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Continental Shelf Archaeology: where next?

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Until very recently the case for systematic exploration of the now submerged landscapes of the continental shelf was taken seriously by rather few mainstream archaeologists, and advocacy in support of underwater prehistory was usually regarded as evidence of enthusiasm for diving, hopeless optimism with regard to the prospects of discovering useful information, or indulgence in fanciful speculation. Developments in the technology of underwater exploration, the steady accumulation of finds, the quality of preservation of organic materials, and above all the realization that coastal regions for most of human prehistory are now submerged and most likely played a key role in many of the most important developments in prehistory, are slowly shifting the climate of opinion. The question now is not whether we should undertake underwater exploration, but how we should go about it. Here, there are still powerful inhibitions and uncertainties, especially when it comes to the deeper areas of the shelf and to the systematic discovery of archaeological sites. Large-scale international collaboration, engagement with industrial and commercial partners, development of purposeful and realistic strategies of exploration, a new and growing generation of trained practitioners, an expanding knowledge base about the taphonomy of underwater landscapes and archaeological remains, and the progressive extension of experience from land to shallow water, and from shallow to deeper water, are all foreseeable ingredients of the next phase of investigation.

Keywords: coastlines, Farasan Islands, Gibraltar, Red Sea, shell mounds, underwater archaeology

Introduction

The publication of this volume, and the organization of the conference session that gave rise to it, are evidence of a broad and growing shift of opinion within archaeology about the desirability and viability of undertaking systematic exploration of the submerged landscapes of the continental shelf drowned by sea-level rise at the end of the Last Glacial. Indeed, the acceleration of interest within the past decade in the possibilities of such work and the desirability of carrying it out has been quite dramatic. There is, however, a difference between stating that something is desirable, and actually acting on that motivation, let alone achieving the hoped for results. There remains at the present time quite a large gap between aspiration and achievement, and probably quite a long period of exploration and experimentation still ahead of us before we can talk about approaching the full realization of an integrated discipline dedicated to the submerged prehistoric archaeology and landscapes created when sea levels were lower than the present, or continental shelf archaeology (hereafter CSA). The aim of this paper is to summarize the steps in my own conversion to the cause of CSA, to review the intellectual case for promoting it, and to evaluate the problems and possibilities of realistic engagement and the strategies for dealing with them, using recent fieldwork in the Farasan Islands and Gibraltar as a basis for discussion.

Background

Like many archaeologists interested in coastal prehistory, my awareness of the problem created by sea-level change, that most coastal sites and shell middens pre-dating the Middle Holocene would most likely be submerged or destroyed because of sea-level rise at the end of the Last Glacial period, has a long history, in my case going back to the beginnings of my research career. A key factor in my own thinking was the growing body of evidence for a sea-level regression of at least 100 m during the Last Glacial Maximum and its likely impact on the visibility of coastal shell middens or other archaeological evidence for the use of Pleistocene coastlines. In the 1970s, there were still considerable gaps in our understanding of sea-level change and ongoing speculation about possible high sea-level stands within the Last Glacial. The demonstration that oxygen isotope ratios in deep-sea cores provide a direct measure of changing ice volumes and therefore by definition a sea-level curve, marked a significant step toward an agreed eustatic sea-level curve of universal applicability, although there were still uncertainties about sources of error and the correlation of isotope ratios with sea-level depths (Shackleton 1967, 1977; Shackleton and Opdyke 1973). Another significant landmark was the La Jolla conference organized by Pat Masters and Nic Flemming in 1981 (Masters and Flemming 1983a), at which there was extensive discussion and optimism about the prospects for moving the discipline forward and mounting sustained investigations of the submerged shelf, deploying a range of techniques and technologies from a variety of disciplines. It is symptomatic of the barriers and inhibitions to this type of research, especially the high costs of conducting underwater investigations and the high ratio of intellectual risk to reward, that, in spite of the growth in the number of finds and systematic underwater archaeological excavations in certain key regions, the integration of the results into the mainstream of archaeological interpretation has been relatively slow, and their impact on the broader narrative of world prehistory quite limited.

Like many then and since, I had no clear view about the viability of direct underwater exploration, no practical knowledge of how to go about it, and little information with which to judge the effects of sea-level rise on the survival or visibility of archaeological deposits, in spite of an optimistic assertion that conditions might exist in which substantial midden deposits could survive inundation and be accessible to discovery (Bailey 1983; Masters and Flemming 1983b). Also, not being a diver or a sailor, I had little inclination to dip my toe, literally or metaphorically, into these uncharted waters. Moreover, the archaeological application of remote sensing techniques to the reconstruction of submerged landscapes using acoustic survey and underwater vehicles was still in its infancy. Most of my analysis of the problem was confined to demonstrating the changes in the visibility of evidence for shell gathering, marine resource exploitation, and maritime activity generally, which must result from changes in sea-level. Even that simple point was open to challenge by large sections of archaeological opinion that wanted to see in the explosion of Middle Holocene evidence of coastal activity an indicator of population growth and intensification, rather than the effect of increased visibility of evidence following stabilization of sea level. Both sides of this argument remained stalled by negative evidence: I could not prove that Upper Palaeolithic or earlier coastal shell middens existed and awaited discovery 20 m or more beneath the sea, and those who opposed that view could not disprove that possibility.

My interest in the problem received further impetus with the culmination of the Klithi project in northwest Greece (Bailey 1997a). Dedicated to investigating the wider landscape context of human activity in the region throughout the Palaeolithic sequence, one of the main outcomes of that project was to point to the extensive and now submerged areas of coastal territory as most probably the main regional focus of human settlement and activity: '… one of our greatest areas of ignorance, and one of the greatest challenges to future research' (Bailey 1997b: 674). We considered the possibilities of offshore exploration in that project, but further development of these ideas was halted by a variety of inauspicious circumstances and changing political conditions, including the heightened security risks of operating in Greek waters close to the Albanian border in the early 1990s.

Resumption of new research on coastal shell middens in Europe and the coastal factor in early human dispersals (Bailey and Milner 2002; Flemming *et al.* 2003; Milner *et al.* 2007) led to a further articulation of the case for the likely importance of coastal environments and marine resources in the deeper time ranges of human prehistory, and highlighted the need for underwater exploration (Bailey 2004a, 2004b; see also Erlandson 2001; Erlandson and Fitzpatrick 2006). From 2004 onwards, new field research in the Saudi Arabian sector of the southern Red Sea and offshore of the Neanderthal caves in Gibraltar provided an opportunity to experiment with underwater exploration as part of more broadly based investigations of coastal archaeology in these regions, which is still ongoing (Bailey *et al.* 2007a, 2007b, 2008, in press; Bailey 2009, 2010; Alsharekh *et al.*, in press). In the past 20 years there has also been rapid development and deployment of technologies for underwater survey, driven in large part by the expansion of industrial activity on the seabed, which have transformed the potential for underwater work. It is not my purpose in this chapter to give a detailed account of the offshore work that we have conducted in the Red Sea or Gibraltar, but I will refer to that work as a source of reflection about the current state of CSA.

What are we missing?

What difference would it make to our understanding of human prehistory if archaeological and palaeoenvironmental evidence from periods of lower sea level were preserved underwater and could be systematically investigated? What are we missing by not engaging with the exploration of CSA?

The case for the survival of evidence underwater and the general methods available for its investigation is made at length elsewhere (Fischer 1995a; Flemming 1998, 2004; Bailey and Flemming 2008; Ballard 2008; Gaffney *et al.* 2009; chapters in this volume). Suffice it to say here that enough investigations have now been carried out to show that archaeological sites can survive inundation, sometimes in great numbers and with excellent preservation of organic materials. In favoured conditions, as in the calm and shallow waters of Denmark and northern Germany, underwater investigation has revealed whole categories of evidence that would not occur on land, or would only rarely be preserved in terrestrial deposits, such as plant fibres and wooden artefacts, communal fish traps, boats, and house structures (Andersen 1980; Lübke 2003; Skaarup and Grøn 2004; Fischer 2007; Harff *et al.* 2007). Also, it is now clear that seismic records collected for other purposes by the oil industry can be successfully used to give detailed reconstructions of submerged landscapes, given sufficient computing power (e.g. Gaffney *et al.* 2007, 2009). The Mousterian site of Fermanville off the coast of northern France (Scuvée and Veraghue 1971; Cliquet, this volume), the Early Stone Age finds off the coast of South Africa (Werz and Flemming 2001), and the recently recovered finds of handaxes and a Neanderthal skull fragment from the North Sea (Glimmerveen *et al.* 2004; Hublin *et al.* 2009) demonstrate that material significantly earlier in date than the Last Glacial Maximum can be recovered. There are, however, some very major gaps in our current knowledge, particularly with regard to the discovery of archaeological sites on the deeper parts of the continental shelf, and an understanding of the underwater conditions in which sites are likely to be preserved and accessible to discovery. I shall return to these problems later. They represent areas of research where the chances of success are unpredictable and the costs of investigation likely to be high. If they are to be worth pursuing, something must first be said about the intellectual justification for doing so.

