-energy inundation provides the best conditions for site survival—a factor that has been repeatedly identified in many global contexts. The implication of this analysis for Australia has the potential for predictive mapping to guide the focus and priorities of future research. Such mapping would seek to identify those areas where rapid, low-energy inundation occurred and where pre-inundation resource availability was likely to be conducive to the development of specific habitation site types. Some key potential areas are considered in the conclusion to the 'Surviving Inundation' study (Nutley 2006, pp. 61–66).

In developing predictive modelling, the 'Surviving Inundation' study pointed to the need for:

- Identifying submerged landforms associated with habitation and subsistence
- A focus on sea-level curves
- Erosion modelling to determine extent of land surface removal during inundation
- A full compilation of reported inundated sites in Australia
- Identification of coastal areas-associated low-energy wave activity
- Mapping of offshore peat beds

To date, only the first of these established needs has been addressed through the early 1980s survey at Cootamundra Shoals (Flemming 1982), the study and mapping of the inundation of Port Phillip Bay (Steyne 2008) and remote sensing in the Dampier Archipalego (Ward 2013). Work on the other needs has yet to progress.

The value of oceanic core sample data through examination of foraminifera deposits to interpret sea surface and atmospheric temperatures to model broad-scale change in climatic conditions is also well documented (Dortch 2004, pp. 26–27). In an environment where sheer-sided excavation spits are rarely even remotely possible, core sampling also provides a controlled, stratigraphical sample that can be analysed under controlled conditions. Core sampling surveys may well prove to be the most cost effective technique to both broad-scale and site-specific mapping of potential areas of inundated habitation sites and, if appropriate, for subsequent and more traditional 'open-cut' methods of excavation.[1]

The heritage that is being investigated is the heritage of Aboriginal Australians and all targeted site investigations would require close liaison with Aboriginal communities as well as the relevant government authority or authorities. The perspectives of Aboriginal oral histories are often based on information that has been hand-

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[1] See Faught (Chapter 3), Pearson et al. (Chapter 4), Bayon and Politis (Chapter 7), and Bicket et al. (Chapter 12) for specific examples of coring and sedimentary analyses.

ed down from many generations and provides important understanding of cultural practice and values that can help predict site locations.

Archaeology is by its very nature a multi-disciplinary approach of understanding the past. For archaeological research in the underwater environment to be effective, it is important that it draws upon expertise from a number of disciplines including geology, hydrography, and marine biology as well as anthropology and history. Sedimentology, erosion modelling, and mapping of fossil landforms are all specific skill areas that need to be accessed.

There are perhaps two main directions in which the resources for future research need to come from for increased investigations of riverine, estuarine, and lacustrine sites, and inshore tidal zone investigations. One is the integration of academic research programs such as those previously discussed at the University of New South Wales and Macquarie University. Academic integration requires close dialogue among researchers and illustrates the importance of multidisciplinary presentations at significant conferences, e.g. geologists, biologists, and hydrographers presenting papers at archaeological conferences, and archaeologists presenting papers at conferences with a focus on those other disciplines.

The other direction, though closely related, is to form alliances with the offshore industry where it is undertaking complementary research. This can include collaboration where drilling is being or has been undertaken for oil or gas. If such exploration were, for example, to identify a layer of peat, it would provide a key pointer to where pre-inundation soils have survived and, therefore, a focus for archaeological investigation. The 2013 ‘Offshore Industry and Archaeology: a creative relationship’ conference in Denmark is an example of how collaboration with industry can be effective (SPLASHCOS 2013). It is hoped that the papers from this conference are to be published as they could well be the inspiration researchers need to break new ground in the investigation and understanding of Australia’s Aboriginal past.

The challenge now is for archaeological researchers to continue to extend Pleistocene research below the water’s edge. The reward would be to throw a glimmer of new light into the human history of this remarkable island continent—and the human history that flowed from that first Ancestral footprint.

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Chapter 15
State and Perspectives of Submerged Sites in Japan

Kenzo Hayashida, Jun Kimura and Randall Sasaki

Previous Research on Submerged Prehistoric Sites in Japan

A chance discovery at Lake Suwa in Nagano Prefecture in 1908 sparked the interest of the Japanese archaeological community in submerged archaeological resources. Lake Suwa, located in a basin surrounded by mountains, is relatively shallow, averaging only 6 m deep. Several stone arrowheads were discovered at the point known as Sone, approximately 300 m from the shore. After the finds were published in 1909, archaeologists debated over the site formation processes involved at this location. A number of underwater sites, including prehistoric sites, have been identified in Lake Biwa, the largest lake in the country. The 1924 identification of the Tsuzura Ozaki Lake site in the northern part of Lake Biwa was a landmark discovery. The significance of the site was first noted by Oye Yoshio, a pioneer of underwater archaeology in Japan (Oye 1970, 1982). Artifacts were found on a steep slope from 50–70 m in depth (Akita 1997, p. 12). A few artifacts were collected, dating to diverse periods ranging from the prehistoric period to the ninth century. Lake Biwa also has been the focal point of submerged cultural heritage management in Japan. After the lakefront renovation plan was enacted in 1972, a total of 114 sites were investigated (Shiga Prefectural Association for Cultural Heritage 2010, p. 41).

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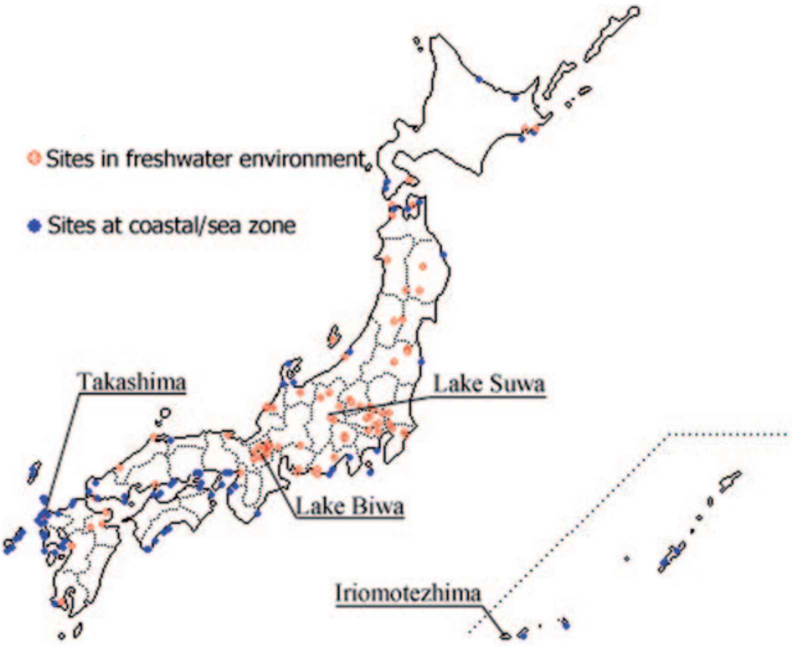


Fig. 15.1 Location of the underwater sites, plotted based on the survey of the Agency for Cultural Affairs. (Map by Jun Kimura)

Following underwater survey by divers, almost all of these sites were excavated by inserting cofferdams around the sites and pumping the water out to allow the "dry land" excavation (Shiga Prefectural Association for Cultural Heritage 2010, p. 19). A tremendous amount of information was collected through these rescue excavation projects (Shiga Prefectural Association for Cultural Heritage 2010, p. 23).

