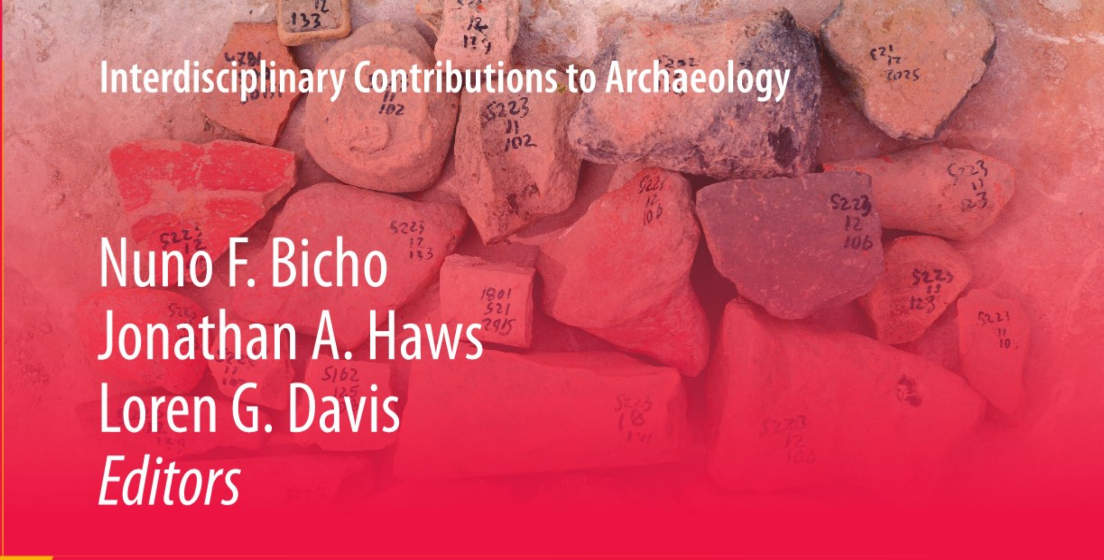

Interdisciplinary Contributions to Archaeology

Nuno F. Bicho
Jonathan A. Haws
Loren G. Davis
Editors

Trekking the Shore

Changing Coastlines and the Antiquity of Coastal Settlement

Springer

Trekking the Shore

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Prologue

Nuro F. Bicho, Jonathan A. Haws, and Loren G. Davis

In the last decade, several review articles have laid the groundwork for a new appreciation of prehistoric human coastal adaptations and food resources (e.g., Bailey and Milner 2002; Bailey et al. 2008; Bailey and Flemming 2008; Erlandson 2001; Erlandson and Fitzpatrick 2006). These articles have renewed and updated many themes from previous decades and reframed the importance of coasts for human societies by casting off many negative assumptions about marine resources and environments. Coastal zones are no longer dismissed as marginal areas full of "fall-back" resources of limited economic value. Instead, coastal zones are being recast as primary eco-niches for humans from the earliest periods of prehistory to the present. This perspective shift flows from eight themes driving current interest in coastal archaeology that Erlandson and Fitzpatrick (2006) outlined in their inaugural article for the new *Journal of Island and Coastal Archaeology*. Much of the impetus for renewed interest in the antiquity of coastal adaptations derives from a number of research prerogatives including: the role marine resources played in human evolution and dispersal, including migration routes; improved paleoenvironmental studies that have led to new models for human eco-dynamics in coastal zones; application of new technology to explore, map, and characterize submerged landscapes; the recognition of human impacts on ancient marine environments; and cognitive approaches that use ethnography to inform on past human perceptions of coastal landscapes and seascapes. The majority of this new work has been developed in traditional areas of coastal archaeology including Scandinavia, the British Isles, and the Pacific Rim.

In the spirit of this new focus, we organized two conference symposia on the antiquity of coastal adaptations: one in Lisbon organized by Bicho and Haws for the 2006 UISPP congress, the other in Austin organized by Davis for the 2007 Society for American Archaeology meeting. While the SAA session focused on late Pleistocene colonization of western North America, the UISPP symposium emphasized prehistoric hunter–gatherer coastal adaptations in regions outside traditional research areas. The present volume seeks to expand the spatio-temporal coverage by highlighting the latest research on the antiquity of coastal adaptations.

Coastal Resources in Human Evolution

The earlier use of marine and estuarine resources during the Paleolithic has been documented over the last several decades (Antunes 1990–91, 2000; Barton 2000; Bicho and Haws 2008; Cleyet-Merle and Madelaine 1995; de Lumley 1969; McBurney 1967; Roche and Texier 1976; Roubet 1969; Souville 1973; Stiner 1994; Waechter 1964). Many of the early reports give simple lists of species without any critical review of how they got there or their importance in terms of hunter–gatherer adaptation. In spite of the recognition that most Pleistocene shores are now submerged and potential sites are unavailable, most archaeologists dismissed or ignored this evidence as incidental and concluded that Paleolithic people rarely utilized marine resources.

Within the last two decades, researchers have come to see coastal resources in a new light. Moving beyond energetic considerations that minimize their value, coastal resources are now thought to have played important roles in Paleolithic diet and subsistence (Kuhn and Stiner 2006; Parkington 2001; Pettitt et al. 2003; Stiner et al. 2000). In particular, coastal resources may have played a critical role in the development and expansion of the human brain and retinal quality by providing long-chain polyunsaturated fatty acids, specifically docosahexaenoic acid (DHA) and arachninoid acid (AA) present in the Omega 3 and Omega 6 series (Broadhurst et al. 1998, 2002; Crawford et al. 1999; Cunnane et al. 1993; Parkington 2001; Uauy and Dangour 2006). These fatty acids, invaluable during pregnancy and early childhood, are not produced in the human body (Broadhurst et al. 2002; Jensen 2006; Milligan & Bazinet 2008) but occur naturally in aquatic plants and animals. Many of these resources are easily gathered and thus would have been important elements in Paleolithic subsistence. Some of the easiest resources to collect are marine shellfish that also provide important sources of essential nutrients for brain development. Among edible species of shellfish, limpets produce the highest amounts of AA and DHA, at least during spawning periods (Brazão et al. 2003; Gardner & Riley 1972). Limpets are also the most common species in many of the early sites with coastal resources, including Neanderthal sites, such as Grotta Breuil, in Italy (Stiner 1994), Gorham's and Vanguard caves in Gibraltar (Baden Powell 1964; Barton 2000; Fa 2008; Brown et al. 2011), and Figueira Brava Cave in Portugal (Antunes 1990–91; Callapez 2000). For modern humans there are many early examples in South Africa at Klasies River Mouth (Voigt 1982), Pinnacle Point (Marean et al. 2007), Blombos Cave (Henshilwood et al. 2001b), Ysterfontein 1 (Avery et al. 2008), and Hoedjies Punt 3 (Parkington 2003) (see also Marean 2011; Sealy and Galimberti 2011) and in North Africa (Steele, this volume). For the Upper Paleolithic, there are numerous sites with shell assemblages dominated by limpets in Iberia including La Riera (Ortea 1986), Vale Boi (Bicho and Stiner 2006; Manne et al., this volume), Bajondillo (Cortés et al. 2008), and Cueva de Nerja (Morales et al. 1998).

If diet choice enabled human brain development and expansion then determining the antiquity of coastal adaptations becomes a critical research prerogative.

The current evidence places coastal resource use back to the Middle Pleistocene during which a significant leap in the encephalization quotient occurred with the appearance of *H. heidelbergensis* (Ruff et al. 1997). The presence of *H. erectus* in Indonesia on the island of Flores ~800 ka (Morwood et al. 1998) offers tantalizing evidence for very early sea crossing capability and would suggest good knowledge of tides necessary to make the trip (see Marean 2011). In Europe, the Middle Pleistocene sites Clacton-on-sea and Boxgrove (Roberts and Parfitt 1999) are located in coastal settings but no direct evidence of marine resource use has been documented. So far, the oldest evidence for shellfish consumption (de Lumley et al. 2004; Villa 1983) comes from Terra Amata (400 ka) and Grotte du Lazaret (250 ka) associated with *H. heidelbergensis*. Cognitive abilities are widely thought to have increased markedly in anatomically modern humans ~200 ka (Marean 2011; McBrearty and Brooks 2000). Early modern human shellfish exploitation is evident now at Pinnacle Point in South Africa dated to ~165 ka (Marean et al. 2007; this volume) and the other sites mentioned above. Evidence also exists for coastal settlement and resource utilization by *H. neanderthalensis*, in Italy (Stiner 1994), Portugal (Bicho 2004; Bicho and Haws 2008; Haws et al. 2011), Spain (Cortés, et al. 2008; Zilhão et al. 2010), and Gibraltar (Finlayson 2008; Brown et al. 2011). In any case, this evidence seems to suggest a frequent use of the coastal settings.

In the last two decades, archaeologists have documented human impacts on ancient marine and estuarine animal populations. This has emerged as a major research focus in coastal archaeology leading to a proliferation of data from around the world. For the Holocene, worldwide evidence now exists for “fishing down the food web” in coastal environments (Mannino and Thomas 2002; Rick and Erlandson 2008). For the Pleistocene, Klein (1998; Klein et al. 2004) and Stiner et al. (2000) have measured size diminution in shellfish between the Middle Stone Age/Middle Paleolithic and Late Stone Age/Upper Paleolithic assemblages in Africa and the Mediterranean Basin. Steele, Sealy, and Galimberti (this volume) present data to support and question the nature of the evidence.

Human Dispersal and Migration

Modern human development and diaspora is closely linked to the sea and the coastal settings. The intensive use of marine resources with specialized technologies seems to be an exclusive trait of modern humans. The presence of bone harpoons at Katanga (Yellen 1998) and bone points in association with fish bones in Blombos Cave (Henshilwood et al. 2001a) provide the earliest evidence for innovation. Rose (2007) and Petraglia and Rose (2009) have championed a Red Sea crossing from the East Africa (Kenya, Somalia, Djibouti, and Eritrea) to the Arabian Peninsula (Oman and Yemen), for the dispersion of modern humans out of Africa and into Asia. The sea was a fundamental factor on the dispersal of modern humans to many archipelagos in the Indian and the Pacific oceans, including New Guinea/Papua (>35 ka), Australia (40 ka), New Ireland (30 ka), and the Japanese islands

(26 ka) (Allen et al. 1989; Matsu'ura 1996; Roberts et al. 1990; Thorne et al. 1990). These cases are remarkable because they challenge widely held beliefs that humans lacked significant seafaring capabilities prior to the mid-late Holocene.