The intellectual case depends first and foremost on an appreciation of the history of sea-level change and its implications. The broad pattern of sea-level change in response to the glacial–interglacial cycle has been transformed by the deep-sea isotope record, as noted earlier. Modelling of relative sea level in many regions incorporating refinements of the isotope record and dated evidence of sea-level stands has produced an increasingly detailed and well-supported framework of sea-level change (Chappell and Shackleton 1986; Shackleton 1987; Lambeck and Chappell 2001; Siddall *et al.* 2003) (Fig. 25.1). The curves reproduced in Figure 25.1 are of course smoothed and subject to various potential margins of error, depending on which deep-sea records are used and on the degree of correction required to account for other factors such as temperature change that can contribute to the isotope signal. Higher resolution records in some regions and for some periods do of course also show smaller-scale fluctuations. Earth crust (isostatic) response to changing loads of ice and water masses also affects the relative position of sea level in different regions. Furthermore, the integration of geophysical modelling and dated benchmarks of sea-level position is constantly being refined (Lambeck 1996a, 1996b, 2004). A comparable pattern of amplitude and periodicity can be

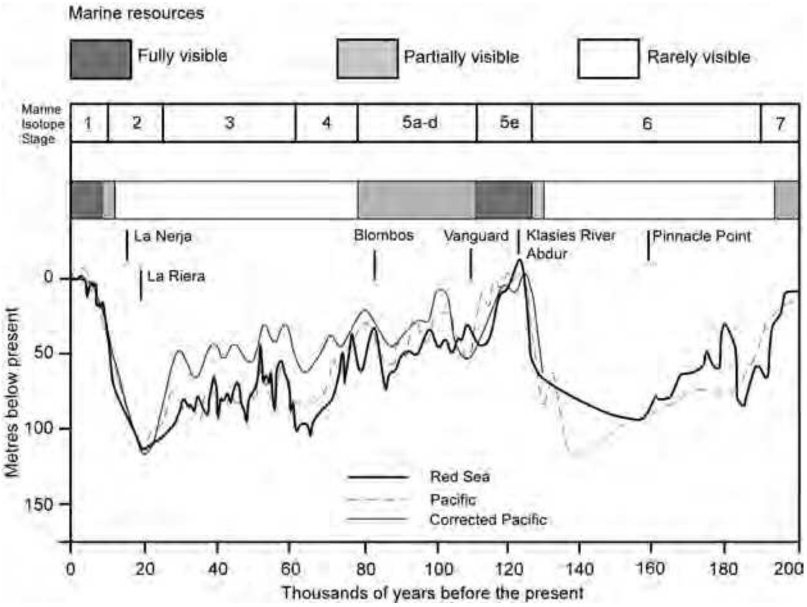


Figure 25.1: Sea-level curve over the past 200,000 years, showing likely impact on the visibility of coastlines and archaeological evidence of marine resource exploitation. Site names refer to coastal sites in Africa and the Gibraltar Peninsula with early evidence of marine resources (Sea-level data from Chappell and Shackleton, 1986; Shackleton 1987; Lambeck & Chappell 2001; Siddall et al. *2003; Waelbroek* et al. *2002)*

extended back to about 0.8 million years, with similar qualifications. In the earlier time ranges of the Pleistocene, the isotope record indicates a lower amplitude of sea-level change but with clear evidence of ongoing periodicity (Shackleton and Opdyke 1976). There remain uncertainties of measurement and variations between different records, but these cannot obscure the main point: for most of human history on this planet, eustatic sea levels have been substantially lower than the present, by about 40 m for most of the glacial cycles during the past 0.8 million years, and for shorter periods by over 100 m, with sea levels at or close to the present level accounting for no more than about 10 per cent of the total record. At the end of the Last Glacial period, sea level rose from a depth of -130 m after *c.* 19 ka cal BP to reach the modern level at *c.* 6.8 ka cal BP, so that any evidence of shoreline settlement and adaptation before that time is likely to be partially or wholly below present sea level.

Some impression of the amount of land exposed at lower sea level can be gained by looking at simple bathymetric contours. On a world scale, extensive areas of shallow shelf were exposed at the Last Glacial Maximum (Fig. 25.2). Some of these areas are at high latitudes, which would have been scarcely habitable. A conservative estimate of the additional habitable territory made available at maximum marine regression is 16 million km^2, amounting to some 10 per cent of extra land (Bailey 2004a). In Europe, the amount of new land exposed at the Last Glacial Maximum was some 40 per cent of the current European land mass (Fig. 25.3).

The first and most obvious implication of such changes, and the one most often commented on, is the increased opportunities for population dispersal or cultural contact across sea barriers between continents. Lower sea levels would have created new land connections or the narrowing of sea channels to distances that could be crossed quite easily by swimming, floating, or simple rafting without the need for advanced seafaring skills. Connections between Africa and Asia, Africa and Europe, Siberia and Alaska, and between Britain and mainland Europe, would all have benefited from these effects, and are

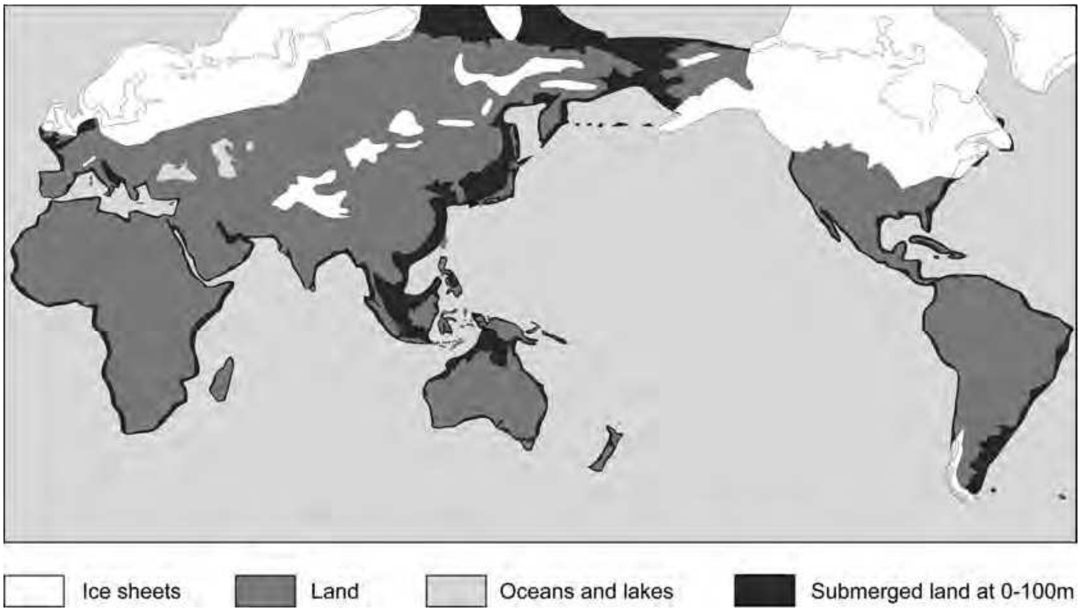


Figure 25.2: World map showing the distribution of the continental ice sheets and the extra increment of land in coastal regions at the Last Glacial Maximum (Redrawn from: Klein 1980).

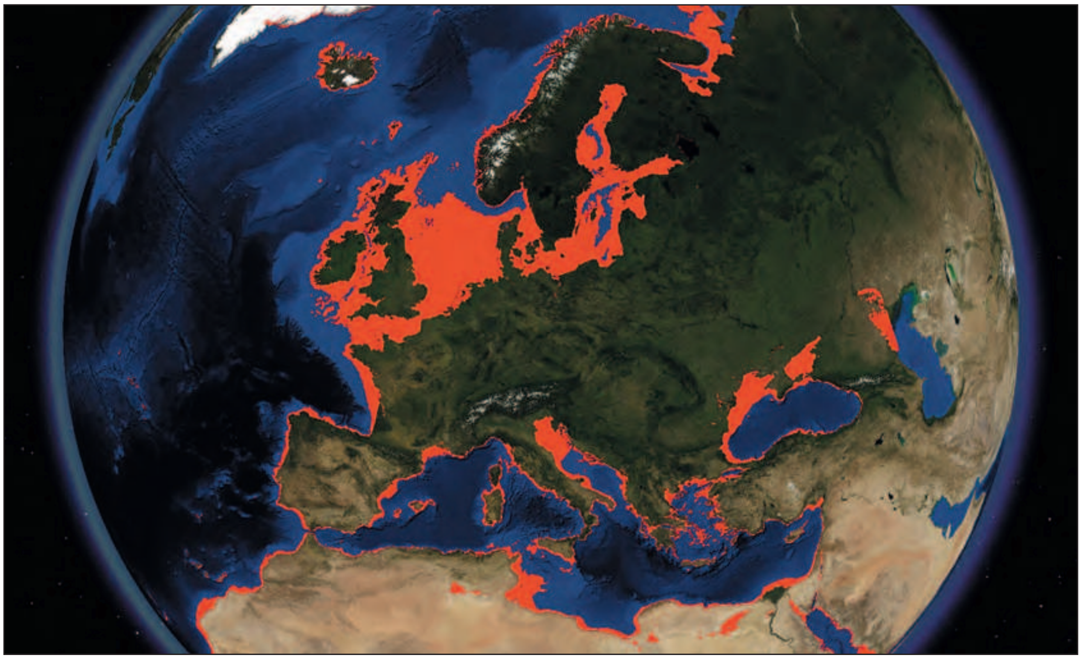


Figure 25.3: Satellite image of Europe showing, in red, the maximum extent of land exposed at the Last Glacial Maximum (Courtesy of Simon Fitch and Ben Geary, University of Birmingham, with data from USGS NED and ETOPO2)

the focus of intense current interest in relation to the history of population dispersal during the Pleistocene (Bailey *et al*. 2008; Erlandson *et al*. 2008; Petraglia and Rose 2009).