Between 1989 and 1991, the Agency for Cultural Affairs conducted a project to examine underwater cultural heritage in Japan in cooperation with the Kyusyu Okinawa Society of Underwater Archaeology (presently named the Asian Research Institute of Underwater Archaeology, or ARIUA). This included conducting a questionnaire with local municipalities in the country to understand the current status of research and distribution of underwater sites in Japan (Agency for Cultural Affairs 2000). All 3,245 municipal offices in Japan at the time were targeted in the survey. Of them, 2,356 offices indicated the possible presence of underwater sites or artifacts recovered from their waters. A total of 216 sites were regarded as significant for further investigation. As a result of this secondary survey, the details of the sites including the recovered artifacts, the location, time periods, and brief context were reported. Of the 216 sites, 109 sites were located at sea or in coastal areas, and 88 sites were found in inland waterways, such as lakes and streams (Kimura 2009) (Fig. 15.1). A larger number of marine sites are located in southwestern Japan while more fresh water sites are found in eastern and northern Japan. Reported sites range from simple scatters of artifacts to submerged features, structures, and shipwrecks.

Among these reported sites, eight sites are from the Paleolithic period, and 70 sites date from the Jomon Period. Less than ten dated later than the Jomon period. More than 70 sites did not date to any specific period. Only 44 sites had been excavated at the time. Fourteen of the 44 sites date to the Jomon Period, and 2 sites are identified as Paleolithic in age. The results illustrate a great potential for the Jomon Period research. The distribution of sites suggests that the Jomon people utilized inland waters extensively; however, more coastal sites should be investigated to refine the maritime adaptation pattern of the past. It is also important to note that a number of sites dating from the Jomon Period have been excavated since the study was conducted, especially at Lake Biwa.

In recent years, the previously mentioned ARIUA emerged as a leading institute in Japan for the study of submerged archaeological sites. ARIUA started the Comprehensive Survey of Japanese Underwater Cultural Heritage Project in 2009, funded by the Nippon Foundation. The purpose of the project is to locate known and unknown underwater sites nationwide, including submerged prehistoric sites, and to create a database for further studies. The members of ARIUA recognize the importance of the Underwater Cultural Heritage management, and protection of underwater cultural heritage as proposed by the 2001 UNESCO Convention. This project serves as a foundation upon which future works will be conducted. In early 2011, the online database created by ARIUA provided information on 124 Jomon Period underwater sites.

Prehistoric Environments and Archaeological Sites in Japan

The prehistory of Japan, beginning with the initial peopling of Japan, is connected to the fluctuation of sea level and climate change. For most of Japanese prehistory, sea level was at least 40 m below the current level; during glacier advances, sea levels were much lower, perhaps 120 m below that of today (Bailey and Flemming 2008, p. 2153). Sea levels show rapid and irregular fluctuations after 75,000 years ago, preventing the formation of stable ecosystems that early humans could exploit. The change in sea level was relatively stable between 49,000–33,000 years ago, allowing lagoons and swamps, rich in exploitable resources, to form (Pope and Terrell 2008, p. 8). Although not completely dry at the time, the 100 km wide Tsushima Strait, which separates Japan and Korea, was much narrower. People only had to cross 50 km or less of water in order to reach Japan from Korea (Pope and Terrell 2008, p. 5). No research has been conducted to locate Paleolithic sites along the "Tsushima land bridge," but the importance of such sites when discovered will be grave.

The Paleolithic population of Japan is thought to have hunted megafauna. Along with such subsistence, they hunted large sea mammals but did not collect small fish and clams based on the presence of harpoons, and the absence of fish hooks from Paleolithic sites (Abe 2008a, pp. 15–16; Sato 2010, pp. 5–6). The climate started to change to warmer weather around 15,000 years ago and the megafauna began to die off; humans had to adapt to a changing environment and exploit new resources, namely fish and other marine species (Toizumi 2008, p. 120). A plethora of evidence indicates that people began to collect marine resources intensively during the Incipient Jomon, which started around 16,000–14,000 years ago (Pope and Terrell 2008, p. 14). The Jomon culture is marked by the beginning of pottery use, intensive foraging, and a more sedentary way of life. Perhaps one of the first pieces of direct evidence for the use of marine resources is from the Maeda Kochi site in Tokyo, where a salmon jawbone was identified (Sato 2010, p. 12). It is believed that people captured salmon that were swimming upriver to spawn. There are other examples of early exploitation of marine resources, including the Yugura Cave site of Takayama Village in Nagano Prefecture (Toizumi 2008, p. 120). Nevertheless, it is shell midden sites that characterize the Japanese use of marine resources.

It is usually understood that during the Younger Dryas period (12,800–11,500 B.P.) the climate of Japan was slightly cooler and generally dry, as the weather was directly influenced from the continent. This occurred because the Tsushima Strait was closed, thus blocking the warm Tsushima current from flowing into the Sea of Japan (Sato 2010, p. 4). The forests in Japan were mainly composed of coniferous trees, but after 12,000 years ago, they were largely replaced with nut bearing deciduous trees (Pearson 2006, p. 239). The sea level was much lower than today, but around 9,000 years ago or earlier, sea level began to rise (Ishiga et al 2000, p. 223). It is difficult to ascertain the precise relationship between the rise of sea level and the climate, but it is generally believed that rainfall increased when the Tsushima current started to flow into the Sea of Japan (Lutaenko et al. 2007, p. 387). The warming trend was somewhat delayed on the Pacific side, attesting to the introduction of warm currents to the Sea of Japan, creating an oceanic warming trend (Lutaenko et al. 2007, p. 387). Lake sediments from many locations exhibit deposits of enriched organic matter and nutrient salts, suggesting a developed fluvial system and rainy conditions after 9,000 years ago (Ishiga et al. 2000, p. 233). The appearance of the first shell midden in Japan around 10,000 years ago is thought to be associated with this warming trend; it is considered an important marker for the beginning of intensive marine resource exploitation (Pope and Terrell 2008, p 14). The majority of shell middens from this period, which are comparably smaller than later middens, are found in the Kanto plain in eastern Japan where many lagoons and brackish lakes formed. These environments may have been favorite locations for the Jomon inhabitants to gather marine resources (Ishiga et al. 2000, p. 224). The middens are usually full of discarded artifacts, including fish hooks, harpoons, and manos and metates, which exhibit the complex and extensive array of existing subsistence systems (Abe 2008b, p. 20). People exploited a range of marine resources, including fish and shell species from inland and offshore, suggesting an already well-established tradition (Toizumi 2008, p. 121). The warming trend continued through the Early and Middle Jomon, accompanied by a rapid rise in sea level (Lutaenko et al 2007, p. 343). This event is known as the Jomon Transgression; it reached a maximum stage in Tokyo Bay around 6,500–5,300 years ago (Lutaenko et al. 2007, p. 347). By 6,500 years ago, trees such as *Quercus* (oak) and