Three decades after Fladmark's (1979) logical argument, it now appears that the peopling of the Americas was likely a coastal migration. A coastal migration readily explains the early settlement of Monte Verde at the tip of South America. Coastal settings were highly rich in biomass and offered numerous easy accessible dietary resources. Not surprisingly, the earliest evidence for human settlement along the West coasts of both continents also includes use of coastal resources (Erlandson et al. 2007, 2008; for a critical review see Davis 2011).

Coastal Environments and Human Adaptation

Fifteen years ago, Price (1995) called for increased understanding of the linkages between coastal productivity and the archaeological record of human adaptations. As Perlman (1980) noted previously, coastal environments are highly variable in productivity and attractiveness to humans. As a result, human settlement and resource use in these areas will vary in space and time as productivity changes.

Two of the richest types of coastal environments are associated with estuaries and upwelling zones. Human settlement often occurs in these environments because they are ecotone settings where aquatic and terrestrial ecosystems converge. Thus, it may be possible to predict human settlement intensity in areas with good paleoenvironmental data sets. A substantial body of paleoclimatic and oceanographic research completed in the last couple of decades has enabled ever increasing spatio-temporal resolution of data for paleoenvironmental reconstructions in coastal zones. We now have improved data showing important fluctuations in ocean productivity through time that can be used to build and test models for human settlement that attempt to correlate the two. During cold events in the Pleistocene, upwelling systems strengthened along western Europe as wind circulation intensified due to the growth of ice sheets and compression of temperature gradients towards the equator. Terrestrial ecosystems on the European continent suffered reduced biomass as a result of altered precipitation patterns. Coastal zones were probably critical places for survival along the western margins of the European continent. With lowered sea level, water tables shifted and increased surface water availability near shores (Faure et al. 2002; Sauer 1962). This in turn would have led to the concentration of terrestrial plants and animals in the coastal zone creating a rich ecotone setting for human exploitation. It is not surprising that we find early coastal sites along the western margins of the European continent where upwelling zones occur.

Along the Pacific Rim of the New World, geologic records indicate that, unlike Europe, upwelling systems were apparently quite variable during the Pleistocene, and cold glacial and interstadials periods were accompanied by lower marine productivity. Furthermore, western North American precipitation patterns were greatly enhanced during the Pleistocene, promoting the growth of massive pluvial lakes and highly productive wetland ecosystems throughout modern-day desert regions. Although different than the European situation, North American marine ecosystems are clearly used by the Younger Dryas interval and South American coastal resources are first used during the Bølling-Ållerød period.

Archaeological Record of Coastal Settlement and Resource Use

The archaeological record of coastal settlement is well documented for the period since present sea level was reached in the last few millennia. The best known places include the North Atlantic, especially Scandinavia and the British Isles, and the Pacific Rim. These areas have been investigated for well over a century and have produced a substantial body of evidence for Holocene coastal adaptations. Despite this research there are still many areas that require systematic survey of coastal margins to understand regional variability in coastal settlement and resource use. Chapters by Brown, Manne, Bonomo, Muñoz, Stothert, Tabarev, and Ulm illustrate this variability in the appearance coastal settlement and of marine and estuarine resources (fish, shellfish, shore birds, marine mammals).

The lack of evidence for widespread Pleistocene coastal adaptations has been the subject of discussion and debate for decades (e.g., the Broad Spectrum Revolution model – Brinford 1968; Flannery 1969). The most basic factor limiting the visibility of coastal sites is the position of ancient shorelines. The distance to the shore is a major factor in the location of coastal sites in prehistory. As many have observed, coastal food resources are rarely transported more than 10 km away from the shore and most of the evidence has accumulated with 2–4 km (Meehan 1982; Erlandson 2001). The position of ancient shorelines is critical to the antiquity of coastal adaptations (Bailey and Parkington 1988; Shackleton 1988). This requires local and regional scale studies of offshore bathymetry, submerged landscapes, coastal geomorphology, isostatic rebound, and neotectonism that can be used to build predictive models of coastal settlement and target archaeological survey for early Holocene and Pleistocene coastal sites. Obviously, discovering earlier coastal sites is made difficult by the impact of postglacial sea level rise on the Paleolithic archaeological record. The fact that for the last 120,000 years sea level remained considerably lower than today (–60 to –120 m) means that the continental shelf extended considerably in many places. The now-submerged platform used by Paleolithic hunter–gatherers, was also exposed before the previous sea highstand, the MIS 5e. It is very likely that an incredibly high number of sites were submerged and may still be preserved underwater (Bailey and Flemming 2008). The submerged region is a very large exceeding 16 million km^2 (Bailey 2004), or about 10% of the total current habitable land surface.

Finding the Sites

There are a number of possible situations for discovering earlier coastal sites: submerged sites from previous lowstands, sites from previous interglacial highstands still visible on land, tectonically or isostatically uplifted sites from before the Atlantic transgression. This present volume includes several contributions by Gusick and Faught, Des Lauriers, Mackie, Davis, and Haws that cover these situations.

Submerged Landscapes and Underwater Archaeology

In the early twentieth century, Clement Reid recognized the "lost world" of now-submerged Pleistocene landscapes around the British Isles. His book, *Submerged Forests* (1913), documented the first evidence of the flooded landscape of what is now known as Doggerland. The implications were not lost on Grahame Clark who subsequently articulated the archaeological significance of this drowned landscape (Clark 1936). Over the following decades, geographers and archaeologists began to compile evidence for Pleistocene coastal settlement and resource use around the world. Work focused on the potential for submerged archaeological sites on the inner continental shelf (e.g., Emery and Edwards 1966) and the importance of coastal resources to prehistoric people (e.g., Meighan 1969; Moseley 1975; Sauer 1962). Additional effort was aimed at correlating raised marine platforms with glacial/interglacial cycles. Lacking precise radiometric dating methods, stone artifact typologies were used to establish age control in the Old World. In the 1960s, Richards and Fairbridge (1965, 1970, also Richards 1974) complied annotated bibliographies to systematically compile the global evidence of Pleistocene raised beaches and archaeological sites. The works collectively demonstrated the existence of extensive geological and archaeological records of interglacial sea-level highstands, tectonically raised marine deposits with associated Paleolithic artifacts and potentially widespread evidence for Paleolithic coastal adaptations. In the 1980s, Masters and Flemming (1983) published a landmark volume on the antiquity of coastal adaptations and archaeological evidence for coastal settlement. Their collection, *Quaternary Coastlines and Marine Archaeology: Towards the Prehistory of Land Bridges and Continental Shelves*, evolved out of a Scripps conference focused on sea-level fluctuations, paleoenvironmental setting of submerged prehistoric sites and up-to-date information from surveys and excavations of submerged sites around the world.

Since then, new technologies for deep-sea exploration have been increasingly applied to searching for submerged archaeological sites, including shipwrecks, and landscapes. Robert Ballard's (2008 and Ballard et al. 2001) work in the Black Sea captured the public imagination that is an important element in attracting the necessary funding to support submerged archaeology. Less publicized but equally important research on submerged landscapes and archaeology has been undertaken in many places including the Pacific Northwest (Josenhans et al. 1995; Mackie et al. 2011), Baja California (Gusick this volume), Gulf of Mexico (Dunbar et al. 1992;

Evans et al. 2007; Faught 2004; Gusick and Faught 2011), New England (Coleman & McBride 2008), Newfoundland (Westley and Dix 2006), Ireland (Quinn et al. 2008), the U.K., (Plets et al. 2007), the North Sea (Coles 1998; Gaffney et al. 2008), Denmark (Fischer 1995), Mediterranean Sea, Red Sea, and South Australia (Flatman et al. 2006). Most of these projects are tied to significant questions of anthropological interest or cultural heritage. The striking potential of submerged archaeology is best seen by the discoveries of Tybrind Vig off Denmark and Bouldnor Cliff off the Isle of Wight. These Mesolithic sites have yielded amazing preservation of organic materials that attest to large amount of evidence that is missing from terrestrial sites. As the new technologies become more widely applied we expect to see similar evidence from Paleolithic sites emerge from greater depths. Many ongoing projects have the potential to yield significant new information about the antiquity of coastal adaptations.

In the United States, the National Oceanic and Atmospheric Administration and private interests have funded a new underwater project by James Adovasio and Andy Hemmings to survey and map the submerged landscape and archaeological record off the coast of Northwest Florida using side-scanning sonar, sub-bottom profiling, and diving. The project titled, "*The First Snowbirds: The Archaeology of Inundated Late Pleistocene Landscapes in the Northeastern Gulf of Mexico*" is designed to address the nature and timing of human entry into the New World. On the opposite coast, Gusick and Davis (2009) have also received NOAA funds to search for early submerged shorelines and sites in Mexico's Sea of Cortez. Mackie and Fedje (this volume) have been conducting similar research funded by the Canadian government.

The Deutsches Archäologisches Institut has been conducting an underwater survey of northern Germany. The project, "Sinking Coasts: Geosphere, Climate and Anthroposphere of the Holocene Southern Baltic Sea" (SINCOS II), began after discoveries of late Mesolithic and Neolithic sites offshore in the 1990s.

In the U.K., Byrony Coles (1998) renewed archaeological interest in the submerged landscape of Doggerland with her "speculative survey." Following up on her work, Gaffney et al. (2007) engaged the exploratory oil and gas industry to use their seismic surveys to make highly detailed maps of Doggerland topography and hydrology. Along this vein, the Irish National Strategic Archaeological Research (INSTAR) Programme recently funded a Submerged Landscapes Archaeological Network (SLAN) project to engage cooperative relationships with the Joint Irish Bathymetric Survey in an effort to reconstruct the paleogeography of submerged landscapes and investigate the potential archaeological record.

The recent European Union funding of the transnational and interdisciplinary project *Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf* by the European Cooperation in Science and Technology (COST) program demonstrates a significant commitment to submerged archaeology and the antiquity of coastal settlement. The project is not geared towards data collection as it is building awareness of the significance of drowned landscapes and underwater archaeology as a first step to establishing a framework to bring together scientists, government agencies, commercial and industrial entities to promote research, guide heritage management and policy-making, and understand the impact of future sea-level change. The enormous costs for characterizing and investigating the submerged landscapes and archaeology of the continental shelf require a cooperative engagement between scientists, industry, and government. This framework is designed to encourage sharing knowledge and expertise. This represents another combined academic and governmental agency project that will efficiently use resources to increase the feasibility of submerged landscape archaeology.

The challenge in all of the current underwater research is to get deeper to older submerged landscapes. With seismic surveying, side-scanning sonar and sub-bottom profiling, potential survey areas can be identified but excavation is problematic due to logistics and cost. Nearly all of the projects operate within the limits of SCUBA and getting deeper requires more expensive submersible transport vehicles to conduct extensive excavation.