Even in Australia and New Guinea, where the persistence of sea barriers even at lowest Pleistocene sea levels would have required considerable sea journeys, the changed configuration of coastlines, islands, and archipelagos when sea-level was lower needs to be taken into account in judging the ease or likelihood of successful sea crossing and landfall. Unless earlier dated evidence awaits discovery, the timing of first entry into Sahul (Australia and New Guinea) occurred in a period, currently judged to lie between about 60–40 ka BP, when sea levels were substantially lower than present. Regardless of whether or not we think that oceanographic and ecological conditions associated with lowered sea level were more favourable to sea crossings than at periods of high sea level, the evidence required to judge the causes and circumstances of first entry is now mostly submerged. The settlements that formed the point of departure for sea travel, the settlements that were created on first landfall, the coastal environments in which these settlements occurred, the evidence for pre-existing patterns of exploitation, including any evidence of fishing or other exploitation of marine resources, must, for the most part, now lie underwater. Tectonic uplift and steep offshore topography around the edge of the subducting Pacific plate has provided some unexpected windows into marine exploitation in the time range 45–35 ka cal BP at archaeological sites like Jerimalai on East Timor (O'Connor 2007) and Matenkupkum in the Bismarck Archipelago (Gosden and Robertson 1991), but this is still a fragmentary record. As in other parts of the world, the necessary archaeological, geological, and palaeoenvironmental evidence to advance such investigations must be sought on the seabed.

In the first instance, then, the extra increment of land exposed by lowered sea level around the rim of the continental margins, or as newly emerged islands, can be viewed as a pathway linking previously unconnected land masses. But it is not simply changes in the configuration of coastlines that are significant here, or the addition of new territory. This body of new land had its own ecological and environmental characteristics that may have created more or less attractive conditions for habitation and population movement. Persuasive arguments have been advanced that the resources available on these exposed coastal lowlands would have been qualitatively different from those further inland. Coastal regions tend to provide more fertile conditions for plant and animal resources on land, with more extensive wetlands and alluvial basins, and better supplies of groundwater. For human populations, there would have been the addition of marine resources at the shore edge, representing an alternative pathway for population expansion

(Erlandson 2007), enhanced in some regions by increased fertility in response to changes in upwelling currents during the Pleistocene (Bicho and Haws 2008). Coastal regions also typically benefit from more moderate climatic conditions than their adjacent hinterlands, with warmer temperatures and better water supplies, factors that would have been of particular significance at periods of lowest sea level, when global climates were generally colder and more arid than today. Faure *et al.* (2002) have hypothesized increased flow of groundwater through springs in coastal regions at low sea-level stands, which could have further enhanced the relative attractions of low-lying coastal territory in arid climatic zones. Coastal regions also often offer convenient pathways of communication, movement and contact around the edges of continental margins, and easy access to alternative hinterland resources along river courses.

This is not to assert that coastal regions were uniformly or universally attractive regions for resource productivity and migration or contact. Coastal regions were undoubtedly quite variable in this regard as they are today, and presented a changeable and often unstable focus for human settlement because of changing sea levels and processes of erosion and sedimentation at the shore edge (Westley and Dix 2006). Nevertheless, now submerged coastal regions, especially those extending over large areas, are likely to have supported higher concentrations of settlement and higher population densities than their adjacent hinterlands, providing generally more attractive ecological conditions, and population refugia during periods of climatic deterioration.

The scale of sea-level change raises another fundamental issue about the socio-economic dynamics of early prehistory, and that is the impact that cumulative and repeated exposure of new land at the coast margin and its subsequent inundation would have had on patterns of social geography, demography, migration, economic adaptation, and cosmology. If coastal regions were primary zones of settlement, then they must have been as sensitive to the consequences of sea-level change as in the modern era. At a time when we are increasingly concerned about the potentially destructive impact over the coming decades of a sea-level rise of a few metres, it brings a new perspective to bear on the modern situation to realize that prehistoric societies across the world faced a sea-level rise of 130 m between *c.* 19 and 6.8 ka cal BP. That change, of course, was spread over many human generations and many millennia, so that the full effects would not have been experienced within a single human lifetime. Nevertheless, the rate of sea-level rise would have been sufficient to have perceptible effects within the lifetime of an individual, to say nothing of collective memories extending further back in time, particularly in regions of shallow coastal topography. The long-term cumulative effect of sea-level rise and loss of territory would have been dramatic. Similar effects, we must presume, would have accompanied progressive lowering of sea level at the beginning of the glacial cycle. At present, we can say little about these social effects because we have so little evidence to work with. And that brings us back to the fundamental question of what evidence has survived and how it is to be investigated.

The most immediate effect of sea-level change from an archaeological perspective has been to hide from view or destroy large swathes of territory likely to have been occupied by human settlement, and most of the archaeological evidence relating to the use of this submerged territory, especially the evidence for the early history of marine resource exploitation and maritime activity. Short-lived periods of high sea-level, as during the Last Interglacial, or regions of coastal uplift associated with tectonic plate motions or isostatic rebound, afford glimpses of Pleistocene coastal activity, but these conditions are too rare or too atypical to offer more than a fragmentary record, or to obviate the need for underwater exploration (Bailey and Flemming 2008).

If this general characterization of coastal regions as attractive zones for human activity is correct, then it must follow that we are missing key evidence for many of the great formative processes that shaped the development of human society before the establishment of modern sea-level at *c.* 6.8 ka cal BP, and that what we are left with is a severely truncated archaeological record that may be missing some of the most important evidence. Human dispersals and migrations, the extinction of the Neanderthals in Europe and their replacement by incoming populations of anatomically modern humans, the Pleistocene history of marine resource use and the earliest development of fishing and seafaring, the expansion of anatomically modern humans into Asia, the Americas and Australia, the post-glacial re-entry of human populations into the deglaciated regions of Northwest

Europe, the early development and dispersal of agricultural economies, and the early stages of social and economic change that ultimately gave rise to the first great civilizations – these are all developments that took place, for the most part, when sea levels were lower than the present.

The discovery of the Pre-Pottery Neolithic site of Atlit-Yam (Galili *et al.* 1993, this volume), submerged in 11 m of water offshore of the Israel coastline, is an indicator of what may be missing even from relatively recent periods when sea level was close to reaching its present level. This site demonstrated the presence of a coastal village with evidence of fishing, farming, and seafaring, revealing a hitherto unsuspected maritime component to early agricultural developments in the region. The earliest dispersal of agricultural economies westwards from their centres of origin in the Near East certainly involved island colonization and coastwise movements in the Aegean and the Mediterranean. Moreover, this would have occurred at a time when sea levels were rising toward their present level, but still somewhat lower than present, so that the low-lying island margins most likely to have harboured first landfall and the earliest agricultural settlements are now underwater (Flemming 1983; Lambeck 1996a; Runnels 2009; Ammerman 2010; Broodbank 2010). Even before this period of early agricultural dispersal, Mesolithic sites now seem to be reliably present on a number of Aegean islands (Runnels 2009). The inhabitants of Franchthi Cave were obtaining obsidian from the island of Melos from at least 12 ka cal BP, requiring a series of sea crossings of up to 20 km (Lambeck 1996a), while Cyprus was visited, if not permanently occupied, from about the same period (Ammerman 2010, this volume; Knapp 2010). The palatial settlements of Minoan Crete developed in an Aegean maritime setting with their roots in a tradition of island use and seafaring that we now know extended back before the Neolithic period. Because of sinking coastlines in many areas of the Aegean, Late Neolithic and Early Bronze Age sites are now partially submerged, as in the case of Pavlopetri (Henderson, this volume). The Ubaid settlements of Mesopotamia, which formed the earliest stage in the trajectory that gave rise to Mesopotamian civilization, were present when sea level was still rising, and must have had their roots in the vast and well-watered valley that occupied the area of what is now the Persian Gulf, until it was progressively inundated after *c.* 12 ka cal BP, and replaced by fertile marine waters and coastlines as sea level approximated its present position (Lambeck 1996b; Kennett and Kennett 2006; Carter 2010; Rose 2010). The role of coastal margins and low-lying valleys in contributing to the foundations of early agricultural and urban development and expansion has scarcely begun to be appreciated, to say nothing of the dynamic impact of loss of territory and changing ecological conditions during the process of Late Glacial and Early Holocene sea-level rise. Yet, we can at present say little beyond plausible speculation about these earliest developments, or the complex and dynamic interplay between changing environmental and climatic conditions on coastlines and hinterlands, because so little of that underwater realm has yet been explored.