Castanopsis began to spread rapidly (Lutaenko et al. 2007, p. 347). Analysis of the available tool kit and midden waste indicates marine resources were an important component of subsistence activity (Toizumi 2008, pp. 122–123). During this period, shell middens located in different ecological zones across Japan usually produced different sets of species. For instance, coastal sites exhibit a majority of small coastal fish while sites located inland exhibit more reliance on small inland fish species (Komiya 2005, pp. 119). Komiya (2005), however, suggests that some coastal fish species were found even in inland shell middens, suggesting that populations living inland utilized boats to travel extensively to catch fish, or perhaps they had a seasonal camp near the coast. The Middle Jomon is thought to be the time when the Jomon way of life fully matured. The number and size of shell middens grew during the early part of the Middle Jomon when climate was optimal (Lutaenko et al. 2007, p. 365). This corresponds to population booms at large and permanent settlements, such as Sannai-Maruyama in northern Japan. Significant cooling of the climate took place around 4,500 to 4,000 years ago and sea levels began to drop, eventually reaching the current level (Lutaenko et al. 2007, p. 387). In general, there appears to be two types of shell middens during this period: the village (or hill) midden and the coastal midden (Uetsuki 2008). A village midden, as the name suggests, is associated with a village, and can be seen as a disposal site for locally produced trash. Village middens, like the well-known Kasori shell midden (Toizumi 2008, p. 123), usually contain various types of used artifacts and a large variety of food resources (Uetsuki 2008, pp. 24–26). Coastal middens formed as a result of the intensive exploitation of a small number of species, perhaps by occupants of seasonal camps. The Nakazato shell midden is characteristic of the coastal type; the site was used as a shell processing area (Toizumi 2008, p. 124). The number of shell middens, as well as average midden size, rapidly decreased during the Late and Final Jomon, corresponding to the disappearance of resource-rich lagoons and brackish lakes (Suzuki 2008, p. 40). Some shell middens date to the Yayoi Period (3,300–1,750 years ago); however, the represented resources are limited to near-shore or inland lagoon species (Toizumi 2008, p. 126). During this period, innovative fishing techniques appeared and regional variations in styles of fishing and use of resources became more prominent (Toizumi 2008, pp. 126–127).

The Study of Site Formation Processes

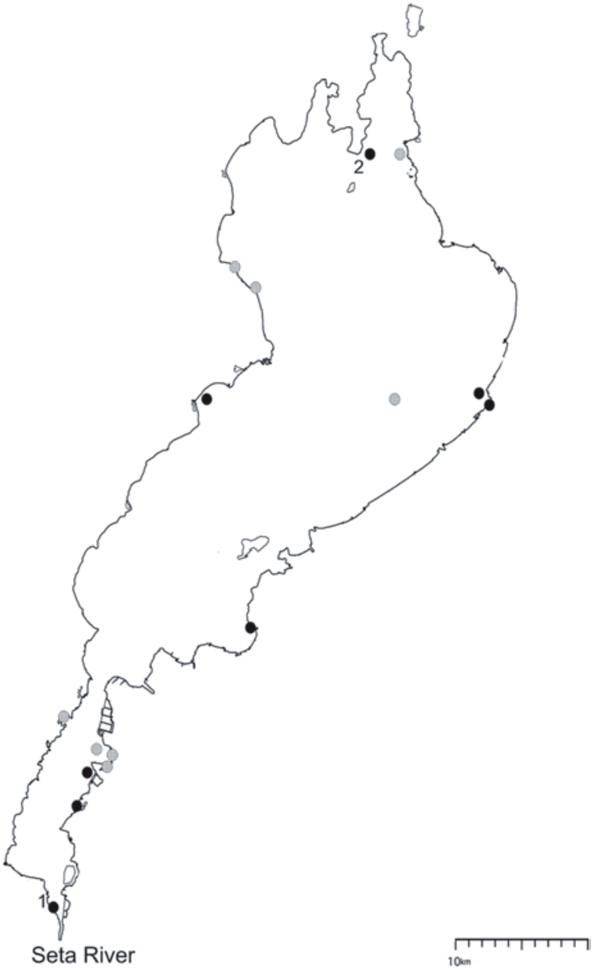
The study of site formation processes has been one of the major focal points of submerged archaeology in Japan. Although some terrestrial sites may have been deliberately submerged by modern development work, the site formation processes of many submerged sites in Japan are likely to be caused by two main physical events. The first includes earthquakes, land uplift or subsidence, as well as mudslides that changed the context of the site rapidly. Another factor is a long-term process of climate change and subsequent alteration in water levels. Cultural factors may also impact submergence and include past religious and ceremonial practices, such as dedicating objects into sacred waters where they would remain in a more intact condition. These and other factors must be taken into consideration when determining how a particular site was formed. To illustrate the differences in site formation processes, case studies of several sites are discussed below.

Sites Around Lake Biwa

Lake Biwa, the largest inland lake in Japan, has 240 km of coastline and has been an important waterway for trade and a source of food for thousands of years for the people who lived in central Japan. Over 100 submerged sites exist along the shores ranging from the prehistoric to the historic periods. These include midden sites of the Jomon Period and medieval residential remains. It is suggested that the formation of submerged sites of the Jomon Period around Lake Biwa is partly related to active tectonic processes (Akita 1997). Some historical documents record that in the past, residences along the foreshore of the lake were significantly damaged by periodic tectonic movements. It is presumed that during the Jomon Period, earthquakes occurred occasionally. A terrestrial site in the vicinity of Lake Biwa, known as the Kitoge Nishi Kaido site dating back to the periods of the Jomon and Yayoi, shows evidence of soil liquefaction from an earthquake that occurred around 3,000 years ago (Sangawa 2009).

The tectonic processes, including earthquakes, do not explain the cause of the submergence of all the sites in Lake Biwa. Akita (1997, p. 270) suggests the impact of water-level change on the site formation processes. Over 100 waterlogged sites, including both prehistoric and historic sites, in Lake Biwa are positioned around an altitude of 81–84 m. Sites dating to the Early Jomon tend to be positioned at lower altitudes than sites dating to the later periods. This suggests that the water level during the Jomon Period was lower where the change in water level took place across the lake. Earthquakes may have caused some sites to submerge, but those tend to be localized events and the depth or altitude would be different from site to site. The water level appears to have changed several times in different periods and people gradually moved their settlements to higher locations. The change of water level is regarded as a primary factor that formed the submerged sites in Lake Biwa; however, the process of inundation at each site requires detailed investigation. The reason for the change in water level at Lake Biwa must be investigated further. The increase in the amount of rainfall at the beginning of the Jomon Period does not fully answer this question (Tsuboi 1994, pp. 156–158). A most notable characteristic of Lake Biwa is that it only has one drainage point, at the Seta River located at the southern tip of the lake (Fig. 15.2). It has been suggested that the silt accumulation in the Seta River or perhaps a localized uplift along the river may have changed the drainage rate of Lake Biwa (Akita 1997, p. 23). When there is uplift at this small drainage point, Lake Biwa would be blocked and the water level would have slowly begun to rise (Shiga Prefectural Association for Cultural Heritage 2010, p. 44).