Visibility on Land

Pleistocene coastal sites are seldom visible on land except under special conditions. During earlier highstands like MIS 5e, the sea was 3–5 m higher than today and coastal sites dated to the Last Interglacial have been found in close proximity to ancient shores. Examples exist from North Africa at Grotte des Contrabandiers (Roche and Texier 1976; Souville 1973; Steele, this volume) and Haua Fteah (McBurney 1967), along the Red Sea at Abdur (Bruggeman et al. 2004; Walter et al. 2000), and South Africa at Klasies River Mouth (Singer and Wymer 1982, Marean 2011), Blombos cave and Pinnacle Point (Marean 2011). Many other possible sites exist in Africa and Eurasia but these are undated and occur in secondary context on raised marine platforms.

In areas with narrow continental shelves and steep bathymetry, the distance to the glacial shorelines is lessened and evidence for coastal settlement and resource use may be found. Situations like this are found along the Iberian Peninsula and include Nazaré and Sesimbra, in central Portugal (Haws et al. 2011), Algarve (Bicho 2004; Bicho and Haws 2008; Manne, this volume), Gibraltar (Brown et al. 2011), Malaga (Morales et al. 1998), and Cantabria (Bailey and Craighead 2003; Gutiérrez Zugasti 2011).

Secondly, in tectonically active areas, coastal uplift may alter the relative distance from sites to the ancient shoreline (Bailey and Flemming 2008; Bicho and Haws 2008; Haws et al. 2011). Many sites including Mira Nascente and Figueira Brava in Portugal (Benedetti et al. 2009; Haws et al. in press, 2011) have been preserved on land due to these processes.

Organization of the Volume

We organized the volume in two sections, based on latitude. Part I includes chapters on North America and Eurasia; Part Two comprises papers on South America, Africa and Oceania (Fig. 1).

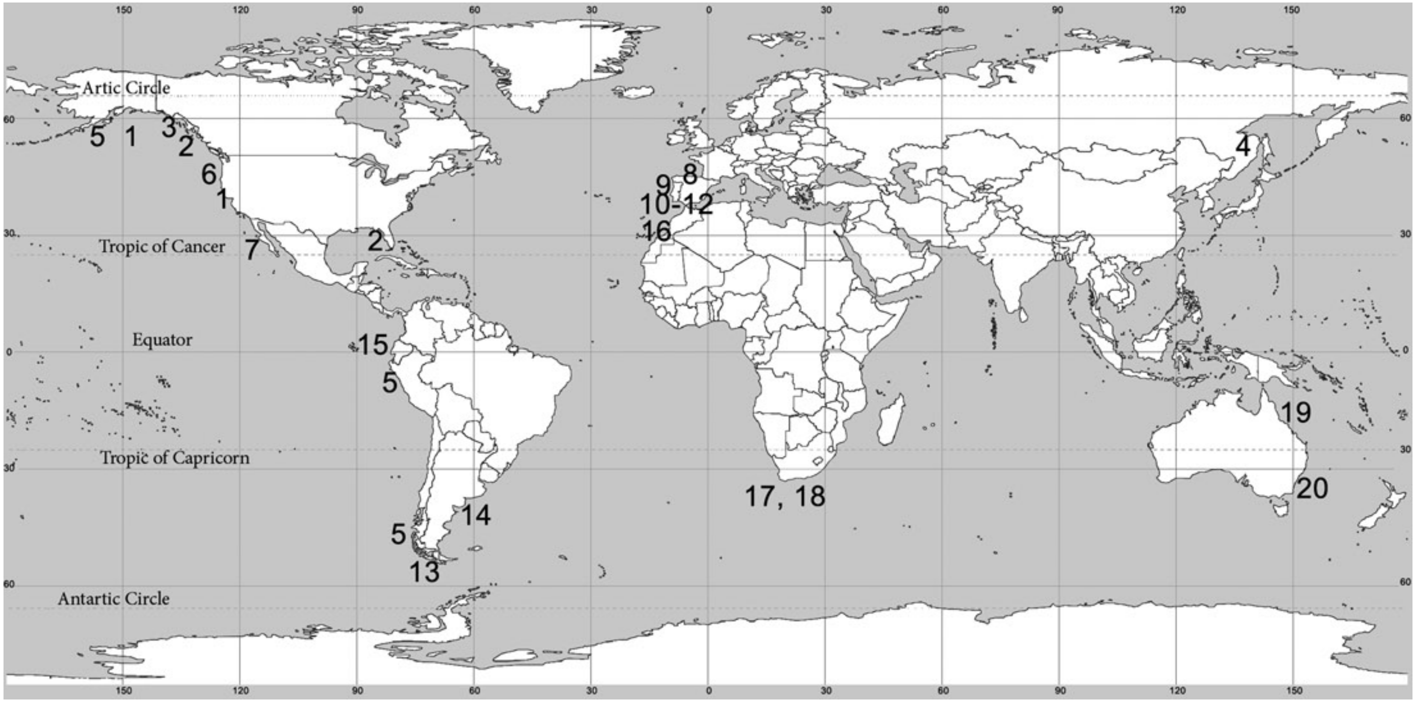

Fig. 1 Map with location of sites from each chapter. Base map adapted from http://kantan-net.main.jp

Davis leads off Part One with a contemporary and provocative review of the archaeological evidence for early coastal settlement of North America. Gusick and Faught present compelling arguments for the importance of underwater archaeology in the study of early coastal human occupations and migration routes for initial peopling of the Americas. The antiquity of North American coastal adaptations is reviewed and critically evaluated in various papers, covering the eastern Pacific from Canada's Northwest Coast (Chap. 3), the Pacific Northwest (Chap. 6), and Baja California (Chap. 7). Willis and Des Lauriers offer a broad view of technological patterns revealed in late Pleistocene-aged coastal sites from North and South America and their implications for early maritime adaptations.

On the other side of the Pacific, Tabarev describes the development and consolidation of salmon fishing in the Russian Far East. Brown et al. and Haws et al. address the late survival of Neanderthals in Iberian coastal zones and their subsequent replacement by modern humans, seen in and Manne and Bicho on Southern Iberia.

Gutiérrez Zugasti centers his discussion on the importance of shellfish exploitation in the Bay of Biscay during the Upper Paleolithic. The question of whether coastal resources were important during the emergence of the Neolithic in Southern Iberia is discussed by Dean and Carvalho, suggesting that in fact, at least in the process of neolithization of Portugal, coastal resources were used as frequently as any terrestrial prey species.

In Part II, chapters by Bonomo, Muñoz, and Stothert on South America focus on early prehistoric coastal settlement and resource use, giving unequivocal evidence for the early use of marine mammals, fish, and shellfish. Attenbrow and Ulm provide similar evidence for southeastern and northeastern Australia, respectively. Chapters by Marean, Steele and Sealy and Galimberti bestow attention (either centrally or peripherally) to the importance of coastal zones for the emergence and spread of modern humans around the African continent.

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Part I
North America and Eurasia

Chapter 1
The North American Paleocoastal Concept Reconsidered

Loren G. Davis

Introduction

The Pleistocene archaeological record of North America's Pacific coast is understood from only a handful of sites that postdate the continent's earliest interior sites by at least 500 radiocarbon years. Like other coastal regions of the world, the reasons that early North American Pacific coastal sites are so few in number relate to late Quaternary environmental history: postglacial marine transgression submerged older coastal terrains and sites, leaving behind only a small portion of a previously larger coastal and pericoastal landscape and any sites it might contain (cf. Davis et al. 2009). Although many early continental sites were also surely destroyed or concealed by periglacial and postglacial geomorphic processes, few regions, such as those parts of the Pacific Northwest's Columbia River drainage that were affected by the catastrophic outburst floods of Glacial Lake Missoula and Pluvial Lake Bonneville, share the same extremes of postdepositional history as the world's coastal zones. In spite of these difficulties of site preservation, a small number of late Pleistocene-aged North American Pacific coastal sites are known from British Columbia to Baja California Sur.

In addition to postdating North America's earliest interior Paleoindian sites (i.e., Clovis cultural components), North American Pacific coastal sites are also much younger than other key pre-Clovis contenders of the New World's western margin, including South America's Quebrada Jaguay, Quebrada Tacahuay, and Monte Verde sites (Keefer et al. 1998; Sandweiss et al. 1998; Dillehay 1989; Dillehay et al. 2009), and the Paisley Five Mile Rockshelter site in southern Oregon (Gilbert et al. 2009) (Fig. 1.1). Although the route of initial human entry into the Americas was traditionally assumed to include a pedestrian migration from eastern Beringia

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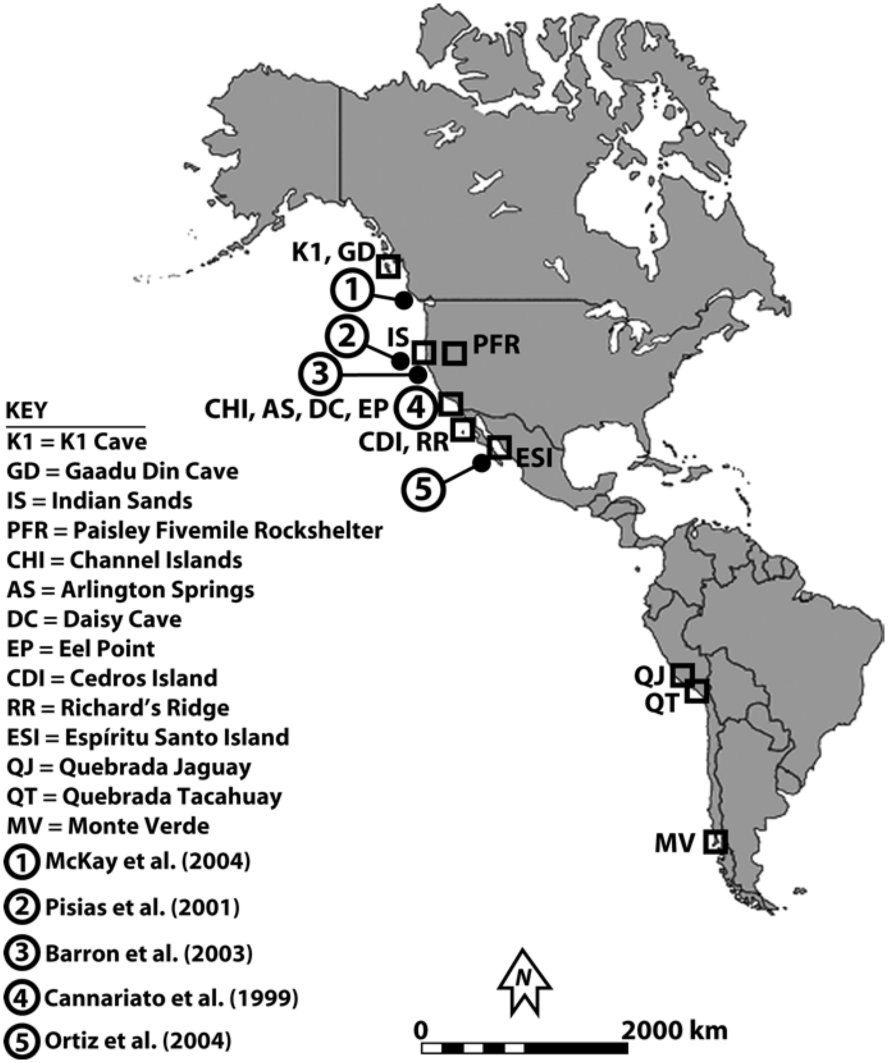