Where next?

In order to identify what remains to be done, it is important first of all to appreciate the limits of current knowledge. The great majority of currently known underwater sites first came to light as the result of chance exposure or discovery of material by fishing and dredging operations, removal of protective marine sediments by storms or currents, or the activities of sport divers. Systematic archaeological investigation and underwater excavation have usually been applied in areas where finds had previously been reported, and where there was a high likelihood of collecting new material. Considerable quantities of Mesolithic artefacts were known to exist on the seafloor of the western Baltic in Danish and German inshore waters as a result of dredging and fishing activity for many decades before these received the systematic attention of archaeologists. Once some of these finds had been excavated, a body of information began to grow, which could be used to predict the likely locations and preservation conditions of other sites, so building up the momentum and the incentive for fresh discoveries (Fischer 1995b, 2007). Important sites like Bouldnor Cliff in the Solent (Momber, this volume), and Atlit-Yam, were discovered by the chance combination of exposure of archaeological material by natural erosion, sometimes quite a short-lived exposure before renewed shifting of sediments and currents re-buried or removed the archaeology, and the presence of informed archaeological divers at the time when the material was being

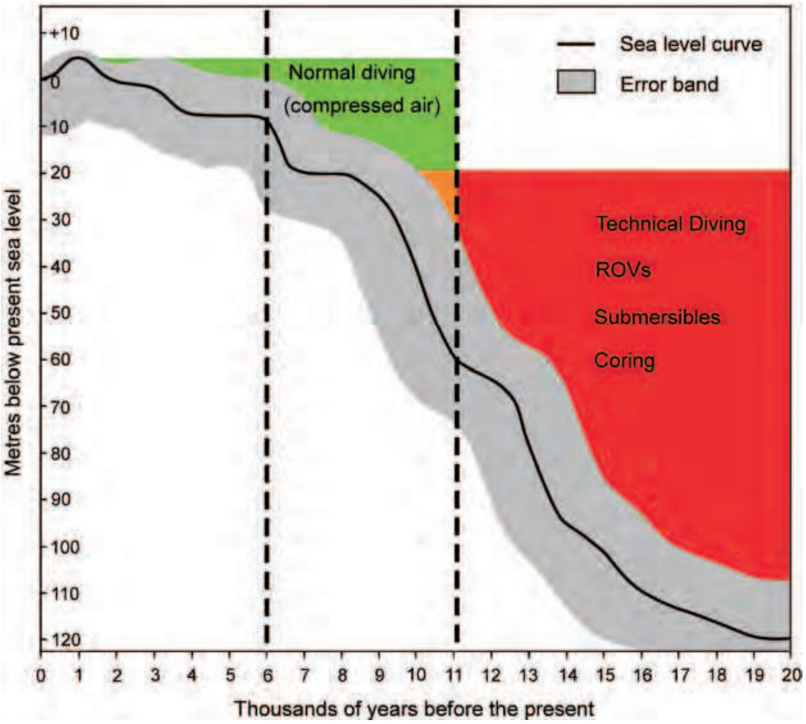


Figure 25.4: Diagram showing the relationship between the depth of the continental shelf, the age of submerged archaeological sites, and the technological gap between working in shallow water and working in deep water. Vertical dashed lines show the age range within which submerged archaeological sites accessible to divers using compressed air are likely to occur. Diving with compressed air is technically possible down to depths of 50 m, but loss of mental concentration, curtailment of time spent on the seabed, margins of error, and risks of decompression sickness all progressively increase with increased depth, and the effective limit for archaeological purposes without use of nitrox or trimix gas mixtures is likely to lie within a 20 m depth range. ROVs and other technologies can of course be used in shallow water as well as at depth (Sea-level curve from Siddall et al. *2003, showing error range of ±12 m)*

exposed. Moreover, most of this systematic archaeological excavation has taken place at shallow depths in inshore locations, where the operational logistics are relatively straightforward (Fig. 25.4).

This known material provides the basis for two types of predictive model that are important in the discovery of new material: the environmental and landscape features that are likely to have attracted repeated human activity and settlement, and hence led to the formation of archaeological deposits; and conditions in which the original archaeological deposits are likely to have been protected from destruction or dispersal by wave action and violent water currents during the process of inundation. In the Danish case, a fishing site-location model, based on modern and ethnographic information about the best shoreline locations and topographic conditions for fishing activity, has proved to be a powerful predictor of underwater sites, and deposits of peat or gyttja a good indicator of conditions with preserved archaeological material, resulting in the discovery of at least 2000 underwater find spots (Fischer 1995b, 2004; Skaarup and Grøn 2004). Similar conditions obtain in the Wismar Bay of northern Germany (Harff *et al.* 2007; Lübke *et al.*, this volume). The shallow gradients and the relatively limited tidal movement in these marine basins have also undoubtedly contributed to the preservation of material.

The concentration of finds in the western Baltic is exceptional, and gives grounds for optimism that similar material may await discovery further to the east on the sinking coastlines of the southern Baltic in Poland and Lithuania. However, we do not know how typical these conditions are of other marine basins and inshore waters. Nor do we know whether the existence of isolated sites elsewhere, such as Bouldnor Cliff or Atlit-Yam, is simply the first visible indicator of a much more widespread distribution of similar well-preserved sites awaiting future discovery, or symptomatic of the few that have survived the destructive effects of inundation. The large quantities of Pleistocene terrestrial fauna that have been dredged up from the sea bottom in the southern sector of the North Sea, together with occasional finds of handaxes and a fragment of a Neanderthal skull (Glimmerveen *et al.* 2004; Hublin *et al.* 2009), suggest that a former land surface with archaeological material is accessible close to the present surface of the seabed in many areas, and would be a worthwhile target for more detailed investigation. The use of seismic records from the North Sea oil industry, though not designed for the purpose of archaeological landscape reconstruction, shows that detailed features of the palaeolandscape are still present and can be reconstructed to enable broad predictions of site locations and areas of potentially good preservation (Gaffney *et al.* 2007, 2009).

There is, however, a geographical gap in the North Sea between the areas that have produced archaeological material and the areas that have received detailed seismic survey. The former have not yet given rise to systematic acoustic surveys or close inspection of the seabed for palaeoenvironmental and archaeological material. Predictions based on landscape reconstruction in the latter areas have not yet been followed up with seabed survey or targeted coring to see if any archaeological material has survived or is accessible to study.

This is symptomatic of a more general gap between the collection of acoustic survey data by geophysicists and geologists, and the investigation of archaeologically-defined problems, and highlights the 'technological gap' between working in shallow water and working in the deeper parts of the shelf (Fig. 25.4). In the former, targets can be identified with precision, and predicted landscape features and likely locations of archaeological sites can be ground-truthed and examined at close quarters relatively easily with high-resolution acoustic survey, coring, and divers. In the deeper areas, close inspection of the seabed will require the deployment of more costly and elaborate technologies involving sea-going ships with a variety of acoustic and coring equipment, remotely operated vehicles and cameras, and divers trained in mixed gas techniques and capable of working safely at greater depths. The exploration of mutual interests and research collaborations between archaeologists, on the one side, and scientists who already command such facilities for the purposes of geophysical and palaeoenvironmental survey, on the other, are likely to play an important role in future research. Mobilization of such a project in the North Sea will be a major undertaking and is still at the discussion stage, involving an extensive collaborative network of interested parties including academic researchers, developer-funded archaeologists, and government agencies (Peeters *et al.* 2009).

The Farasan Islands

All of the problems noted above, of integrating work on land, in shallow water and in deeper areas of the shelf, and of site survival or destruction under different oceanographic conditions, are ones that we have begun to confront in the Saudi Arabian sector of the southern Red Sea (Fig. 25.5). The impetus for this project, which began in 2004, is the growing interest in the 'southern corridor' – across the southern end of the Red Sea and the Arabian Peninsula – as a primary pathway for human dispersal out of Africa, particularly by anatomically modern humans after *c.* 150 ka BP, and the possible significance in such a dispersal of new capabilities in seafaring and the exploitation of marine resources (Stringer 2000; Walter *et al.* 2000; Oppenheimer 2003).