Fig. 15.2 Submerged sites around Lake Biwa: *1* Awazu submerged site; *2* Tsuzua Ozaki submerged site; *black dots* Jomon sites; *checkered dots* Yayoi and historic sites. (Map by Randall Sasaki)



The exact mechanism of when and how the uplift or silt accumulation changed the drainage pattern has to be investigated. To explain the site formation processes of the submerged sites in Lake Biwa, the impact of multiple factors, such as the change of the drainage system as well as long-term climate change, needs to be considered.

The Lake Suwa Site

As mentioned above, the Sone archaeological site in Lake Suwa was one of the earliest sites in Japan where artifacts were discovered underwater. Archaeologists continued searching for artifacts in the 1920s and again in the 1960s; however, they

Fig. 15.3 A photograph showing Tokonami harbor excavation. (Photo courtesy of Asahi Shinbun)

were merely collecting objects and the vertical and horizontal extent of this site was never recorded. Today, it is believed that the Sone area was once connected to the present shore, but became isolated as the land began to subside gradually. The change in water level at Lake Suwa occurred over thousands of years. The recovered artifacts have been dated between the late Paleolithic and the Incipient Jomon; it can be assumed that it was around this time that the site was abandoned, possibly due to the rising water level.

The Takashima Underwater Site

Takashima in Nagasaki Prefecture is well known as a historical battle site, where a number of Kublai Khan's Yuan Dynasty ships were lost during the attempted invasion of Japan in 1281 AD (Delgado 2008). What is less known is that artifacts from the Incipient Jomon were discovered at an elevation of −25 m beneath the stratum from the Mongolian invasion period (Takashima Board of Education 1993). The fact that the prehistoric site was discovered underwater in Japan has been briefly mentioned in an English resource (Flemming 2004, p. 1228). While the detailed state of the remaining site has not been ascertained due to the poor condition of the waters, the recovered artifacts are most likely to have been identified in situ. An underwater archaeological rescue excavation off the Tokonami harbor in southern Takashima revealed a number of artifacts including Jomon earthenware, lithic tools, bones, ceramics, a stone anchor stock, and wooden remains (Fig. 15.3). A total number of 251 fragments of Jomon pottery constitute the majority of the discovered artifacts (Fig. 15.4). Almost all of them were dated to the Incipient Jomon. The date of the Jomon sherds assemblage appears to correspond with the results from radiocarbon dating on two different species of intertidal shells, *Lunella coronata coreensis* (8630 ± 105 B.P.) and *Monodonta (Modonta) labio* (8410 ± 105 B.P.) (Takashima Board of Education 1993, pp. 75–97). The discovery of the Incipient Jomon sites at such a depth is quite unusual. Although a few Jomon sites have been previously dis-

Fig. 15.4 A photograph of Jomon pottery found at Takashima. (Photo by Kenzo Hayashida)

covered underwater, they are positioned in shallow waters with an elevation of less than −10 m. Identifying the specific site formation processes at this site has been highlighted as the most critical issue. According to the study by Nagaoka Shinji in the site report, there is no clear evidence of mudslide that occurred locally based on the result of the survey of the sub-bottom profiler. Tectonic movements that would have caused mass subsidence of 20 m within 8,000 years are unlikely, since there is no indication of tectonic movements such as active faults around the concerned area (Takashima Board of Education 1993, pp. 105–110). Instead, the submergence of the site probably can be explained by the rise in sea level. The Imari Bay where Takashima is located shows a relatively shallow depth of 60 m on average. The bay was almost dry when the sea level was the lowest around 15,000 years ago. Later, the sea level gradually increased, and the site formed on dry land perhaps around an estuary of the ancient Tokonami River close to the shoreline. Around 8,500 years ago, the sea level reached a current altitude of around −25 m, and the site was inundated with water. Compared with other submerged sites in the region, the beginning of inundation of Takashima around 8,500 years ago is reasonably confirmed; a consistent sea-level rise from the melting of ice caps in the polar areas that occurred between 14,000 and 6,000 years ago has been recorded (Nakada et al. 1994). It is also suggested that hydroisostasy and asthenospheric viscosity affected the submergence of sites located along the west coast of Kyū su Island (Nakada et al. 1994, 1998).

The Katsuura Midden Site, Iriomote Island

The Katsuura midden site is located on Iriomote Island in Okinawa. Okinawa is the southernmost prefecture located in the subtropical climate zone. Iriomote Island is a part of the Sakishima (or Yaeyama) Archipelago, further south of the main island of Okinawa. The Katsuura midden site is identified in very shallow water with a depth of 1.5 m in the estuary of the River Urauti. The details of the site are

Fig. 15.5 Shell mound of the Katsuura midden site at the mouth of the River Urauti. (Photo by Jun Kimura)

available in a Japanese archaeological site report (Excavation team of the Amitori site and Katsuura site 2007). A few shell mounds and artifacts remain in an area of approximately 50 × 12 m^2 (Fig. 15.5). Fifty percent of the shell species was identified as *Geloina coaxans*. The site has been dated to the seventh century AD by the characteristics of a grind stone and several shells from the midden mounds that have a small hole on the surface. This perforation is said to be a part of the decoration of ornaments, and similar products have been identified from other midden sites in this region. The result of radiocarbon dating on an animal bone seems to correspond with the time period estimated from the artifacts. The time period of the site is likely to be classified into the "pre-historic periods" in Okinawa's history where their society substantially relied on a hunter-gatherer system, distinctive from mainland Japan. During this period, it is believed that the people of the islands utilized marine resources extensively.

The result of trench excavations at the site indicates that the current state of the Katsuura midden does not represent an in situ deposit. One reason for this hypothesis is that the shell mounds are exposed on the riverbed and form a very thin layer. Apart from the small number of the abovementioned artifacts, there are no specific remains, such as plant remains that are typically identified in well-preserved submerged midden sites. Contemporary shell mounds are preserved inland around the estuary of the River Urauti, near the current Katsuura midden shell mounds. Although a detailed mechanism of how the site formed is not known, it is believed that the shift of the waterway caused the site to be submerged.

The Tsuzura Ozaki Site

The Tsuzura Ozaki site located in Lake Biwa is considered to be an important underwater site in discussing site formation processes because of its unique feature. The majority of artifacts found were mostly complete Jomon pottery (Akita 1997,

Fig. 15.6 A scene from the recent research at Tsuzua Ozaki submerged site using ROV. (Photo courtesy of Kenichi Yano)

p. 262). Combined with the fact that the site is located at a greater depth compared to other sites in Lake Biwa, it is believed that most of the artifacts were deliberately deposited by a cultural factor. Perhaps, Jomon people offered pots filled with offerings at this location. A few remote sensing surveys and sediment sampling have been conducted here, yet no systematic excavation has been undertaken. The water depth and strong lakebed currents have prevented archaeologists from accessing the site; however, a team of researchers from Ritsumeikan University used a ROV and was able to locate and record artifacts in situ (Sakagami 2011) (Figs. 15.6 and 15.7). This ongoing research may reveal a clearer picture of site formation processes once extensive studies are conducted.