Fig. 1.1 Map of the New World showing archaeological sites (*squares*), marine cores (*closed circles*; numbers in *open circles* correspond with reference in key), and islands mentioned in text

southward through a gap between the Laurentide and Cordilleran ice sheets, this path may not have been available or viable in time to allow humans to arrive at pre-Clovis sites before 12,400 RCYBP (14,500 cal BP). In this context, a Pacific coastal route of initial entry is given considerable attention because it has no clear restrictions to pre-Clovis human migration (Mandryk et al. 2001). If the First Americans initially moved south beyond Beringia by skirting the edge of Late Wisconsinan ice along the shores of modern-day Alaska, British Columbia, Washington, and Oregon, we should expect that the region will hold archaeological sites that predate 12,400

RCYBP (14,500 cal BP). If the hypothesis that the initial peopling of the Americas included an aspect of coastal migration is correct, then the northeastern Pacific coast is a critical area of archaeological concern (Fladmark 1979; Gruhn 1988; Dixon 1999; Erlandson 2002; Mandryk et al. 2001; Goebel et al. 2008); however, at this time, we possess no knowledge about North American Pacific coastal sites dating between 12,400 and 10,700 RCYBP (14,500–12,800 cal BP) – the period contemporaneous with the earliest evidence of New World human occupation.

The North American *Paleocoastal* concept has been used to define the earliest period of human occupation along the northeastern Pacific Ocean shoreline and provides a salient example of how the early record of North American Pacific coastal prehistory is conceptualized by some archaeologists (e.g., Davis et al. 1969; Moratto 1984; Erlandson et al. 1996; Erlandson 2009; Cassidy et al. 2004; Rick et al. 2005). Although this concept is primarily rooted in archaeological research conducted in southern California and is based on late Pleistocene to early Holocene (LP-EH) period archaeological evidence that postdates 10,700 RCYBP (12,800 cal BP), it is more broadly considered to closely reflect the adaptations employed by the First Americans, and perhaps even by initial coastal migrants. Despite its conceptualization as a potential analogy of the New World's first coastal peoples, I argue here that the North American Paleocoastal concept is flawed for two main reasons: first, the concept is based on an archaeological record that is too young to represent the First Americans; second, the concept is not applied within a full conceptualization of the late Pleistocene environmental context of the eastern Pacific during the time of initial human entry, and thus, cannot directly inform our understanding of the earliest New World coastal adaptations. Instead of being based on relevant perspectives on early coastal archaeological patterns, our current view of a North American Paleocoastal adaptation is based on sites with cultural components that were contemporaneous with postglacial oceanographic conditions, which are much more relevant to Holocene-aged archaeological patterns. This is a significant problem that I believe is keeping archaeologists from understanding the adaptive context of North America's late Pleistocene-aged coastal environments and the influence they had on early foraging peoples and their archaeological record. To resolve this problem, we must improve our knowledge of late Pleistocene oceanographic and pericoastal conditions in ways that contribute information about the environmental and economic conditions in which the first North American coastal peoples lived. Toward this particular end, this chapter discusses the contextual basis of New World Pacific late Pleistocene coastal adaptations by reviewing the archaeological record of the earliest North American coastal sites, examines the historical use of the Paleocoastal concept and gauge its appropriateness, presents a meta-analysis of late Quaternary environmental conditions of the eastern Pacific Ocean, and discusses the potential archaeological implications of these conditions as related to the adaptive context of early North American coastal peoples. Ultimately, I hope to clear out some of the unnecessary conceptual underbrush that is currently associated with early North American coastal archaeology so that we might move forward unencumbered by these theoretical views and develop better models of Pleistocene period coastal prehistory.

The North American Paleocoastal Concept as an Archaeological Construct

Davis et al. (1969) provide the first comprehensive use of the Paleocoastal concept in North American archaeology, which they define as a coastal variant of their larger "Western Lithic Co-Tradition" concept. The Western Lithic Co-Tradition concept provides a synthesis of shared lithic industries seen in late Pleistocene to early Holocene-aged sites in western North America that notably include the following: nonfluted stemmed and foliate projectile points, domed scraper planes, unifaces, crescents, utilitarian ovate bifaces, and informal flake tools produced on macroflakes struck from unidirectional, multidirectional (i.e., amorphous), and centripetal cores, and the use of lower quality locally abundant raw materials present in cobble form (Davis et al. 1969:22–28). Economic variability expressed in these early sites is considered to reflect the range of cultural activities performed in different environments, extending from the Pacific coast to the interior desert regions. Davis et al. (1969:9) describe the early Holocene-aged San Dieguito cultural component from the Harris Site in San Diego County as part of a "Paleo-coastal Tradition," not only in part due to its technological patterns but also apparently due to its age and its close proximity (ca. 10 km) to the Pacific Ocean.

To Moratto (1984), the *Paleocoastal Tradition* is primarily defined on the basis of an economic orientation toward the use of marine resources as evidenced by late Pleistocene to early Holocene-aged midden sites along the California coastal zone. Following Davis et al. (1969), Morratto (1984:104) suspects that the Paleocoastal Tradition shares cultural affinities with the contemporaneous inland-oriented Western Pluvial Lakes Tradition – an archaeological construct that is similar to Bedwell's (1970) Western Lithic Co-Tradition concept due to "Comparable flaked-stone tool inventories, found throughout southern California between 11,000 and 8,000 BP, [that] evince widespread technological relationships. The coastal manifestations are set apart mainly with respect to exploitative practices, settlement patterns, apparent degree of sedentism (although this has been defined only tenuously), and artifacts other than flaked stone."

Erlandson (2009) considers *Paleocoastal* to mean "seafaring Paleoindian" peoples, based on their interpretation of terminal Pleistocene to early Holocene-aged (8,600 to ~11,500 cal BP (Erlandson and Jew 2009)) maritime resource use at Daisy Cave, which is located on San Miguel Island in the Northern Channel Islands of southern California. Erlandson et al. (1996:370) elaborate on this particular use of the term:

"Thus, the terminal Pleistocene component at Daisy Cave currently represents the earliest known Paleocoastal occupation on the California coast. Currently, it seems most likely that these early maritime peoples were descended from even earlier Paleoindian peoples who appear to have left Clovis-like fluted points on the southern California coast (see Erlandson et al. 1987) a millennium or more prior to the initial occupation of Daisy Cave. Nonetheless, the data from Daisy Cave provide additional evidence for the relatively early diversification of Paleoindian economies in western North America."

In this particular approach to definition, we are readily able to measure the adaptive aspect of seafaring simply by considering the location of late Pleistocene-aged sites on islands that were never connected to mainland North America; however, the Paleoindian aspect is not demonstrated and is in clear contrast to other descriptions of early Pacific coast cultural patterns. What is meant by the use of "Paleoindian" in a coastal context? To use a standard definition of the Paleoindian technological pattern, we should expect to see a distinctive toolkit marked by the presence of fluted bifacial projectile points, unfluted Llano- and Plano-style lanceolate projectile points (e.g., Clovis, Folsom, Goshen/Plainview, Agate Basin, Hell Gap, Cody), extensive lithic reduction of bifacial preforms to produce formal bifaces, limited use of informal flake tools, and/or prepared macroblade cores and blades (Stanford 1999), all of which are typically created on high-quality toolstone materials. In comparison, the Arlington Springs skeleton dated to ca. 10,590 RCYBP (12,685 cal BP – Erlandson et al. 2008; Davis 2009) represents the earliest dated evidence of human occupation on the Channel Islands; however, we know nearly nothing about the technological patterns associated with this individual and cannot otherwise assign a Paleoindian cultural affiliation. Other younger sites such as Daisy Cave and Eel Point contain lithic assemblages with bifacial preforms made on macroflakes, gravers, unifaces, reamers, wedges, abraders, flake drills, and multidirectional, unidirectional, boat-shaped, and microlithic cores (e.g., Erlandson and Jew 2009; Cassidy et al. 2004). Nothing in these lithic assemblages clearly indicates the presence of a Paleoindian technological tradition. The process of invoking a direct evolutionary relationship between Clovis Paleoindian and later LP-aged coastal cultural components requires a tacit assumption that an ancestor–descendant relationship exists between the bearers of fluted and nonfluted technologies, which has not been demonstrated to any degree in early North American Pacific coastal sites.

What, then, about using technology as a defining basis for a Paleocoastal concept? The review of North American Younger Dryas-aged coastal sites presented here does not reveal any significantly different technologies or modes of application that are restricted only to the LP-EH period. Moreover, many technological elements from these sites are found in both older and younger New World coastal sites. For example, there's nothing clearly "paleo" about the early archaeological components at Daisy Cave, Arlington Springs, and Eel Point. Instead, these sites show us instances of temporally early (relative to the currently available North American dataset) exploitation of marine resources in ways that will be closely repeated into late Holocene times (e.g., Rick et al. 2001). It is unclear how the technological, economic, or settlement patterns of these sites might be used to establish a Paleocoastal pattern that is distinctly different from younger cultural patterns, particularly since their records can be interpreted by direct reference to ethnographic examples (e.g., Cassidy et al. 2004).