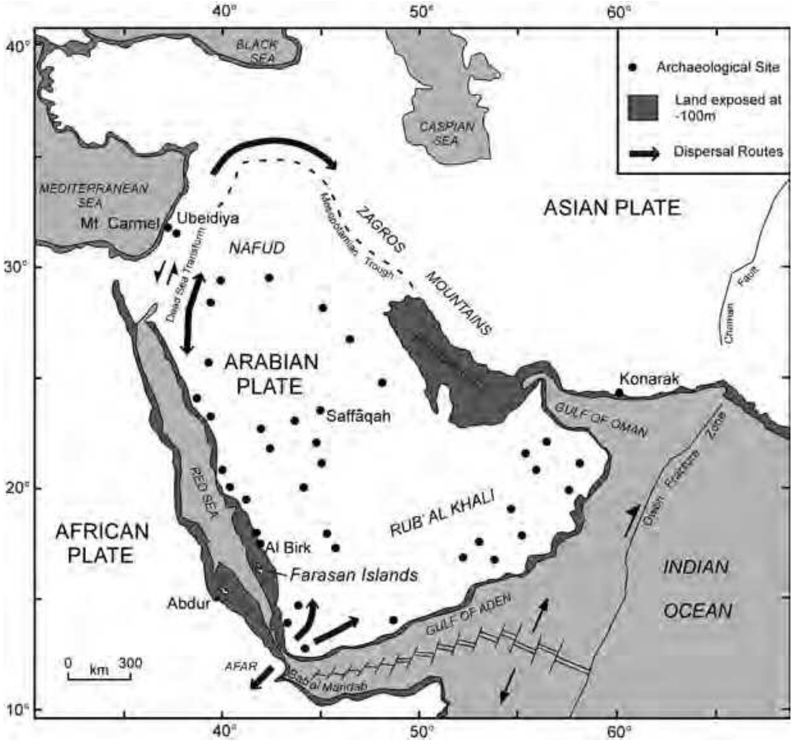


Figure 25.5: Map of the Arabian Peninsula and adjacent regions, showing the location of the Farasan Islands, the shelf regions that would have been exposed at very low sea level, major tectonic features, and a general indication of Palaeolithic sites and potential hominin dispersal routes (Drawing: G. N. Bailey and C. Vita-Finzi)

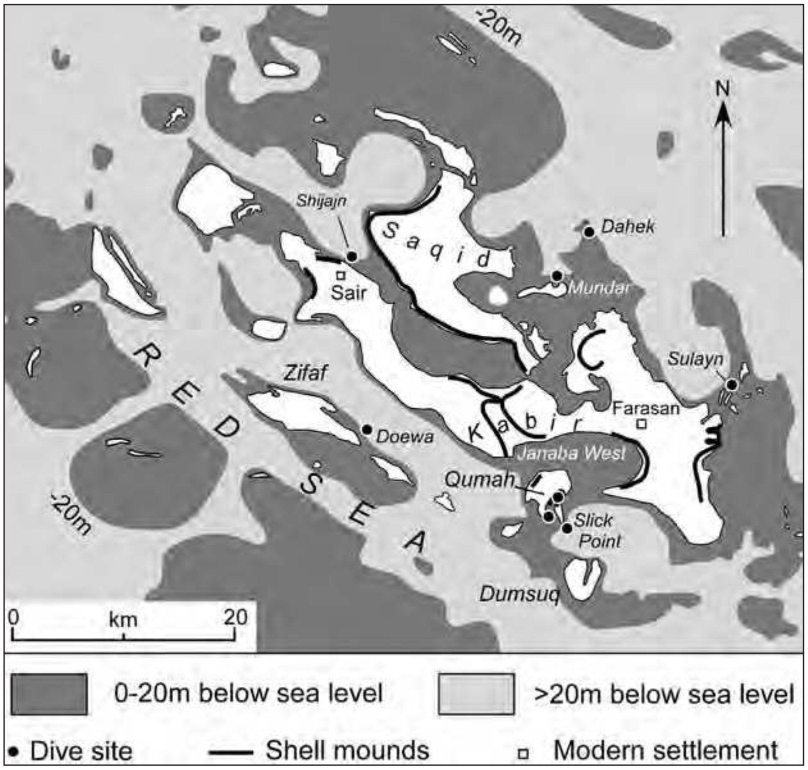


Figure 25.6: Map of the Farasan Islands showing general distribution of shell mounds on land and the location of dive areas (Drawing: G. N. Bailey and M. G. M. Williams)

Figure 25.7: Excavated shell mound at Janaba East, Farasan Islands, sitting on an undercut coral terrace. Collapsed blocks of terrace are visible in the foreground and to the right of the shell mound (Photo: Hans Sjoeholm, May 2006)

A primary objective of our project is to search for evidence of Palaeolithic occupation in the wider region and especially evidence of coastal sites. An underwater component was built into this project at the original planning stage, including a trialling of offshore methods in deep diving. The project was designed as an integrated onshore–offshore project, with survey and excavation on land proceeding hand in hand with underwater exploration, and the results of work on land acting as a guide to what to look for underwater. After a preliminary reconnaissance in 2004 to assess reported claims of Pleistocene and Holocene coastal sites, we settled on the Gizan region close to the Yemen border, and the Farasan Islands about 40 km offshore, as the focus for further fieldwork (Fig. 25.6). The Farasan Islands are composed of fossilized corals and limestone that have been progressively pushed up by the action of salt tectonics since at least the Miocene. The islands would also have been part of the mainland when sea levels were lower than about 40 m, so that access to them during the Pleistocene would not have depended on sea travel. Occasional finds of Middle Stone Age or earlier artefacts confirm that the islands were visited during the Pleistocene (Alsharekh *et al.*, in press). As sea levels dropped during glacial cycles, an extensive coastal landscape with a complex topography of deep depressions, alluvial valleys, archipelagos and convoluted shorelines and embayments would have been exposed, reaching a maximum width of some 100 km on both sides of the southern Red Sea. This would have created a potentially important addition of territory. In addition, the sea passage through the Hanish Islands and the Bab al Mandab would have been reduced to a long and narrow channel or series of channels posing little barrier to human transit between Africa and the Arabian Peninsula (Bailey 2009).

Surveys and excavations on land were conducted in 2006, 2008 and 2009, combined with deep offshore work in 2006, and diving work in shallower water using conventional SCUBA techniques in 2008 and 2009. The results of this work are reported in detail elsewhere (Bailey *et al.* 2007a, 2007b, 2008, in press; Bailey 2009, 2010; Alsharekh *et al.*, in press). Here, I summarize the strategic and logistical issues.

The key to the initial strategy lies in the immensely rich concentration of shell mounds that we discovered during the course of land survey on the Farasan Islands in 2006 and the location of many of them on shorelines consisting of a fossilized coral terrace that has been undercut by the erosive effect of seawater (Fig. 25.7). The number of shell mounds, more than 1000, and the size of the largest, exceeding 4 m in height, is exceptional by any standards. It reflects in part the high marine productivity of the shallow tidal bays around the islands and a rich and extensive molluscan fauna, and probably, in part, the lack of modern development on the islands until very recently and hence the preservation of the shell mounds from destruction and removal by industrial activity. Such shell middens are not unique to the islands. Similar sites have been reported along the coastlines of the Arabian mainland, but the concentration and conditions of preservation of the Farasan sites are unusual.

As might be expected from other parts of the world, the earliest radiocarbon dates for the shell mounds are in the 6th millennium cal BP, coinciding fairly closely with the establishment

Figure 25.8: The MV Midyan in Farasan waters (Photo: Hans Sjoeholm, May 2006)

of modern sea level. If the appearance of the shell mounds from this date onwards is solely the result of increased visibility after cessation of sea level rise, then it follows that earlier shell mounds should have formed when sea levels were lower than the present. We further hypothesized that, if the submerged shorelines of earlier periods were associated with stillstands and the creation of undercut notches like those visible on much of the present-day shoreline, it should be possible to locate these earlier shorelines underwater, and that this in turn would provide an identifiable target in the search for submerged shell mounds or other archaeological material.

Initial underwater work involved single beam acoustic survey and diver inspection at a variety of depths with a team of divers trained in the use of mixed gas diving (nitrox and trimix), and capable of working at depths down to about 90 m. This work required the use of an offshore platform large enough to house a diving team of six personnel, a decompression chamber, diving equipment, a supply of gas cylinders, and two small boats for accessing dive sites. The cost of chartering a suitable vessel from a base in the Gulf or northern Egypt proved prohibitive given our budget at that time, but in the event a suitable vessel, the 2000 tonne MV Midyan (Fig. 25.8), based at the port of Jeddah in the Red Sea, was made available free of charge by Saudi ARAMCO. Without that offer, offshore work, especially in deeper water, would have been impossible. A series of mixed gas dives were successfully completed, and deeply submerged palaeoshorelines with characteristic notched undercuts were found at depths ranging from 12 m to 60 m. These were mapped over short distances and sampled for geological material by the diving team. Small deposits of shells that might represent cultural remains were identified but lack of time prevented more detailed investigation.

The offshore work was successful in establishing the parameters and logistics of working in deep water in this region. It demonstrated the feasibility of diving work at depth, showed the presence of easily identifiable submerged palaeoshorelines, and identified constraints on future diving work. In some cases the submerged shorelines were covered by marine sand and were identifiable only as a break in slope. In other cases the shorelines were fully exposed with an undercut notch extending laterally over considerable distances. This variation highlights the variable impact of marine currents and patterns of marine sedimentation on the visibility of features in the original terrestrial landscape. Some submerged shorelines were also clearly tilted as a result of tectonic movements, and similar tilting is visible on the present-day shoreline.