Fig. 15.7 A photograph captured by the ROV of possible Jomon Pottery from Tsuzua Ozaki submerged site. (Photo courtesy of Kenichi Yano)

The Contribution of Submerged Sites to a Larger Archaeological Community

There are many advantages of exploring submerged archaeological sites; however, perhaps the most significant contribution that such sites can provide for the better understanding of the Japanese prehistoric way of life is the fact that waterlogged sites often contain well-preserved organic materials that typically do not exist in a terrestrial context. This is because Japan is located in one of the most active volcanic zones and the soil is predominantly acidic in nature and therefore detrimental for the preservation of organic materials (Hongo 1989, p. 334). For instance, many shell middens produce a large number of small fish, suggesting that people used nets (Nishino 2008, pp. 30–31). Many net weights were found beginning in the Initial Jomon (Maeyama 2010, p. 32). Nets, made of organic materials, rarely survive in archaeological records, and archaeologists must rely only on net weights to infer how people in the past used nets (Tainaka 2010, p. 155). In other words, our understanding of the method of net fishing is far from complete (Komiya 2005, p. 133). A wide gap exists between our knowledge of lithic and pottery technologies and that of technologies based on organic materials, such as basketry or weaving. A large amount of basketry was discovered at a partially inundated Higashi-Myo site in Saga Prefecture dating from the Initial Jomon, and it appears that such trade was already well developed before 7000 B.P. (Bleed and Matsui 2010, pp. 362–363). Such technologies need to be explored and analyzed, but the real potential for submerged sites is that such sites can tell more about past subsistence patterns.

In Japan, 2,375 Jomon shell midden sites were reported in 2007. This number illustrates the importance of middens for the Japanese archaeological community (Mizunoe 2008, p. 58). However, the data that can be collected may be skewed considering differential preservation conditions (Yoshida 2008, p. 51). Bailey and Flemming (2008, pp. 2156–2157) note that "even the astronomical numbers of shells in the largest postglacial shell mounds are not evidence of economies dominated by shell food or even of marine specialists." A recent study of stable isotope analysis of human skeletal remains suggests that the Jomon people had an extremely diverse diet but relied more heavily on plant products, despite the fact that most of the shell middens are void of plant materials (Yoshida 2008, p. 53). This study indicates that the Jomon's subsistence pattern was more complex and diverse than previously thought; however, the study of midden sites on land alone cannot reproduce this sophisticated way of life. The investigation of waterlogged midden sites is, thus, necessary to comprehend the Jomon culture.

Two submerged sites, the Awazu and Torihama submerged midden sites, produced valuable information regarding the early plant utilization by the Jomon people. The submerged Awazu site is located close to the southern tip of Lake Biwa where the lake narrows at the only outlet, Seta River (Tsuboi 1994 p. 42). Three shell middens were analyzed, and the smallest midden, dating to the Middle Jomon, or around 4500 B.P., has been fully excavated and another two middens are preserved in situ (Matsui and Kanehara 2006, p. 263). The other middens date to the Incipient and Early Jomon (Shiga Prefectural Association for Cultural Heritage 2010, p. 148). The site, distributed across 370 × 400 m, was excavated on "dry land" by using a cofferdam to drain off the water (Tsuboi 1994, p. 44). The shell midden consisted of thick layers containing plant remains between the layers of shells, and another layer of plants in between (Matsui and Kanehara 2006, p. 263). It is suggested that plants were discarded during the fall and shells in the spring, thus making an annual layer (Tsuboi 1994, p. 52). Such layering has not been seen on any other midden sites in Japan. Chestnuts and acorns were the major component of the plant remains. Surprisingly, the plants discovered included beans (*Vigna spp.)*, gourds *(Lagenaria siceraria)*, and edible burdock *(Lappa major)* (Matsui and Kanehara 2006, p. 264). These plants are considered to have been cultivated, making the Awazu site one of the earliest sites that exhibits evidence of extensive plant utilization in the country. The reconstruction of diet from the Awazu site indicates that the subsistence patterns of the Middle Jomon people were diverse. Vegetables or plants comprised about 50 % of their diet, while fish or marine resources contributed about 40 %, and the remainder of their diet came from land animal sources (Shiga Prefectural Association for Cultural Heritage 2010, p. 155). Not only edible plants but also such utilitarian species as Urushi or lacquer tree (*Rhus verniciflua*), considered to be native plants of China, were found (Noshiro 2010, pp. 94–97). The cultivation and utilization of Urushi require extensive knowledge of the tree, and why and how the Jomon population came to possess such a comprehensive understanding of a single species of tree needs further research and explanation (Noshiro et al. 2007).

Another waterlogged site located just north of Lake Biwa, in Fukui Prefecture is the Torihama site at Wakasa Bay; the area the site is located was a cape extending into an ancient lake, and the shell midden was formed by people disposing garbage into the lake (Hongo 1989, pp. 333–334). The excavation began in 1962 (Matsui and Kanehara 2006, p. 262). The site was occupied during the Incipient and Early Jomon, and then again after a hiatus, from the Final Jomon to the beginning of the Yayoi Period. The shell midden is about 120 m across (Hongo 1989, p. 334). No fish hooks were found, but the presence of net weights and part of a logboat indicate that the people used nets from watercraft (Hongo 1989, p. 349). The people who lived at Torihama collected tidal species of mollusks along with fish, and the catchment analysis suggests that people collected resources close to the site, perhaps within a 5–8 km radius (Akazawa 1981, p. 249). During the Late Jomon, more reliance on game meat is evident (Hongo 1989, p. 352). Archaeologists learned a great deal about the exploitation of marine resources from the Torihama site; however, it was the analysis of plant remains that revolutionized or reconceptualized the understanding of the Jomon in Japan (Taniguchi 2010, p. 25). The excavation and analysis became the model of later research for plant or animal and environmental studies (Toizumi 2010, pp. 4–5). Plants such as the beefsteak plant (*Perilla frutescesns*), egoma (*Perillao cymoides*), paper mulberry (*Broussonetia apyrifera*), flax (*Cannabis sativa*), and gourd were discovered, all dating between 6000 and 5220 B.P. (Matsui and Kanehara 2006, p. 263). Analysis of the wooden remains points to the fact that different tools were made with different wood species suggesting that the people knew the specific properties of the timber and utilized them accordingly (Noshiro 2010, p. 91). The most prominent plant remains found at the site were kuri or sweet chestnut (*Castane spp.*); it consisted of up to 80 % of all the wood species found at the site (Noshiro et al. 2007, p. 92). The use of kuri may have been the most important tree that Jomon people utilized. Selective management of trees is suggested because kuri does not grow as a single forest in nature, but the Jomon people utilized this single type of tree intensively; people may have cut down other trees to encourage the growth of kuri forest (Taniguchi 2010, p. 8). The size of the kuri nuts was smaller during the Early Jomon compared to that of the Middle or Late Jomon (Noshiro 2010, pp. 92–94). The estimated growth rate of kuri trees using annual tree rings from samples found from archaeological sites was compared to that of natural kuri trees. The results suggest that the kuri trees found in an archaeological context exhibit faster growth rates than the trees found in nature, suggesting human intervention (Toizumi 2010, p. 11). The kuri tree is easy to cut down, strong against decay, and it is one of the fastest growing trees in Japan. These properties may be part of the reasons why the Jomon people utilized the tree extensively (Noshiro 2010, pp. 92–94).