Turning beyond California's Channel Islands, Paleoindian lithic technologies are also absent in other early North American Pacific coastal sites, including K1

Cave (~12,500 cal BP) and Gaadu Din Cave in British Columbia (~12,000 cal BP – Fedje and Mathewes 2005), Indian Sands in southern Oregon (12,255 cal BP – Davis et al. 2004; Davis 2009), and Richard's Ridge on Cedros Island (12,100 cal BP – Des Lauriers 2006). Instead, these sites bear lithic assemblages that relate to cultural-historical frameworks reserved for early nonfluted technological traditions that lack clear evolutionary links to the Paleoindian Tradition (e.g., Western Stemmed Tradition (Bryan 1980, 1988, 1991; Bryan and Tuohy 1999)) and are more recently argued to represent a larger Paleoarchaic Tradition in western North America (Beck and Jones 2010; Davis and Willis 2008). While a small number of fluted Clovis projectile points are known from some parts of the North American Pacific coast, they have not yet been found in an intact archaeological context. Regardless, the discovery of a fluted point in any of the aforementioned early coastal sites would not change the fact that their lithic assemblages lack technological patterns commonly associated with a classic Paleoindian *chaîne operatoíre* (Davis and Willis 2008; cf. Des Lauriers 2006). The presence of fluted Clovis projectile points in North American Pacific coastal zones reflects a poorly understood aspect of early coastal prehistory involving the co-occurrence of Paleoindians and unrelated Paleoarchaic peoples. The rarity of fluted points along North America's Pacific Coast may indicate that Paleoindians played a minor role in the region's initial settlement. For example, if the distribution of fluted projectile points in the coastal landscape represents a proxy indicator of Clovis settlement patterns, the low number of fluted points found along the Pacific coast indicates an extremely limited regional presence, relative to other areas of North America (Anderson and Faught 2000). The rare discovery of fluted points could also represent the curation of these items that were obtained elsewhere and transported to the coast during the LP or afterward or that only the technological ideas, not the Paleoindian peoples themselves, spread along the Pacific coast. Thus, the presence of Clovis Paleoindian-style artifacts along the North American Pacific coast is difficult to fully interpret and explain, and contrasts sharply with our current understanding of LP-EH coastal prehistory.

The antiquity of coastal adaptations is sometimes cited as a defining aspect of a Paleocoastal pattern: "Once a largely hypothetical construct, the existence of a California Paleo-Coastal tradition (Moratto 1984) is now firmly established by occupation of the Channel Islands during the Terminal Pleistocene and Early Holocene (Erlandson and Colten 1991; Erlandson et al. 1996, 1999; Raab et al. 1995). Archaeological data from Early Holocene sites including the information presented here [from Eel Point] show that maritime cultural traits, including deep-water seafaring and intensive maritime subsistence practices, have their roots far deeper in time than traditional models have suggested" (Cassidy et al. 2004:111).

In spite of the fact that the age of early North American coastal sites overlaps with post-Clovis-aged Paleoindian cultural phases defined from the North American Great Plains and American Southwest regions, no cultural elements of the Paleocoastal concept have ever been shown to clearly relate to the North American Paleoindian Tradition. Thus, we should not consider LP-EH-aged coastal sites to be exceptional, on the basis that they might retain an ancestor–descendant relationship with Clovis. Although the antiquity of North American coastal sites is now known to be far greater than was thought possible only 25 years ago (Erlandson 2002), we cannot consider coastal sites dating to the early Holocene or terminal Pleistocene to qualify as "Paleocoastal" simply because they are "old." In doing so, how has this improved our understanding of early coastal adaptations? Thus, any conceptualizations of a Paleocoastal period or adaptation that are based simply on time (e.g., older than 8,000 RCYBP) lack sufficient meaning and must be avoided. I am guilty of using the term in this way (e.g., Davis 2007). One might argue that, in light of the discovery of earlier coastal sites, we could just reserve the use of the Paleocoastal label for LP-aged occupations; however, the process of simply shifting the temporal boundaries of a Paleocoastal pattern to an earlier time frame does nothing to solve the problem that the term lacks a requisite degree of clarity and utility.

Basing the Paleocoastal concept on the appearance of marine-oriented economic activities in coastal zones (e.g., Davis et al. 1969) is a difficult proposition, given the time transgressive nature of marine adaptations. Research shows that the use of marine resources in the Pacific Rim may date back to *Homo erectus* (Choi and Driwantoro 2007), or at least to the last interglacial period 125,000 years ago (Deacon and Shuurman 1992; Henshilwood et al. 2001), making this activity simply a part of the larger history of *Homo* dispersal throughout the globe (Walters et al. 2000; Stringer 2000; Erlandson 2002; Bailey 2004). Thus, definitions that feature the use of marine resource use as the core of a Paleocoastal concept lack specificity and significance. The fact that the earliest record of human occupation along the North American Pacific coast is associated with high rates of marine transgression and subsequent environmental change might be cited as another reason to consider LP-EH-aged cultural components as being Paleocoastal in nature. This reason, however, is also arbitrary considering that the environmental effects of marine transgression continued well into the late Holocene period. Might we instead place special emphasis on those situations where early coastal adaptations occur in nonanalogous marine environments?

In the case of Richard's Ridge on Cedros Island, we see the early application of a non-Paleoindian lithic technology that is more readily related to other LP-EH technological patterns throughout western North America (e.g., Paleoarchaic, Western Stemmed Tradition), in the pursuit of marine resources, some of which are absent from or later are in more limited areas of the local environment (e.g., Pismo clam and red abalone), during a time when Cedros Island was a peninsular extension of Baja California. In addition, Des Lauriers (2006) argues that sea turtle hunting was far more intensive during the LP-EH due to the presence of eelgrass meadows along protected shorelines that disappeared once rising sea levels submerged the island's land connection to the Baja California peninsula. Once Cedros Island became disconnected from the peninsular mainland, its archaeological records show an extended period of consistent resource use under environmental conditions that are essentially modern; however, earlier economic patterns, such as sea turtle hunting, continue through time, although to a limited degree (Des Lauriers

2006, 2011). Although contextually different than other early North American coastal sites, even the early cultural components at Richard's Ridge fail to show us archaeological elements that clearly demarcate a Paleocoastal pattern on the basis of dramatically nonanalogous environmental situations or the application of unique adaptive patterns therein.

To summarize, Davis et al. (1969) and Morotto (1984) define the Paleocoastal pattern on the basis of its economic and geographic aspects: late Pleistocene to early Holocene-aged coastal sites showing use of marine resources. In the case of Erlandson (2009) and Erlandson et al. (1996), defining Paleocoastal as "seafaring Paleoindians" seems to suggest the presence of a cultural tradition (*sensu* Willey and Phillips 1958:27), which is defined as "temporal continuity represented by persistent configurations in single technological or other systems of related forms." If Paleoindian-style lithic technologies were actually associated with early North American coastal sites, then it would seem fitting to consider a Paleocoastal Tradition as a viable conceptual construct, as it would be a distinctly marine oriented cultural variety of Paleoindian. As it stands, the technological assemblages associated with New World late Pleistocene-early Holocene period coastal sites are highly diverse, lacking "persistent configurations," and missing elements that are associated with Paleoindian technological patterns (see Willis and Des Lauriers-this volume). Admittedly, the Paleocoastal concept is difficult to define on the basis of its material culture, which leads me to wonder if the concept has utility if aspects of its affiliated sites provide meaningful analogies for the adaptive patterns practiced by initial New World coastal settlers? To answer this question, we must examine the paleoenvironmental context of the northeastern Pacific Ocean during the late Pleistocene to early Holocene period.

Paleoenvironmental Context of the Northeastern Pacific Ocean

Paleoenvironmental information plays a critical role in any evaluation of the timing, manner, and mode of human entry into the New World. A review of the archaeological literature reveals that LP-EH paleoenvironmental conditions of the northeastern Pacific Ocean are only generally understood and integrated into archaeological interpretations (Mandryk et al. 2001), or are not considered to be nominally different than those seen during the Holocene. A recent example of the latter statement is exemplified by the Erlandson et al. (2007) hypothesis that maritime-adapted peoples entered the New World during the late Pleistocene by following and exploiting a highly productive kelp forest biome. The authors claim that a "kelp highway" extended along the northern Pacific Rim from northeastern Asia to western North America due to the presence of colder oceanic conditions corresponding to the last glacial period. Erlandson et al. admit that their concept is difficult to evaluate due to the fact that empirical proxy measures of kelp in LP deposits are not currently available. Despite these problems, Erlandson et al. offer stimulating new thinking that demonstrates the importance of considering the human ecological context of a potential coastal migration into the Americas; however, in order to understand the human ecological context of North America's Pacific coastal environments, we need empirical information that informs us about past ocean conditions, particularly related to late Quaternary marine productivity and its potential economic implications for early coastal foragers. What paleoceanographic evidence is currently available and what does it tell us about the early human ecology of the northeastern Pacific Ocean?

Late Quaternary period marine records are available from sediment cores collected from offshore areas of British Columbia, Canada to Baja California Sur, Mexico. Of these published marine records, some studies reveal proxy indicators of northeastern Pacific Ocean biological productivity covering the last glacial to Holocene period (Fig. 1.2). These marine records were selected because they provide different yet convergent indicators of oceanic productivity that can be related to the human ecology of the northeastern Pacific margin during the LP-EH. Each of the proxy records is described in turn, followed by a discussion of their larger implications for early human ecology.

Vancouver Island

McKay et al. (2004) examine the deposition of terrestrial and marine organic matter in a core located offshore of Vancouver Island. Accumulation of terrestrial organic matter was high during the late glacial period, but marine organic matter was relatively low before 14,300 cal BP, signaling greatly reduced primary production due to diminished upwelling effects. This pattern changed during the Bølling-Ållerød interval (14,700–12,900 cal BP), as a dramatic increase in marine organic matter marked an increase in marine productivity. Marine productivity returned to late glacial conditions during the Younger Dryas interval (12,900–11,500 cal BP). Indications of higher productivity levels marking interglacial marine conditions appeared by 11,000 cal BP.