The original plan in 2008 and 2009 was to follow up the offshore work with more extensive mapping of submerged shorelines and other topographic features using the full range of acoustic techniques (multibeam, sub-bottom profiling, and side-scan), alongside continued survey and excavation on land. However, the difficulties of sourcing suitable boats and equipment available for use in the inshore regions of the Farasan Islands led to a change of strategy, and the offshore work switched to diving in shallow water. The objectives of this work were to target submerged shorelines at shallow depth in areas adjacent to modern shorelines with concentrations of Middle Holocene shell mounds, to concentrate in particular on sub-marine areas with limited accumulation of marine sediments, or areas where marine channels might have cut through previously accumulated sediments, thus exposing earlier terrestrial land surfaces, to search for archaeological sites, and more generally to develop a fuller understanding of the taphonomic processes affecting submerged landscapes and archaeological material.

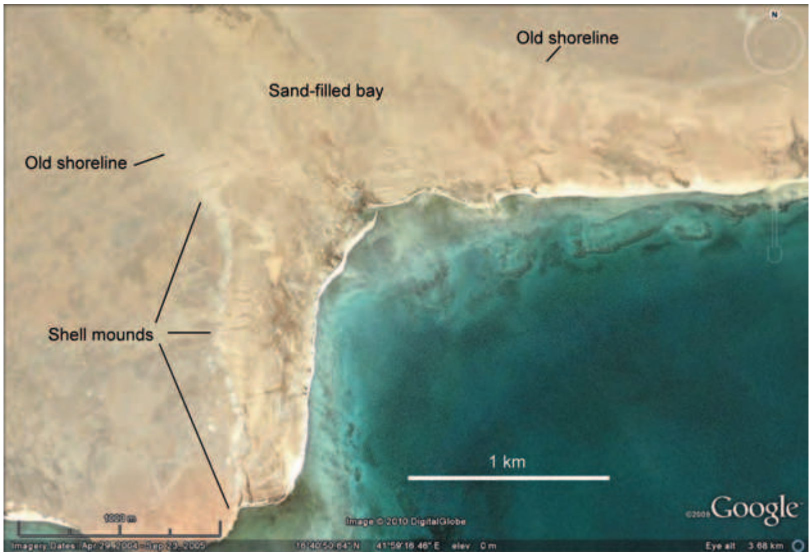
We have identified a number of palaeo-shorelines in the 6–20 m depth range, some with deeply undercut overhangs that would have provided excellent shelter for temporary human encampments, and we have conducted preliminary underwater excavations in selected locations under rock overhangs. Artefacts or sediments with clear evidence of prehistoric activity have so far proved elusive. This may reflect the limited sources of distinctive material suitable for making stone artefacts in the wider region, such as basaltic lava or fine-grained siliceous rocks. Even in surveys on land and excavations of the shell mounds, stone artefacts are rare, comprising items made on non-local volcanic stone, and local materials consisting of fine-grained limestone and *Tridacna* shell. The latter is a large, thick-walled shell, which can be flaked, and produces material which, on first appearance, looks rather like a coarse-grained chert.

Relatively small underwater shell deposits or shell scatters of limited extent have been identified but these pose the difficulty of distinguishing between anthropogenic and natural shell deposits. This is a problem even with shell deposits on dry land, and there are many cases where shell accumulations believed to be middens have turned out to be natural, or where deposits claimed to be natural have been demonstrated to be cultural (Bailey *et al.* 1994; Sullivan *et al.*, in press). These problems are, if anything, greater for submerged material, because even cultural shell deposits are likely to have undergone some erosion by water action, which is often taken to be the distinguishing feature of natural shell deposits. Moreover, the seabed is littered with extensive scatters of shells representing natural death assemblages. This is a major taphonomic challenge for underwater shell deposits, and work is ongoing to identify robust criteria for classifying the Farasan underwater material.

What we have not so far found underwater are any substantial shell deposits that might be described as discrete shell mounds like those visible on land, and this may be for at least four reasons. First it is possible that even substantial shell mounds on shorelines well protected from the full force of wave action and water currents during submergence undergo degradation and dispersal of material by water action, so that what remains is quite different from the original deposits, perhaps representing a diffuse scatter of shells that may be very difficult to distinguish from the background noise of natural death assemblages of shells on the seabed.

A second possibility is that we have not yet looked in the right underwater areas. Even on the modern shoreline, the shell mounds are quite patchy in their distribution, with extensive areas of coastline that lack shell mounds or have only ephemeral evidence of human activity such as small surface scatters of shells and occasional hearths. Also, the area that can be covered in a given time by divers is much more limited than on land, where extensive areas can be covered on foot and by vehicle, aided by satellite images on which the larger shell mounds are clearly visible (Fig. 25.9). It is possible that high-resolution acoustic survey techniques may in due course be able to identify underwater shell mounds, but until we have some understanding of how shell mounds are degraded by submergence and what the acoustic traces of known deposits look like, progress on this front is likely to be slow.

Figure 25.9: Google Earth image of Janaba West showing shell mounds visible from the air on the western shoreline of a former, large, marine inlet, which has now become filled with sand. Numerous shell mounds are also distributed along the former shoreline on the opposite side of the sand-filled bay, but are not so easily visible from the air



A third possibility is that the ecological conditions necessary for the establishment of large beds of shells were not present on the now-submerged shorelines, or only rarely so. It is a notable fact that the largest known concentrations of shell mounds are associated with large shallow bays, which in many cases have now become dry sand-filled basins as a result of ongoing accumulation of marine and windblown sands or tectonic uplift, or both processes working together (Fig. 25.9). Shallow bays of this type are highly dynamic in geomorphological and ecological terms, representing relatively short-lived windows of opportunity for the establishment of large shell beds and intensive shell-gathering, even with a stable shoreline and a stable sea level. During a period when relative sea level is undergoing a sustained rise, or a sustained fall, these subtle shoreline changes affecting shell habitat are likely to be even more dynamic, and it is possible that beds of living shells were never established in sufficient numbers in one place to allow the accumulation of substantial midden deposits during the period of sea-level oscillations characteristic of the Pleistocene record and particularly the period of rapid sea-level rise after the Last Glacial Maximum. Fischer (1995b: 382) has made a similar point about the low visibility of shell middens and the low density of artefact concentrations likely during a period of rapid marine transgression in Early Holocene Denmark because of a constantly moving shoreline. An added factor in the Red Sea context is that when sea levels were very low, reduced inflow of seawater from the Indian Ocean combined with high evaporation rates created very high salinities that could have inhibited marine productivity and substantially reduced the diversity and abundance of molluscan faunas. However, this probably applies with more force to the central and northern Red Sea than the south, and even there only to periods of maximum marine regression.

Finally, we have to consider the possibility that the shell mounds represent an intensification of shell gathering activity associated with changing patterns of human demography, social organization, and settlement unknown at any previous period in prehistory. One factor that may be relevant in the southern Arabian context is that a major climatic change toward more widespread aridity occurred in the Middle Holocene after *c.* 6 ka cal BP (Parker 2009; Carter 2010). During the Early Holocene, the Indian monsoon extended into the Arabian hinterland bringing wetter conditions which saw the spread of settlements into the interior. When climate became drier these settlements were abandoned, and one might argue that this regional shift in settlement and population demography forced populations to intensify the exploitation of alternative resources such as shellfish and other marine resources available at the coast edge. This is a regional variant of the more widespread hypothesis of post-glacial intensification noted earlier, but it remains difficult to test because the date of this postulated change also coincides quite closely with the establishment of modern sea levels and therefore with an increase in the visibility of coastal archaeological sites. It will, therefore, remain very difficult to corroborate without elimination of the alternatives. This in its turn underlines the need for continued investigation of the submerged landscape.

Gibraltar

In 2005, while the logistics of the proposed Red Sea underwater work were being investigated, and further fieldwork planning was put temporarily on hold because of the geopolitical situation, a trial survey and preliminary excavation was undertaken of submerged caves offshore of Gibraltar. These caves had been known about since the 1960s (Flemming 1972), and were selected as a suitable and easily accessible target for the Red Sea diving team to obtain some experience in mixed gas underwater work within the context of ongoing excavation at Gorham's Cave and Vanguard Cave on Governors's Beach at the southern end of the Gibraltar Peninsula (Stringer *et al.* 2000; Finlayson *et al.* 2006; Stringer *et al.* 2008) (Fig. 25.10).