Conclusion

The preceding represents a summary of the current state of research on submerged prehistoric sites in Japan. Only a small number of sites have been investigated in the country, and thus *any* new discoveries would change the content of this chapter. The potential for further research in this field is extremely promising, and the authors hope that this chapter is of use as an initial effort to bring more focus on the subject. The climate, environment, and sea-level changes affected the lifestyle of ancient Japanese people, as is most prominently visible in the formation and disappearance of shell midden sites. The island nation of Japan has always been affected by changes in sea level, and the adaptive strategy of the people who lived along the coasts should be carefully studied. Site formation processes is one of the topics that underwater archaeologists in the country have been discussing for many years, and the complexity of the processes should not be taken lightly. Several inundated sites have already exhibited the potential for telling archaeologists of the diverse and ingenious adaptive strategies of the ancient Japanese people; an intensive investigation across sites located in various environments is overdue.

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Chapter 16
New Developments in Submerged Prehistoric Archaeology: An Overview

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It is now 30 years since Patricia Masters and Nicholas Flemming (1983) published *Quaternary Coastlines and Marine Archaeology*: *Towards the Prehistory of Land Bridges and Continental Shelves*, the outcome of a workshop held at the Scripps Institute of Oceanography at La Jolla, California, in 1981. In retrospect, this stands out as a landmark meeting, which first identified the continental shelf as a coherent and worldwide field of study in its own right, the need for systematic research drawing in specialists from multiple disciplines in marine science and archaeology, and some of the challenges as well as the opportunities of such investigations. As a participant in that meeting, I remember well the stimulation of communication across unfamiliar disciplinary boundaries, the potential for new research collaborations, the sense of enthusiasm at the prospect of new frontiers of knowledge to be breached, and the optimism about the prospects for purposeful new investigations and new discoveries.

In the decades since then, it is fair to say that progress has been slow and, at best, intermittent, confronted by a persistent scepticism, at least within the discipline of prehistoric archaeology, as to whether underwater investigations are either feasible or worthwhile. During the 1980s and the 1990s, the most visible work occurred in relatively isolated circumstances, most notably in Denmark with its seemingly unusual conditions of preservation in the calm and shallow waters of the western Baltic (Andersen 1985; Fischer 1995a), and off the Carmel coast of Israel where a group of Neolithic remains includes the unusual Pre-Pottery Neolithic site of Atlit Yam with its evidence of mixed maritime and farming activity (Galili et al. 1993). Both projects were heirs to regional traditions of underwater research already well represented at La Jolla (Larsson 1983; Raban 1983). However, these results could easily be dismissed as exceptions that contributed little new, beyond unusually good preservation of organic materials, to a wider knowledge of the prehistoric periods in question. Indeed, one of the criticisms of underwater research that persists to the present day is that much work represents the development of new techniques and

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the industrious accumulation of new data with relatively little attention to how this might bring new light to bear on the big questions of prehistory (Anderson 2012).

Much of the recent interest in and new research on submerged prehistory has been focused on Europe (see in particular, Benjamin et al. 2011; Bailey et al. 2012). If there is one clear message that emerges from the chapters in this volume, it is that submerged landscapes and archaeological traces of their inhabitants are now being retrieved and systematically examined across the world in all the major continents and in deeper as well as shallower water, and that there is serious and ever-widening engagement with the intellectual and logistical challenges of underwater research. In reflecting on the current state of play as represented in these chapters, I briefly consider three issues: the tortuous pathway towards the acceptance of new ideas and the factors that have variously impeded or stimulated the growth of new knowledge; the research questions that are now coming more clearly into focus and the directions they suggest for future development; and the challenge of developing purposeful strategies of exploration for the discovery of new archaeological material.

An Emergent Discipline

It is characteristic of a pioneer phase in the development of a new field of knowledge that relevant data are initially acquired haphazardly or by chance, and may languish long neglected in unpublished archives, obscure reports, or museum basements until a change in the intellectual climate gives them retrospective significance. That is certainly the case with the submerged archaeology of prehistoric periods, and one of the interesting revelations from many of the chapters in this volume is the number of scattered underwater finds and pioneer investigations that were carried out in the earlier decades of the twentieth century and even into the 1980s and beyond, but with results that were either not published at the time, or disseminated only in unpublished reports or local journals. Examples are the discovery of underwater stone artefacts in Japan in the early decades of the twentieth century, and the 40-year-long tradition of excavating submerged Jomon lake sites using coffer dams (Hayashida et al., Chap. 15); Dixon's 1976 geophysical survey in central Beringia, which must rank as one of the earliest reported examples of purposeful underwater survey using predictive models of archaeological site location (Dixon and Monteleone, Chap. 6); the discovery of submerged archaeological sites in the Gulf of Mexico in the late 1970s using sediment coring and data from oil and gas exploration to predict submerged land forms and site locations (Pearson et al., Chap. 4); the chance recovery in 1970 of the Cinmar leaf-shaped biface and mastodon tusk on the outer continental shelf offshore of Chesapeake Bay, and their display in a local museum for 30 years before their wider significance was appreciated (Stanford et al., Chap. 5); and the early discoveries of submerged and waterlogged materials in Australia, and more recent work there demonstrating the survival after inundation of archaeological material on lake and river banks (Nutley, Chap. 14). All these examples gain significance in the light of more recent developments in the discipline but were scarcely known about or reported to the wider scientific and academic community at the time.

Undoubtedly two persistent impediments to progress have been the widespread belief that nothing worthwhile is likely to have survived the destruction and disturbance of inundation, and the assumed technical difficulties and high ratio of cost to reward involved in underwater research. This volume provides abundant examples to refute both beliefs. It is clear that archaeological material—and the bones of terrestrial fauna—can be preserved and recovered under a great variety of underwater conditions—on high energy coastlines exposed to the open sea (Bayón and Politis, Chap. 7; Carabias et al., Chap. 8; Bicket et al., Chap. 12; Werz et al., Chap. 13) as well as low energy ones (Jöns and Harff, Chap. 10; Hayashida et al., Chap. 15), and in deeper water (Stanford et al., Chap. 5; Dixon and Monteleone, Chap. 6) as well as in shallow conditions. The case of the Argentinian intertidal site of La Olla is instructive (Bayón and Politis, Chap. 7), demonstrating that a long and straight sandy beach facing the open ocean and exposed to large waves and storms can nevertheless preserve material with stratigraphic integrity and good organic preservation.

Shell mounds, that ubiquitous indicator of coastal economies, are a much sought after indicator on submerged palaeoshorelines, not least because of the likelihood that they may register a distinctive geophysical signature in acoustic surveys (Faught, Chap. 3). They occur worldwide in their hundreds of thousands on mid-Holocene shorelines associated with modern sea level, so much so that many archaeologists have seen them as indicators of postglacial intensification and population growth. That interpretation is suspect, given the close association of the earliest shell mounds with the establishment of modern sea level, and just one discovery on a submerged shoreline of significantly earlier date would change thinking on this topic. However, such finds have proved elusive. Nutley (Chap. 14) doubts the ability of unconsolidated shell-mound deposits to survive inundation, given the evidence of site destruction by storm damage on the modern Australian coastline. We have faced similar difficulties in identifying submerged shell mounds in our work in the Red Sea despite the existence of thousands of extensive mid-Holocene mounds on the modern shorelines of the Farasan Islands (Bailey 2011; Bailey et al. 2013). Here, in addition to possible wave dispersal and destruction of shell material, we also have to factor in the dynamic nature of the coastline. Extensive, shallow intertidal bays capable of generating large quantities of molluscs are, in this region, unstable and short-lived phenomena. A further complication is that when sea levels are changing rapidly, even with a continuously available supply of abundant molluscs, shorelines may not remain in the same place long enough for shell consumption to generate archaeologically visible accumulations of shells before people are forced to move on, a point also made by Fischer (1995b, 382).