Oregon Coast

Pisias et al. (2001) studied radiolaria and pollen frequencies in marine sediment cores collected along the Oregon coast, which led them to conclude that upwelling was significantly reduced prior to ca. 15,000 cal BP and also during the Younger Dryas interval. Radiolaria assemblages reflecting modern upwelling conditions do not appear until after the Younger Dryas interval. Analysis of pollen assemblages reveals a strong correlation between the abundance of coastal redwood pollen and upwelling-sensitive radiolaria assemblages. This correlation is interpreted as revealing the operation of onshore fog produced during summer upwelling, upon

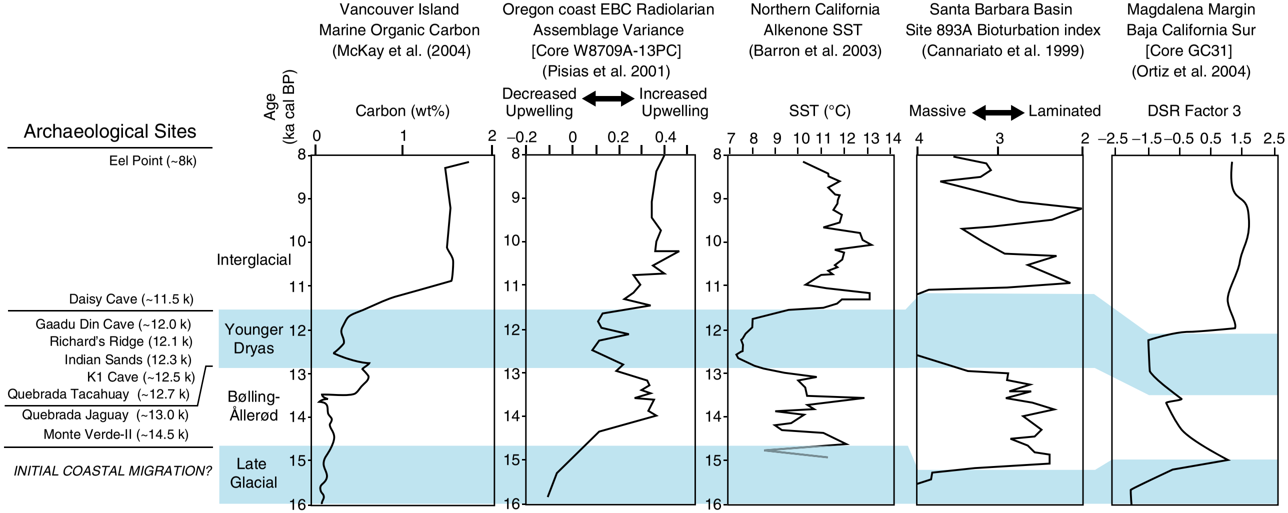

Fig. 1.2 Correlation of northeastern Pacific paleooceanographic proxy records, early coastal sites, and proposed cultural periods for the period between 16,000 and 8,000 cal BP. Proxy records were redrafted from original sources and rescaled by Davis. *Shaded portions* mark periods with lower marine productivity

which coastal redwoods depend. The authors model offshore Ekman transport (i.e., upwelling) along the northeastern Pacific coast between 30 and 46° north latitude (Pisias et al. 2001), to understand the degree of change in summer and winter required to produce their observed biological proxy indicators. Their model shows that Ekman transport was only 33–50% of modern values from the last glacial maximum to the Younger Dryas period, whereas winter upwelling shut off (i.e., switched to downwelling) in coastal areas north of 42° latitude during the same late Pleistocene period.

Northern California

In their examination of marine microfossil tracers (alkenones) and pollen assemblages from core ODP 1019, which is located offshore of the California–Oregon state border, Barron et al. (2003) establish a proxy sea surface temperature record spanning the last 16,000 calendar years. This record indicates late glacial and Younger Dryas temperatures reached below 8°C, which are 3–4°C cooler than modern conditions. By 11,500 cal BP, temperatures had quickly risen back to warmer Bølling-Ållerød levels and achieved modern values by 11,400 cal BP.

Santa Barbara Basin

Cannariato et al. (1999) relate the occurrence of different sedimentological structures in a 60,000 year long sediment core sequence from southern California's Santa Barbara Basin to benthic biological activity. The presence of laminated sediments is linked to the presence of low-O_2 concentrations in deep ocean waters that limit biological activity of burrowing animals. The cause of the low-O_2 conditions is vigorously debated and attributed to three different processes: decreased mixing of oxygenated surface waters into deeper parts of the North Pacific region (i.e., ventilation) (e.g., Duplessy et al. 1989; Kennett and Ingram 1995; Ahagon et al. 2003), high respiration of organic carbon (and subsequent consumption of O_2) in the presence of intense upwelling (Mix et al. 1999; Stott et al. 2000), or alternatively, by the presence of enhanced trophic productivity farther upcurrent in the northwest Pacific (Crusius et al. 2004), which contributed oxygen-depleted and nutrient-poor waters at intermediate depths along North America's western coast. Cannariato et al. (1999) interpret the Santa Barbara Basin sedimentary record to reflect patterns of north Pacific ventilation; however, following the conclusions of the Stott et al. (2000) study, which is based on direct historical observations of southern California marine conditions and their products in twentieth century Santa Barbara Basin sediments, I consider the Santa Barbara Basin lamination record to reflect the differential operation of upwelling processes during the late Quaternary. In this case, bioturbated sediments are produced as upwelling is weakened under late glacial and

Younger Dryas conditions. This interpretation also agrees with the record reported by Pisias et al. (2001) that suggests strengthened upwelling occurred along the southern Oregon coast during the Bølling-Ållerød and after the Younger Dryas. Keigwin and Jones (1990:1020) identify a more complex and complicated process that could involve multiple, seemingly contradictory interpretations, but ultimately point to reduced marine productivity: upwelling of deep, nutrient-poor waters would produce laminated sediments and low productivity as well.

Magdalena Margin

Ortiz et al. (2004) studied a high-resolution marine core spanning the last 52,000 calendar years taken from the Magdalena Margin, which is located near the southern tip of the Baja California peninsula to the west of La Paz, Baja California Sur, Mexico. Their analysis revealed a strong correlation between the diffuse spectral reflectance and marine carbon content of cored marine sediments. Ortiz et al. (2004:523) argue that this record reveals a history of marine productivity that was "drastically lower during past cool stadials and the Last Glacial Maximum than it was during the Holocene and past warm episodes."

Contextual Implications

These marine records indicate exceptionally low marine productivity during the late glacial and Younger Dryas periods, relatively increased productivity levels during the Bølling-Ållerød interval, and a shift to modern levels during the post-Younger Dryas interglacial period in environments stretching along the northeastern Pacific Ocean region from British Columbia to Baja California Sur.

Although the proxy indicators of low marine productivity during cold periods of the late Pleistocene are described above, what systemic factors contribute to the onset of this ecological state? In their review of the history of eastern Pacific coast geoecological and evolutionary processes since the Miocene, Jacobs et al. (2004:5) provide an answer to this question:

"Despite the higher wind regime characteristic of maximum glacial conditions, productivity associated with upwelling was commonly reduced during glacial times. Regional and more distant factors that influence upwelling intensity (e.g., Palmer and Pearson 2003) as well as the variable nutrient content of feedstock waters (e.g., Berger and Lange 1998; Loubere 2002) have been implicated as the causes of this difference between glacial and interglacial times. Arguments invoked to explain this phenomenon provide a set of plausible mechanisms that modulate upwelling and can be used to infer causes of changes in the upwelling regime at other times in the Neogene. It seems reasonable that the high-pressure regime and upwelling intensity along the West Coast would be influenced by the glacial conditions on the North American continent. Ice sheets extended as far south as southern Washington and Idaho, displacing the track of the polar front southward and extending its activity through more of the year (e.g., Kutzbach 1988). Glaciers were present in the Sierra Nevada, and there was substantial lake area in the West during the Pleistocene. All of these factors would have limited the summertime differences in temperature between land and sea, and/or the placement and stability of the summertime high pressure."

How might these observed reductions in upwelling during the late glacial to Younger Dryas period have affected the marine ecology of the northeastern Pacific Ocean? Because the significant biological effects associated with El Niño-Southern Oscillation (ENSO) climate events are due in large part to a reduction in the upwelling of cold, nutrient-rich water along the eastern Pacific coast, they provide an analogy useful for our current discussion. Pearcy and Schoener (1987) provide quantitative estimates of the effects of reduced eastern Pacific Ocean upwelling associated with the 1983 ENSO event on eastern Pacific Ocean primary productivity: "The average density of zooplankton off Newport, Oregon, during the spring and summer of 1983 showed a 70% reduction compared with non El Niño years (Miller et al. 1985). Zooplankton biomass was reduced by roughly half off Vancouver Island, British Columbia, during July 1983 (Seften et al. 1984)." Although warmer waters and northward movement of southern species also contributed to lower overall biological productivity during 1983, Pearcy and Schoener (1987) note significant reductions in the populations of marine fishes and seabirds along Oregon's coast, and "disastrous" declines in anadromous fisheries due to negative changes in primary marine productivity. If the reduction in upwelling strength and nutrient delivery to the upper water column observed along the North American Pacific coast by Pisias et al. (2001) was accompanied by biotic effects more or less similar to that of historically observed ENSO events, then the northeastern Pacific Ocean probably exhibited a significantly different ecology during the LP-EH, compared to its modern (i.e., post-Younger Dryas) state.

Considering the complex history of eastern Pacific Ocean environmental conditions described here, the assumption that cold water represents the only requisite conditions for the development of a "kelp highway" appears to oversimplify the actual situation. Kelp require both cold *and* nutrient-rich waters (Hernandez-Carmona et al. 2001), the latter not present in the northeastern Pacific during the last glacial and Younger Dryas periods due to an interruption of the Ekman transport process (Jacobs et al. 2004). By contrast, the great expansion of kelp forests envisioned by Erlandson et al. (2007) appears only to be possible during warmer periods of the late Quaternary associated with stronger upwelling cycles, including marine isotope stage (MIS) 5e (ca. 125,000 years ago), perhaps at a more reduced level during the Bølling-Ållerød (14,700–12,900 cal BP), and most clearly during the post-Younger Dryas interglacial period (12,900–11,500 cal BP; Jacobs et al. 2004). Since the end of MIS 5e, oceanographic conditions analogous to those seen during the modern period, which support extensive northeastern Pacific kelp forests, are limited to the post-Younger Dryas period. As Fig. 1.2 illustrates, the northeastern Pacific Ocean was cold but nutrient poor during long periods of time between 16,000 and

11,500 cal BP (except for the Bølling-Ållerød oscillations), which contributed to diminished levels of trophic productivity in marine ecosystems during some parts of the late Pleistocene period. These five marine studies suggest that the levels of upwelling required to support highly productive northeastern Pacific Ocean kelp forests did not exist until after Clovis peoples spread into North America. Kelp forests may have been present in some form during part of or the entire Bølling-Ållerød interval, but it appears very unlikely that the ancestors of the peoples who created the Monte Verde II component and the earliest occupation evidence at Paisley Five Mile Rockshelter ever saw much less travelled along a "kelp highway."