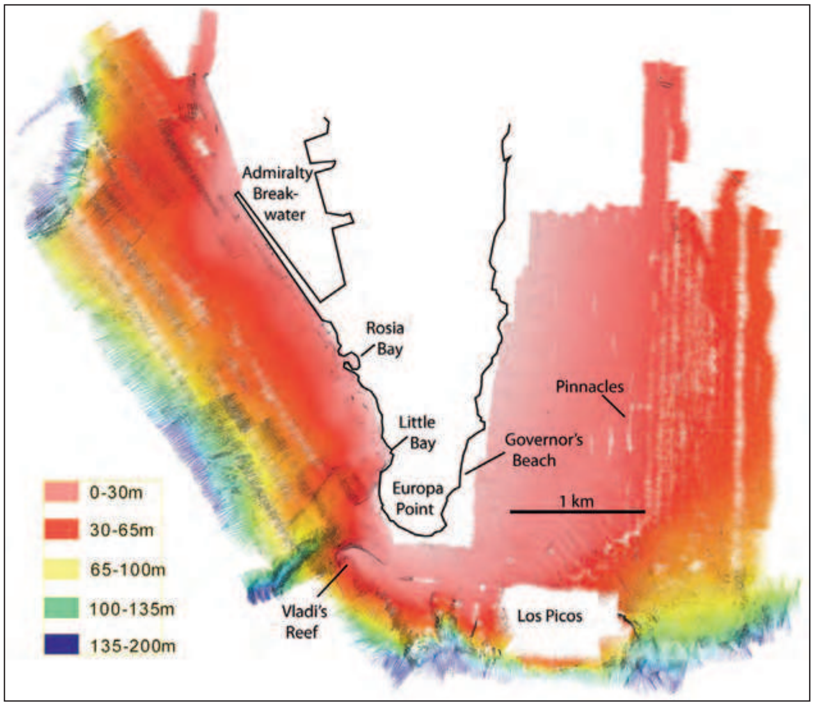


Figure 25.10: General map showing Gibraltar, the general bathymetry of the offshore area around the end of the Peninsula, Vladi's Reef, and other features and locations mentioned in the text (Depth scale in metres; Data supplied by IX Survey Ltd)

Gibraltar is of particular interest for investigating submerged landscapes because the shelf is relatively narrow, not more than about 4–5 km wide at maximum marine regression on the eastern side of the Peninsula, and somewhat less on the western side, thus providing a relatively compact and well circumscribed area for investigation. The region is also of interest as a potential transit for hominin dispersal from Africa into Europe. The width of the strait between Gibraltar and North Africa is about 11 km and, although this would not have been much affected by a drop in sea level, the distance is short enough to raise the possibility of sea

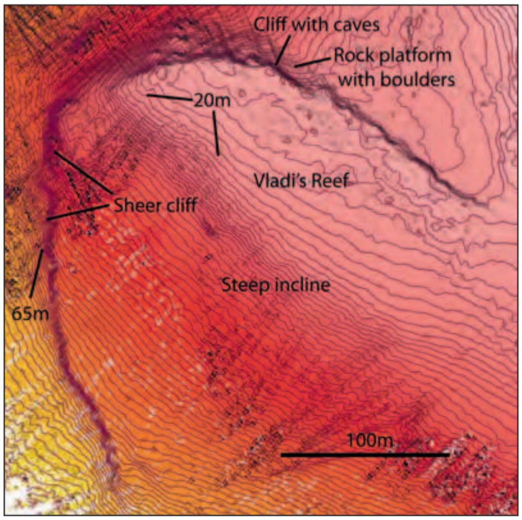
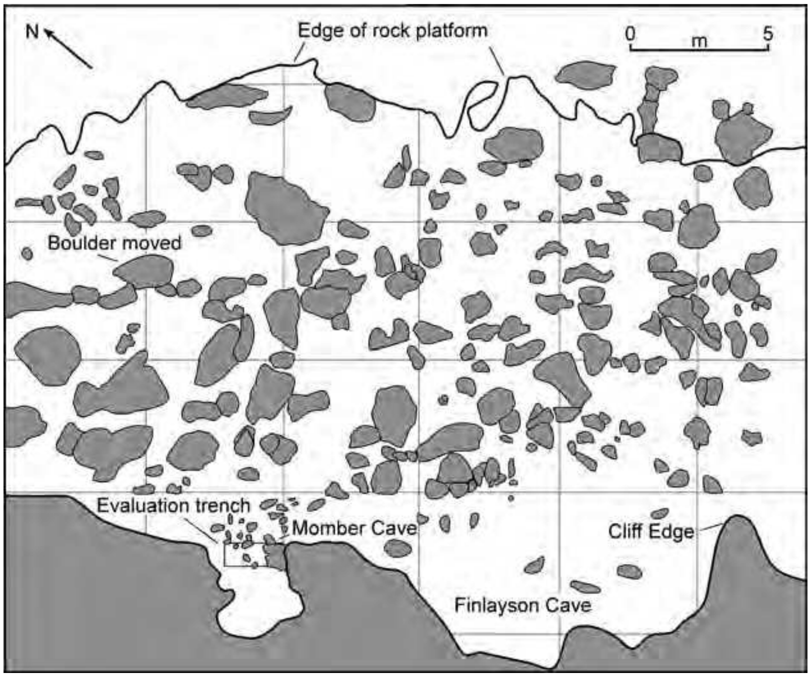


Figure 25.11: High-resolution bathymetry of Vladi's Reef (Data supplied by IX Survey Ltd, with annotations by G. Momber)

crossings by swimming or rafting (Bailey *et al.* 2008). The underwater caves are located on a submerged reef known as Vladi's Reef (Figs 25.10 and 25.11). This is a submerged formation of breccia extending for about 2 km on an east–west axis, with its crest at a depth of about 12 m below sea level, and only about 200 m offshore. On the north face of the ridge, there is a 6 m high cliff with a series of cave openings and a boulder strewn plateau at its base. On the south and west sides there are taller cliffs and at least one cave opening at a depth of 65 m.

In the case of the caves facing toward the mainland, any terrestrial deposits accumulated in the cave mouths are likely to be better protected from the erosional effects of sea-level rise than would be the case if the caves had been facing out to sea and exposed to the full force of wave action. In the event, after a trial exploration of Vladi's Reef, mapping of the boulder field, and preliminary excavation of Momber Cave in 2005 (Fig. 25.12), the focus of our research shifted back to the Red Sea. A further spell of combined underwater excavation and acoustic survey including multibeam, sub-bottom profiling, and side-scan was undertaken in Gibraltar in 2008 (IX Survey 2008). This latter work was dedicated to more extensive mapping and characterization of the submerged landscape around the full perimeter of the Gibraltar Peninsula, to diving inspection of potentially promising locations around Vladi's Reef, Los Picos and the rocky pinnacles on the eastern side of the peninsula, to further excavation of Momber Cave and sediments beneath protective boulders in front of the cave opening, and to collection of rock samples to clarify the geological origin of the reef.

Figure 12: Cave openings and boulder field on the north side of Vladi's Reef (Drawing: G. Momber and G. N. Bailey)



During the course of this work, we faced a number of difficulties that are symptomatic of the constraints on underwater work. Excavation by divers working at a depth of *c.* 20 m is a slow process, which is necessarily subject to frequent interruptions to comply with health and safety regulations, the rotation of diving teams, the lifting of excavated materials to the surface, and the cessation of work because of changes in tidal currents or spells of rougher weather, both of which were a persistent and continuing source of interruption. A fixed grid was positioned on the seabed to facilitate the survey of the caves and their immediate environs (Fig. 25.12), and excavation within the mouth of Momber Cave has progressed over an area of 2 m^2, and down to a depth of 0.6 m through marine silts to reach a layer of rounded boulders. It is possible that deeper deposits lie beneath this boulder bed, or beneath the extensive rockfalls in front of the cave mouth, which represent earlier episodes of roof collapse, and which may well have served to protect underlying terrestrial deposits accumulated in the pre-inundation landscape. However, renewed work on a larger scale with equipment capable of shifting or removing large boulders will be required to test this possibility.

The acoustic survey has provided an overview of the submerged topography but was compromised by a number of factors. A recent shipwreck near Los Picos restricted access to one area, though the salvage company undertook its own bathymetric survey and subsequently made the data available to us. Also, the large number of cargo vessels and oil tankers at anchor meant that transect lines had to be adjusted to avoid them, with some loss of coverage. Bad weather conditions were also a persistent problem, leading to the cancellation or premature cessation of work on some days, and to the repatriation of the survey team to the UK for other work and their return at a later date, with additional mobilization costs. Future work is planned including renewed excavation at Vladi's Reef, higher-resolution acoustic survey of selected areas identified in the existing survey, and coring and diver inspection of other target areas with the potential for recovery of terrestrial sediments and archaeological material.

Discussion

There are three issues that arise from this summary of recent research. The first is that underwater work is slow and painstaking, especially where diving work at depth is involved. Health and safety regulations require diving work to be planned accordingly, with a large enough team of trained personnel to ensure surface supervision of diving activity, medical support, alternating diving teams operating in pairs, and regular rest periods. Diving equipment needs to be properly maintained, boats of suitable size for providing access to diving areas and facilities for refilling gas cylinders need to be available, and rapid access to a recompression chamber and hospital facilities in case of accidents is essential. Divers should ideally have training in archaeology as well as in diving techniques. In contrast to work on land, the area that can be surveyed by divers at any one time is much more restricted. Divers need to maintain direct communication with a surface boat, and cannot undertake repeated ascents and descents because of the threat of decompression sickness. They can only move a few hundred metres laterally during a dive, and this manoeuvre is restricted to depths of the order of 10–30 m. At greater depth they have to be attached to a work station or surface supply. All of this imposes limits on the areas that can be covered and sampled, and this in its turn restricts the number of specific locations that can be identified as targets for more detailed investigation.

Ideally, diving work should be preceded and accompanied by acoustic survey and by remotely operated cameras and remotely operated or autonomous underwater vehicles and submersibles that can cover larger areas and identify potential target areas for close inspection by divers or for drilling and coring work. These techniques can provide a wide range of information but are not a sufficient substitute for diving. Divers can inspect features at close range within their surrounding context, take measurements, make drawings, and take video and still photographs with greater flexibility than remotely operated cameras. They can also collect geological and other samples, and ultimately conduct excavations.