In contrast, Faught (Chap. 3) provides an actual example of a submerged shell mound off the Florida coastline. Here, survival appears to be due both to consolidation of the shell deposit by vegetation growing on the pre-inundation mound surface and also to the accumulation of protective sediments around the deposit as sea level rose. Several authors draw attention to other types of archaeological materials that have survived submergence, or are likely to do so and to be easily detectable—

stone fish traps and fish weirs, rock outcrops, stone structures, semi-subterranean pit depressions or circular features, rock shelters, rock art, and timber work associated with boats are variously mentioned by Faught (Chap. 3), Dixon and Monteleone (Chap. 6), Momber (Chap. 11), and Nutley (Chap. 14). In addition, Werz et al. (Chap. 13) make the interesting point that inundated land surfaces with shallow gradients and lack of sediment cover, typically to be found in deeper water and further offshore on the South African shelf, may be better places to look for early Stone Age artefacts, given that surface finds are abundant and important indicators of early human settlement on the present-day dry land.

The lesson of these examples is that it is not possible to generalize on a large scale about the sorts of coastlines that will be conducive to archaeological preservation or destruction. Local conditions are the key factor; and site survival and visibility will depend on a complex matrix of interacting variables, which include the balance between sediment accumulation and erosion during and after inundation, the ecological conditions for human activity in the near-shore region, the quantity, durability and visibility of the types of materials left as by-products of past human activity, and the discard behaviour of the people in question. If this sounds like a complex research problem, exactly the same is true of archaeological sites on land, and both domains are still at an early stage in developing understandings about 'landscape taphonomy'—the interaction of human behaviour, archaeological visibility and preservation, landscape evolution, land use, and land degradation—as a research field in its own right.

The cost of underwater work remains a major inhibition for many archaeologists, but several chapters demonstrate what can be achieved with relatively inexpensive methods of shallow-water diving and remote sensing (Faught, Chap. 3; Carabias et al., Chap. 8; Momber, Chap. 11). In deeper water, cooperation with industrial companies working on the seabed has undoubtedly helped to open up new opportunities and new discoveries, reinforced by the extension of national legal obligations to manage the underwater cultural heritage, and international treaties such as the UNESCO 2001 Convention on the Protection of the Underwater Cultural Heritage. The North Sea has been especially well served by these developments (Bicket et al., Chap. 12). But even here, differences of approach between different national jurisdictions can impede integration and understanding (Salter et al., Chap. 9), and in the USA, Faught (Chap. 3) notes that only three out of twenty-two coastal states require evaluations of submerged prehistoric material in advance of industrial work on the seabed.

Research Questions

I am often confronted with the view that the large sums of money required for underwater prehistoric research could be better devoted to archaeological investigation on land. This is a fallacious argument as well as a dangerous one, and in any case one that is increasingly irrelevant—fallacious because underwater archaeology is not necessarily more expensive than work on land; dangerous because it assumes without further demonstration the relative value of different research activities and opens the door to the argument that terrestrial archaeology in its turn should be deprived of funds to the benefit of more valuable research in, say, renewable energy or nanotechnology; irrelevant because some archaeologists are now, in any case, securing large-scale funding for research-driven investigations. Examples of the latter are the National Science Foundation (NSF) Gateway to the Americas project (Dixon and Monteleone, Chap. 6), the German Research Foundation (DFG) SINCOS project (Jöns and Harff, Chap. 10), and the European Research Council (ERC) DISPERSE project in the Red Sea (Bailey et al. 2012). Increasingly, funding bodies are attracted to the support of large-scale collaborative projects involving cooperation across national as well as disciplinary boundaries, and underwater research creates and demands exactly those sorts of collaborations, often with the added bonus of producing new knowledge of wider social and economic relevance, for example in understanding the social impact of sea-level change, or the improved management of the underwater cultural heritage. New opportunities of this sort are now being opened up by international research networks such as the European COST-funded SPLASHCOS project (Bailey et al. 2012; Jöns and Harff, Chap. 10).

If the research problem is worth investigating, it should be worth funding, and it is up to those who wish to work under water to make the case for support. Ship time, of course, is very expensive (unless supplied free of charge through collaboration with industrial operators—see Bailey et al. 2007), but increasingly necessary as one moves into deeper water and outer areas of the continental shelf. The key, then, to the funding of research-driven underwater investigations must be the articulation of research questions that are of central importance to a wider understanding of prehistory—and that cannot be answered in any other way.

One such problem is the dispersal of human populations out of Africa during the Pleistocene, the earliest colonization of new continents, and the early Holocene expansion into the newly deglaciated regions of the northern hemisphere. Most of this process of population expansion was taking place when sea levels were lower than present, and cannot be understood without investigation of now-submerged coastal regions. This has long been on the research agenda in North America (Stanford et al., Chap. 5; Dixon and Monteleone; Chap. 6). Regardless of whether one thinks the earliest colonists were big-game hunters or seafarers and fishers—and the likelihood is that they were adept in both the terrestrial and the marine domain—it is clear that coastal regions on both the Atlantic and Pacific coasts must have played a key role. One hint of how this may play out is provided by Stanford et al. (Chap. 5) in their discussion of the Cinmar finds. These provide unequivocal evidence for the early use of the submerged landscape 100 km offshore of Chesapeake Bay on the Eastern seaboard. If the dates are confirmed—and the arguments in favour of associating the laurel-leaf spear point with the radiocarbon-dated mammoth tusk are persuasive—they extend human presence in the Americas by nearly 10,000 years beyond the current earliest widely accepted date of entry, a dramatic result with serious implications for current debates about the timing and mode of entry of the earliest colonists.

Similar arguments and investigations are under way into the role of the submerged landscape in early population movements from Africa across the southern end of the Red Sea into Arabia and the India Subcontinent (Bailey et al. 2007; Lambeck et al. 2011). In Australia, perhaps because human colonization necessarily involved sea crossings and presumed exploitation of marine resources even at lowered sea level, reconstruction of submerged landscapes has been seen as less critical to understanding the process of dispersal. But, as Nutley (Chap. 14) observes, the earliest sites that acted as points of departure in Southeast Asia, and the earliest landfalls in New Guinea and Australia, must now be under water, and investigation of the submerged landscape, which is extensive in this region, is critical to understanding the ecological and social dynamics that propelled human expansion out of Southeast Asia.