Exactly how these different oceanographic conditions of the Late Glacial, Bølling-Ållerød, and Younger Dryas intervals affected a maritime-based cultural adaptation in North America's Pacific coastal region is unclear, largely because our preinterglacial (>11,500 cal BP) archaeological record mainly comprises sites with hunting-oriented components (K1 Cave, Gaadu Din Cave, Indian Sands) and only a single example of marine resource use (Richard's Ridge) (Fig. 1.2). The emphasis on hunting reflected in most North American coastal sites dating to the Younger Dryas interval should not be taken at face value and interpreted to mean that marine resource use was an unimportant economic pursuit prior to the interglacial period; pericoastal and coastal hunting activities are assumed to be an integral aspect of early coastal adaptations, but not exclusively so (Des Lauriers 2006; Davis and Willis 2011), and are arguably easier to discover in the modern coastal landscape, which typically lacks late Pleistocene-aged shorelines and their associated littoral-focused archaeological sites. Moreover, sites reflecting early use of what were previously interior coastal environments should be preserved in the modern coastal environment and more readily found than LP-aged littoral exploitation sites (Waters 1992; Davis et al. 2009). The current view of Younger Dryas interval marine exploitation from the Richard's Ridge site provides unequivocal evidence that early North American coastal foragers were well adapted to their marine environments, while the other sites from this period clearly indicate hunting proficiency. Together, these sites reveal a more complete perspective on early coastal adaptations.

The presence of humans at the Monte Verde site in coastal Chile by 14,500 cal BP (Dillehay 1989) sets a benchmark for considering the timing and contextual implications of an initial migration into the Americas. If humans arrived at the Monte Verde site by way of a Pacific coastal migration that began 1,000 years or so earlier than the age of the Monte Verde II (MV-II) occupation, then the first coastal migrants may have trekked southward under Late Glacial conditions at ca. 15,500 cal BP. If the MV-II occupants took only 500 years to move from Beringia to Chile, then their migration occurred close to the onset of oceanographic changes associated with the Bølling-Ållerød interval after ca. 15,000 cal BP, but before 14,500 cal BP. If an initial coastal migration began during the Late Glacial period, the First Americans would have encountered Pacific Ocean environments with greatly reduced upwelling cycles and subsequently lower marine productivity, relative to conditions present after ca. 11,500 cal BP. Coastal migration that occurred during the Bølling-Ållerød interval probably encountered conditions of somewhat higher marine productivity not precisely the same as seen during Holocene interglacial times, but improved from the Late Glacial period. Following Erlandson et al. (1996:370), if a New World coastal entry occurred "a millennia or more prior to the initial occupation of Daisy Cave," then humans would be forced to contend with a return to marine environmental conditions bearing dramatically lower productivity during the Younger Dryas period. Regardless, if humans entered and spread throughout the New World by way of a Pacific coastal migration route, then they did so during times when the northeastern Pacific Ocean's environments were quite different than those associated with the post-Younger Dryas Interglacial Period – the time in which we know the most about coastal adaptations. In light of these observations, we must reevaluate both the basis upon which the North American Paleocoastal concept is founded and whether it continues to serve our needs.

Toward a Contextual Model of Early New World Coastal Prehistory

Why can't we simply look to our currently available set of early North American coastal sites to inform our understanding of the first coastal migrants? The fact that humans were present in coastal South America about 2,000 calendar years before we first see evidence of their cultural occupation in North American coastal zones, and that they encountered marine environments that were markedly different than the post-Younger Dryas interglacial conditions present throughout the northeastern Pacific Ocean region, requires us to reevaluate the assumptions upon which our views of early North American coastal prehistory are based. Simply put, the LP-period paleoenvironmental record of the New World Pacific coast was a moving target, and we cannot expect to uncover a universal Paleocoastal pattern of coastal adaptation from any one site. Post-Younger Dryas-aged North American coastal sites offer important perspectives on the manner in which humans used maritime resources during the interglacial period, but they do not reveal an adaptation to the nonanalogous coastal conditions that were present before 11,500 cal BP. Instead, coastal sites dating to the interglacial period reflect human adaptation in environments with different levels of marine productivity than compared to the Late Glacial and Younger Dryas intervals. By 11,500 cal BP and afterward, early coastal peoples would have been able to exploit changes in the state of marine ecosystems fed by the return of nutrient-rich upwelling water, which was absent during the Younger Dryas interval. If the initial period of human entry into the America coincides with the occupation of the MV-II component at Monte Verde, or even with the earliest occupations at Meadowcroft Rockshelter and Paisley Five Mile Rockshelter, then we are seeking archaeological sites and associated paleoenvironmental data spanning the Late Glacial, Bølling-Ållerød, and Younger Dryas chronozones. To date, we have not yet found North American coastal sites that date to the time of Clovis (13,100–12,850 cal BP) or even predate 12,500 cal BP.

After considering the range of coastal adaptations seen in LP-aged archaeological sites from the New World Pacific coast, I cannot see how we might redefine the Paleocoastal concept on the basis of time, technology, economy, or settlement to establish an all-inclusive conceptual framework for LP-period coastal prehistory. Although it might be tempting to organize early North American coastal archaeology in a way that seeks to highlight an ever-increasing record of technological or economic complexity (e.g., Rick et al. 2002), we should avoid the application of linear, progressive evolutionary models and seek, instead, to identify the total range of human behaviors as performed in time and space, which will contribute toward a richer, multilinear evolutionary view of New World coastal prehistory.

Based on the points raised above, I argue that the North American Paleocoastal concept is inherently flawed and should be discontinued from use. As I attempt to show here, and as others describe throughout this volume, there are many different cultural adaptations that were practiced in the context of varying marine environments during the LP-EH. As we learn more about the early coastal record of the New World, it is quite clear that there is no single set of adaptive elements or strategies that were exclusively employed at any one time, which might be used to define or redefine the parameters of a Paleocoastal concept. Considering this, I strongly recommend that we leave the Paleocoastal concept behind us and move forward by adopting a neutral organizational framework that enables both diachronic and synchronic comparisons of archaeological evidence across micro (i.e., local), meso (i.e., regional), and macro (i.e., continental, hemispheric, global) scales. A sufficient degree of theoretical neutrality is achieved simply by organizing early North American and New World Pacific coastal sites into already established geologic chronozones of the Late Glacial (>14,500 cal BP), Bølling-Ållerød interval (14,500–12,900 cal BP), Younger Dryas interval (12,900–11,500 cal BP), and Holocene Interglacial period (11,500–7,000 cal BP) (Fig. 1.2). In addition to being able to accommodate the full range of archaeological variability on an interpretation-free basis, this approach avoids the problem of reconciling differences in marine ecology from region to region, which are central to the discussions featured here and are unlikely to show synchronicity along the eastern Pacific Rim. Using this framework also encourages us to think about the actions of early coastal peoples in their particular environmental contexts, which might help to explain differences in New World coastal prehistory throughout the LP period.

Although archaeological sites in coastal North America do not yet predate the Younger Dryas interval, paleoenvironmental data are available from the period between ca. 15,500 and 12,500 cal BP and enable us to consider the human ecological context of earlier LP-aged marine environments. Working from an evolutionary framework that assumes the LP archaeological record of economic, logistical, and technological aspects will, at some level, reflect human behaviors conducted to address opportunities and constraints that were present in their contemporaneous marine ecosystems, we can expect that because the pre-11,500 cal BP ecological context of the eastern Pacific Ocean was significantly different than the post-11,500 cal BP period, its associated archaeological record will also be different than that seen during the Interglacial Period. Just as early Holocene-aged Archaic adaptations of the American Southwest are not applied to interpret the regional Clovis Paleoindian adaptive pattern, evidence from interglacial period coastal sites cannot be expected to directly inform us about the exact manner in which the First Americans used marine environments and their resources. Therefore, we must first carefully consider the archaeological record within the context of each chronozone before we should seek to define new overarching theoretical frameworks of cultural interpretation.

We have not yet seen New World coastal sites that date to the Late Glacial period (>14,500 cal BP); however, we should expect to find them if the MV-II peoples traveled to Chile by way of a coastal migration route. Paleoenvironmental records show greatly reduced levels of marine productivity along the northeastern Pacific during the Late Glacial period, similar to conditions present during the Younger Dryas interval. And because marine conditions were significantly different during the later Bølling-Ållerød interval, at the time of the MV-II occupation, the adaptive patterns expressed in the MV-II component may not necessarily reflect those employed in the context of the Late Glacial Period. The archaeological record of the Bølling-Ållerød interval (14,500–12,900 cal BP) is represented by the South American sites of Quebrada Jaguay, Quebrada Tacahuay, and Monte Verde (Keefer et al. 1998; Sandweiss et al. 1998; Dillehay 1989; Dillehay et al. 2009). These sites show the use of a very limited set of marine resources, including anchovy, drum fish, crustaceans, some mollusks, and seaweeds, which is atypical to the post-Younger Dryas period pattern of marine zone use that generally includes a much broader resource base with a diverse set of shellfish and fish species. The discovery of cordage in these South American sites may point to the earliest use of fishing nets in the New World, an application of a specialized technology, to be sure. The MV-II component shows a more limited use of marine resources but notably includes the remains of seaweed that were procured from the Pacific Ocean, which is considered to indicate a deep traditional ecological knowledge of marine environments and their products (Dillehay et al. 2009). The Younger Dryas period (12,900–11,500 cal BP) includes the Quebrada Tacahuay and the Richard's Ridge sites, which demonstrate clear but divergent orientations to marine resource expoitation, along with the more pericoastal K1 Cave, Gaadu Din Cave, and Indian Sands sites. Whereas the Quebrada Tacahuay site shows a more specialized use of the marine environment, probably involving the use of nets to capture anchovy (which may also reflect a task-specific pattern in an otherwise richer marine setting), Richard's Ridge includes the remains of a broad range of invertebrate and fish species along with a well-developed nonfluted/non-Paleoindian foliate projectile point industry that was probably used to hunt marine mammals and sea turtles. Although northeastern Pacific proxy records indicate a significant reduction in upwelling-driven marine productivity during the Younger Dryas interval, the record from Richard's Ridge does not clearly indicate foraging in the context of a productivity downturn but may instead demonstrate that a greater degree of local environmental variability, caused by the operation of localized factors (e.g., the interplay of local bathymetry, terrestrial physiography, and marine currents during lower sea level), worked to buffer negative effects of Younger

Dryas climatic conditions across the northeastern Pacific at this time. Certain areas of the New World Pacific coast, by virtue of inherent local characteristics, may have exhibited higher productivity marine environments during times when other coastal areas of the northeastern Pacific were suffering the effects of reduced marine productivity (cf. Yesner 1987). If so, then these "marine oases" were probably most attractive to the coastal peoples of the eastern Pacific and might ultimately retain the earliest evidence (i.e., Late Glacial) of coastal adaptations in the New World. Given its unique oceanographic setting, the discovery of intact Younger Dryas-aged and earlier period sites from the Channel Islands may ultimately reflect this pattern as well. Finally, early coastal sites postdating the Younger Dryas (≤11,500 cal BP) exhibit technological, environmental, and subsistence aspects that persist unchanged much longer into the Holocene and appear to reflect the initial development of an Archaic coastal pattern, *sensu* Ames and Maschner (1999).