Offshore work also requires suitable boats. For technologically demanding work, especially for mixed gas diving, drilling and use of underwater vehicles, a large platform is essential, with sufficient deck space and on-board accommodation, typically a ship of 50–60 m length. However, boats of this size have limited manoeuvrability in shallower water where survey may be required, so that smaller boats are also essential for comprehensive survey. Weather conditions can cause delays, especially for smaller boats. In the worst of the weather during the Gibraltar operation the harbour was closed to all shipping. A large ship can ride out rough seas, but diving operations may have to be aborted in such conditions, and acoustic survey may produce poorer resolution or have to be halted. In the Farasans, the coastguard authorities regularly closed down all small-boat activity when winds exceeded a certain strength, sometimes on a daily basis. These constraints are well understood by scientific divers and specialists in offshore and underwater activities, but not necessarily well known to archaeologists who are called upon to plan or participate in such operations, or comment on their results. My own experience suggests that one should assume as a minimum that, for every three days of planned offshore operations, two of these days are likely to be interrupted or written off completely because of various contingencies and operational factors, with obvious cost implications for budget planning and the scope of work undertaken.

The second issue is that of cost. Underwater work is necessarily expensive, especially if ship time is involved, together with the use of specialist skills and equipment. A large ship used in a complex operation may cost anywhere in the range of €250,000 to €500,000 for a 10-day operation, depending on the distance from the home port of the ship to the field location. The additional costs of mounting a diving or drilling operation can easily add another €100,000 to the bill. For more extensive survey, or more detailed work on a subsequent occasion, these figures should obviously be multiplied accordingly. The work we carried out in the Farasan Islands could not even have been contemplated, let alone completed, without very considerable assistance from Saudi Arabian commercial and governmental organizations. Saudi ARAMCO were willing to put at our disposal free of charge a fully crewed ship that would otherwise have been stationed on standby duties. The shallow diving work that we undertook in subsequent years would not have been possible without the provision of boats, gas cylinders, air compressors, and other facilities by the Farasan coastguard authorities. There are no shortcuts to underwater work especially where diving is concerned because of safety considerations. But there are opportunities, as we discovered, for enlisting the help of government agencies and large industrial organizations engaged in offshore work, who often have the necessary facilities and equipment and are willing to make them available for little or no charge as a gesture of goodwill and a contribution to public relations and wider cultural engagement. Acoustic data collected in the course of commercial activity can also sometimes be made available for archaeological purposes. Collaboration with other scientists engaged in offshore or underwater work, for example in relation to ecological, geological, or palaeoenvironmental survey, may offer additional opportunities for cost-savings through sharing of facilities or data.

The third issue is that we are still at a very early, exploratory stage in understanding what to look for when conducting surveys underwater in terms of our understanding of the taphonomic transformation of landscape features and archaeological sites by marine action, and what sorts of locations to target to maximize discovery of surviving material in different environmental conditions. There are still a great many unknowns here, and still little more than the sketchiest framework of general principles. Criteria that work in one set of underwater environments cannot necessarily be transferred without modification to another. Shallow gradients and an abundant sediment supply may minimize the destructive effect of wave action during inundation and promote rapid burial and protection. But these conditions are also likely to produce continued accumulation of sediments with limited opportunities for the discovery of deeply buried archaeological or palaeoenvironmental material. Deep locations near the edge of a shallow continental shelf pose greater technological challenges of access, but may have less overburden of later sediment because of their greater distance from mainland sources of eroded sediment washed into the sea. Complex offshore topographies offer many opportunities for the protection and survival of data because of convoluted shorelines and complex regimes of alternating sedimentation and erosion. Knowledge of taphonomic conditions and likely conditions of site preservation in different types of marine setting is gradually accumulating, particularly in areas such as the North Sea (e.g. Ward and Larcombe 2008; Westley *et al.*, in press). Such investigations could usefully be expanded to other types of marine setting with different geological and oceanographic regimes. Regardless of whether such studies lead immediately to the discovery of archaeological sites, they will help to expand the comparative base of taphonomic knowledge for the discipline as a whole.

Our own surveys have not yet produced unequivocal evidence of submerged archaeology. However, they have enabled us to build up a platform of knowledge and understanding about the taphonomy of the submerged landscapes in which we are operating and the most appropriate procedures and technologies for their further investigation, and these provide an essential foundation for future research. One type of investigation that would be extremely useful in the Farasan Islands, or indeed elsewhere, would be to find shell mounds that have been partially submerged or otherwise affected by marine erosion. Most of the larger shell mounds that we have so far recorded on land are either situated on top of undercut fossilized coral terraces, and are above the reach of modern wave action. Or else they are situated around the inner edge of shallow bays that have become filled with sand and are therefore now well inland of the modern shoreline. Nevertheless, given the effect of the local tectonics in producing localized warping of shorelines with modest uplift in some places and downtilting in others, there is a chance that we may yet find examples of partially submerged archaeological deposits which can provide insight into the effects of marine inundation.

One potentially destructive factor for shell mounds located over undercut notches during a prolonged stillstand, such as the current period of high sea level, is that continued marine erosion of the notch may eventually lead to partial collapse of the overhang and any deposits sitting on top of it. One of the shell mounds where we undertook detailed excavation is in such a position, and blocks of collapsed coral sitting on the strand line immediately below the site attest to partial collapse of the overhang (Fig. 25.7). The seaward edge of the shell mound extends to the very edge of the overhang, and we suspect that some of the midden deposit has already been lost because of such collapse. The notch already penetrates some metres below the surviving mound, and continued erosion may lead to further collapse and loss of archaeological material. We have not yet investigated whether any traces survive on the seabed immediately below the site that could be identified as collapsed midden deposits, but this and other high-resolution studies of midden taphonomy are an obvious target for future investigation.

Conclusion

Many new archaeological finds from submerged landscapes are being discovered, new technologies of underwater investigation are becoming more widely available, and there is considerable optimism about the likelihood of future discoveries. At the same time, CSA is still very dependent on chance finds, and on developing systematic programmes of research that work from known material on the seabed. We have not yet reached the stage where we can imagine planning with confidence a systematic underwater survey for archaeological sites on the submerged landscapes of the continental shelf as a self-contained programme of research in *terra incognita*. The costs involved in such an undertaking and the risks that it might fail to discover any archaeological material still seem too high. At the same time there are clearly ways of moving forward. A great deal can be learned in well-targeted surveys about the topography, environments and preservation conditions of the submerged landscape, even if no archaeological sites are discovered. Moreover, onshore and offshore work, and work in shallower water and deeper water, are all part of a continuum. Each can bring different sorts of information to bear on the interpretation of the submerged landscape and the deep history of coastal archaeology and pose questions that can help to focus further investigations. Also, projects that combine onshore and offshore work provide tactical advantages as well as intellectual ones; by combining predictable targets on land or in shallow water where the chances of success are high with more challenging and speculative targets in deeper water, they offer the best chances of maximizing the return on research funding and investment of time and skills. The greatest chances of success are likely to come in conditions where the full range of available technologies can be integrated and the work implemented within a collaborative framework that can draw on the widest range of funding and resources.

Planning on that scale is currently focused in Europe where there are three research networks currently working toward these goals. The first is the 'North Sea Prehistory Research and Management Framework' (NSPRMF) (Peeters *et al.* 2009). The second is the IGCP 521/INQUA 501-sponsored project on the Black Sea: 'Caspian–Black Sea–Mediterranean corridor during the last 30 ky: Sea-level Change and Human Adaptive Strategies' (Yanko-Hombach *et al.* 2007; http://www.avalon-institute.org/IGCP/). Finally, and most recently, there is the EU-funded COST (European Cooperation in Science and Technology) Action TD0902 SPLASHCOS: 'Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf' (http://php.york.ac.uk/projects/splashcos/), which is funded to coordinate research and management of archaeological and palaeoenvironmental archives on the sea floor across the whole range of European coastal states and their neighbours in the Black Sea and the Mediterranean. The SPLASHCOS programme funds meetings, workshops, and training programmes, and its aims are to develop links with government, industry, and a wider public, and to form collaborative partnerships that can lead to applications for large-scale funding of new CSA projects.

Large-scale collaborative projects are not unknown in archaeology, where major excavations often require large teams of specialists from different disciplines. Successful research in CSA is likely to demand a different order of collaboration, with teams that are capable of cooperating across many international and disciplinary boundaries and the involvement of commercial and government organizations. There will continue to be uncertainties and risks of failure. What is certain, however, is that we will not reduce these risks by doing nothing and staying at home in the belief that we will fail. Nor will we learn anything new unless we set out to look for new evidence on the submerged continental shelf with well devised strategies and techniques. Above all such research will require a new generation of specialists who are trained simultaneously in the disciplines of prehistoric archaeology and underwater survey. As all these ingredients begin to come together, so it may be possible to look forward to the further development of CSA as a recognized field of endeavour in its own right, and as an essential contribution to the deeper investigation and understanding of human prehistory, with the funding and facilities to match.

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