Another problem that is coming more sharply into focus is the social and demographic impact of sea-level change (Lacroix et al., Chap. 2; Jöns and Harff, Chap. 10; Momber, Chap. 11). The idea of flood events as triggers of demographic change has been much popularized by Ryan and Pitman's work in the Black Sea, linking the sudden inundation of coastal terrain with agricultural dispersal (Ryan et al. 1997; see also Turney and Brown 2007). These ideas are controversial because the different marine geoscientists who have worked in the region do not agree on the pattern of sea-level change (Lericolais et al. 2009; Yanko-Hombach 2011); because there has been little exploration of the submerged landscape and no hard evidence for or against pre-inundation farming settlement in low-lying coastal regions, and because agricultural dispersal was likely the outcome of a complex interweaving of ecological, environmental, climatic, and social variables that cannot be pinned down to a single 'prime mover'. At any rate, the Black Sea controversy highlights the need for improved data on sea-level change and on the changing environmental potential and human use of the now submerged landscape, and the need for detailed investigations that integrate sustained and critically evaluated environmental, geophysical and archaeological research. Jöns and Harff (Chap. 10) describe just such a project for the Wismar Bay region of the western Baltic with the discovery of some 20 underwater archaeological sites and the refinement of a sea-level curve that can be projected into the future. This example shows the enormous advances that can be achieved by integrating a multi-disciplinary team and persistent effort over a period of years.

The reality is that sea-level change has been a continuous and world-wide accompaniment to human existence throughout the past 2 million years, and that flood events of greater or lesser severity have occurred repeatedly at many different times and places across the world. Lacroix et al. (Chap. 2) describe a good example from Atlantic Canada 3400 years ago that is still incorporated in the social memory of the present-day indigenous community, and Momber (Chap. 11) considers some of the ways in which progressive and episodic flooding of the North Sea resulted in long-term changes in regional archaeological records. Moreover, it is not only sea-level rise that poses questions about the human implications, but also sea-level lowering, which would have exposed new ecological challenges as well as extensive fresh territory for colonization, in some cases as extensive as the new territory exposed by glacial retreat at the beginning of the Postglacial Period.

Another theme of perennial interest that has seen a recent resurgence is the linkage of Holocene sea-level rise and stabilization to a complex of social and economic changes including intensified use of marine resources, sedentary settlements, increased social complexity, monumental architecture, and the development of early agriculture. The most recent and comprehensive elaboration of this theory (Day et al. 2012) suffers from the difficulties of its many predecessors in discounting or ignoring the contradictory evidence that may exist on the seabed from earlier periods of lowered sea level. Since the archaeological evidence of the social and economic changes in question must occur ex hypothesi in coastal regions, it follows that any similar examples that existed before the stabilization of modern sea level must, by definition, now be submerged and currently unknown, because systematic underwater exploration designed to find the relevant evidence has scarcely begun. The Holocene examples thus gain an exaggerated significance that may be largely illusory. Day et al. reinforce their argument by dismissing the productivity of submerged coastlines on the basis of generalizations about bathymetry and sea-level curves that are oversimplified to the point of caricature. As with everything else that we are learning about submerged prehistory, variability in local conditions and rates of change in the physical character and ecological potential of submerged coastal regions is likely to defy any attempt at simple generalization.

Similar criticisms apply to the belief that the increased representation of marine resources in archaeological sites of Last Interglacial age, notably in Africa, signifies an intensification associated with the appearance of ‘modern humans’ (e.g. Walter et al. 2000), when the evidence probably indicates no more than the increased archaeological visibility of coastal and marine activities during a period of high sea level; or the belief that the submerged coastline around the rim of the Indian Ocean is so uniformly productive that it must hide the missing evidence that is needed to support the hypothesis of a rapid coastal dispersal of modern humans from South Africa to India 60,000 years ago (Mellars et al. 2013). Until investigations of the type described in this volume are more widely applied, the role of the continental shelf will continue to be discounted or exaggerated according to the particular theoretical preconceptions of the authors in question.

Exploration Strategies

Integrated research that combines critical assessment of archaeological and geoscientific data from the continental shelf is difficult, but the potential rewards are considerable, not only in challenging existing archaeological orthodoxy and creating new knowledge about the deep history of coastal, maritime, and seafaring activity, but in refining the understanding of past sea-level change. New problems will place new demands on methods of exploration, and that challenge should not be minimized. The first step in many cases, and one that can be achieved with a high probability of success, is the reconstruction of the physical features and environmental characteristics of the submerged landscape. Even without the discovery of archaeological material, that first step can provide a new perspective on the interpretation of the existing archaeology on land, as demonstrated by Lacroix et al. (Chap. 2) and Werz et al. (Chap. 13). It also provides an essential baseline for locating earlier archaeological material under water.

When it comes to the location of archaeological finds, the risk of failure is higher. Many of the most impressive archaeological sites were initially found by chance, but future work must develop purposeful and successful strategies of site identification. There are, however, many hopeful signs. The use and adaptation of Anders Fischer's site-fishing model to predict the location of submerged sites in European settings is well known (Fischer 1997; Benjamin 2010). Equally impressive in its success is the work reported in this volume that has been going on for some time in North America. Development of predictive models based on known archaeological sites on land, reconstruction of submerged land forms using a combination of diver inspection, video, and acoustic survey, and taking account of preservation issues, and testing and retrieval of archaeological remains using coring, grab sampling, or excavation, are common ingredients of an evolving research strategy on both sides of the Atlantic (Faught, Chap. 3; Pearson et al., Chap. 4; Dixon and Monteleone, Chap. 6; Jöns and Harff, Chap. 10; Momber, Chap. 11). Similar thinking is informing the research design of underwater exploration in Africa and Australia (Werz et al., Chap. 13; Nutley, Chap. 14).

One of the most impressive examples of site discovery is the work of Daryl Fedje and associates off the coast of British Columbia, reported here by Dixon and Monteleone (Chap. 6), involving bathymetric survey of land forms, lakes and stream channels, identification of a likely site location at a depth of over 50 m, application of a bucket grab, and the retrieval of a stone artefact and some wood. Further work on this site should certainly prove of great interest but appears to be stalled for the moment for lack of funds. Dixon and Monteleone, on the basis of their experience of running transects that combine a remotely operated vehicle with side-scan sonar, go so far as to assert that site survey under water may actually be easier than on land in their region. Whether that optimism can be justified elsewhere remains to be seen, but as more work is carried out and more discoveries are made, so the momentum for new research will grow.

Conclusion

The discipline of continental shelf archaeology, or submerged prehistoric archaeology, is still very young, and the logistic and financial hurdles to be overcome remain formidable. Progress over the past 30 years has been slow, but there has been a marked acceleration of interest and work in the past decade, and the range of research now being carried out suggests that the discipline has reached a critical mass that should provide the momentum for future work. As the results of ongoing work become more widely disseminated, so the research problems capable of being illuminated by underwater research will become refined and expanded, and the justification for funding easier to make, creating a virtuous circle of interaction between new field investigations and new ideas. It is not too much to suggest that we are entering a new phase of development, with a panorama of new research opportunities opening up that will transform our understanding in the coming decades.

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Correction to: Submerged Paleolandscapes: Site GNL Quintero 1 (GNLQ1) and the First Evidences from the Pacific Coast of South America

Diego Carabias, Isabel Cartajena, Renato Simonetti, Patricio López, Carla Morales, and Cristina Ortega

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The author Diego Carabias was incorrectly presented in the initially published online version of Chapter 8 "Submerged Paleolandscapes: Site GNL Quintero 1 (GNLQ1) and the First Evidences from the Pacific Coast of South America". This has now been corrected.

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