Conclusion

A review of LP-EH paleoceographic records from the northeastern Pacific reveals a complex marine productivity history with cold climatic periods that correspond to significantly reduced productivity levels at the lowest trophic levels. Considering that fluctuations in lower trophic productivity trigger great effects on the upper levels of the marine food chain, this record is directly relevant to discussions of early New World coastal adaptations due to its bearing on archaeologically measurable aspects of technology, economy, and settlement patterns. The underlying conceptualization of a North American Paleocoastal concept is questioned, and a new organizational framework based on theoretically neutral chronozone subdivisions is offered in its stead.

The marine environmental record spanning the Late Glacial to Holocene Interglacial Periods is complex and highly dynamic, exhibiting tremendous changes not seen during the past 11,500 calendar years. Late Quaternary marine records indicate that northeastern Pacific Ocean environments exhibited, at times, conditions of lower productivity; however, I do not believe that this means that the New World Pacific coast could not support human migrants during the late Pleistocene period. It probably means that the earliest evidence of New World coastal occupation will reveal adaptive strategies based on relatively sophisticated toolkits and approaches that enable them to successfully exploit marine and terrestrial environments alike. Considering that human use of coastal environments occurred in the Old World much earlier than humans are clearly present in the New World, we need not expect that the First Americans experienced significant difficulty in learning how to apply their imported traditional ecological knowledge and technological systems to the coastal and pericoastal environments of the eastern Pacific margin.

While this chapter offers new perspectives on the environmental history of the North American Pacific coast, it is important to emphasize that we do not fully appreciate how these paleoenvironmental conditions directly related to the human ecology of the First Americans. Therefore, it would be premature to say that a coastal migration would have been more difficult under Late Glacial or Younger Dryas interval environmental contexts. That we have found coastal archaeological sites dating to the Younger Dryas interval is clear indication that humans were able to survive and thrive in the context of lower marine productivity. That we ever assumed LP-aged marine environments of the northeastern Pacific should always be highly productive and were somehow exempt from the environmental perturbations seen in contemporaneous terrestrial records is a myth that has been destroyed here.

Having made progress toward attaining a more detailed understanding of late Quatenary paleoceanographic conditions of the northeastern Pacific Rim, it is only natural to raise questions about the utility of the North American Paleocoastal concept, which is based on sites with dated evidence that resides in the middle of the larger temporal span of New World coastal prehistory. Clearly, one would expect that anything with a “paleo” moniker should be at the older end of a cultural historical sequence (if “paleo” should be used at all), or at least be related in significant ways to the earliest cultural periods. The discontinuity between the assumed relevance of the currently available early coastal dataset (e.g., the Daisy Cave or Eel Point sites offer critical analogies for the initial New World coastal adaptations) and the current paleoceanographic synthesis presented in this chapter (i.e., late Pleistocene period marine environments are not analogous to post-Younger Dryas period paleoceanographic conditions) cannot be ignored. Thus, as we learn more about the environmental context of the late Pleistocene-aged New World coastal zone, it has become clear to me that theoretical models that propose to have defined the cultural patterns of the earliest coastal peoples on the basis of existing knowledge are absolutely wrong and must be changed or abandoned. Not knowing how to fix the Paleocoastal concept, with its many conceptual problems, I suggest that we simply move forward by adopting a neutral approach to cultural historical reconstruction.

Although I have only briefly mentioned the recent work of Canadian archaeologists to elucidate the early prehistory and human ecological context of coastal British Columbia, we should emulate the style of their excellent interdisciplinary methodological approaches (e.g., Fedje and Mathewes 2005) as a centerpiece of future research into the late glacial to early Holocene archaeological record of North America’s coastal zone, with a particular emphasis on developing high-resolution records of marine environmental conditions. I hope that the discussion of late Pleistocene period marine environmental history presented here stimulates new thinking about the characteristics, processes, and archaeological implications of a complex and dynamic northeastern Pacific ecological context during the LP-EH. We desperately need archaeological models that incorporate existing and new information about late Pleistocene marine ecology if we are to make meaningful progress toward understanding what remains a vastly uncharted aspect of New World prehistory.

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Chapter 2
Prehistoric Archaeology Underwater: A Nascent Subdiscipline Critical to Understanding Early Coastal Occupations and Migration Routes

Amy E. Gusick and Michael K. Faught

Introduction

Awareness of and interest in the role that coastlines and coastal adaptations played in the development and dispersal of anatomically modern humans have grown over the last few decades. Scattered evidence for marine exploitation between 125,000 and 12,000 cal BP has been identified in Africa (Henshilwood et al. 2001; Singer and Wymer 1982; Walter et al. 2000), Eurasia (Stiner 1999; Straus et al. 1993), and North America (Erlandson et al. 1996). Yet, robust archaeological evidence for coastal activities accrues worldwide predominantly after 10,000 cal BP (Des Lauriers 2005; Dixon et al. 1997; Dunbar 1997; Erlandson 2002; Glassow et al. 2008; Jacobsen 1973; Keefer et al. 1998; Sandweiss et al. 1998; Stothert 1985). This relatively late appearance of clear-cut evidence for early coastal exploitation has been used to propose that early humans had little interest in coasts until stressed to seek less productive resources (Yesner 1987). Conversely, many researchers argue that the paucity of identified coastal sites dating to earlier times is more likely a result of our inability to locate these sites, rather than a lack of interest in coasts and coastal resources by early humans (Dixon 2001; Erlandson 2001; Kraft et al. 1983). Numerous Pleistocene age coastlines were deeply submerged during the postglacial period of eustatic sea level rise; and in areas such as the Northwest Coast of North America, isotastic rebound outpaced sea level rise, leaving Pleistocene coastal landscapes miles inland from current shorelines. These factors conspire to make locating Pleistocene landscapes difficult, and identifying preserved sites on those landscapes, a challenge.

While factors affecting visibility of coastal sites have a global impact on archaeological research, the submersion of North American coastlines due to eustatic sea level rise presents a particularly significant obstacle in clarifying New World archaeological migration models and chronologies. Although the exact manner and

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timing of an initial human migration into the New World remain in discussion (Adovasio et al. 1978; Barton et al. 2004; Bradley and Stanford 2004; Faught 2008; Gruhn 1988), a Pleistocene Pacific coastal migration has been hypothesized to have occurred before 13,000 cal BP, when sea levels were lower than today (Dixon 2001; Faught 2008; Fladmark 1979; Mandryk et al. 2001; Waters and Stafford 2007). Accurate modeling of the initial or any later coastal migration and the full range of settlement patterns employed by early peoples are complicated by the submersion of coastal habitats and the archaeological evidence they contain.

Today, the increased need to identify coastal adaptations and other early sites in submerged contexts in the New World has led researchers to obtain additional data from submerged continental shelf settings. Recent advancements in oceanography (e.g., sound underwater imagery and accurate Differential Global Positioning System (DGPS) mapping, to be discussed) and developments in industry (e.g., precision dredging and resource mining methods) combine to provide researchers with increasing abilities to explore submerged prehistoric archaeological sites in marine environments. While the search for these submerged prehistoric sites is a nascent endeavor, marine submerged prehistoric archaeology can offer a method to investigate more fully coastal environments and their importance to past human development. Current researchers focus mostly on paleolandscape reconstruction and location of paleoshorelines surrounding the western hemisphere that may offer more evidence of New World Pleistocene coastal migration and early habitation sites (Adovasio and Hemmings 2009; Evans et al. 2007; Fedje and Christensen 1999; Fedje and Josenhans 1999; Faught 2002, 2004; Gusick and Davis 2010a, 2010b; Josenhans et al. 1995; Pearson et al. 1986).

Our purpose in this chapter is to organize our experiences, and those of others, to expose some principles and ideas concerning how best to conduct prehistoric archaeology underwater. These principles and ideas are both intuitive and practiced and integrate culture histories, sea levels, paleolandscape, and predictive modeling methods, as well as knowledge of the kinds of equipment that can be integral to identifying archaeological evidence in a marine context. Our goal is to move submerged prehistoric archaeology from a nascent discipline within archaeology to a viable research method considered for most studies conducted in coastal areas.

Background to Submerged Prehistoric Underwater Archaeology

Underwater archaeology gained a place within academic archaeology in the 1960s with the underwater excavation, mapping, analysis, and publication of several Bronze Age shipwrecks in the Mediterranean (Bass 1966, 1967; Throckmorton 1970). Bass and his colleagues at the time (Dumas, du Plat, Frost, and Throckmorton) showed that mapping and excavations underwater could be controlled, that fragmentary ship remains were still useful for study, and that the analysis of ship building techniques and shipwreck trade assemblages could be valuable data for historians, classical archaeologists, and anthropologists (Gould 2000; Muckelroy 1978, 1980).

The underwater archaeology of submerged prehistoric sites is following a path somewhat similar to that of shipwreck archaeology; however, interest in developing specific methods for the underwater archaeology of prehistoric sites has begun to grow within the last few decades. Submerged freshwater prehistoric sites have been known since the nineteenth century in various lakes and rivers; yet, theory building, research, and publication necessary to develop predictive models and accumulate examples for open ocean submerged prehistoric sites did not start to accrue until the 1980s (Bailey and Parkington 1988; Gifford 1983; Hoyt et al. 1990; Masters and Flemming 1983; Stright 1990).

Prehistoric sites submerged in marine environments represent a special genre of underwater archaeological sites, with increasing numbers of examples of published research projects and a growing list of sites found by focused research. Recent studies into submerged terrains have found that excavations and mapping can be accomplished, that reworked sites remain valuable resources, and that archaeologists and anthropologists can use data collected from marine submerged sites to expand their knowledge of past settlement ranges and migration paths (Faught 2004; Master and Flemming 1983).

Worldwide, there are several important examples of marine submerged Early and Middle Holocene age archaeological sites studied by archaeologists (Fischer 1995; Flemming 1983). The best examples are found in low energy brackish water sediments containing Mesolithic age artifacts (8,000–5,000 cal BP) submerged by Holocene sea level fluctuation in Denmark and Germany (Andersen 1987). In the Mediterranean, off the coastline of Israel, Middle Holocene age stone structures and refuse deposits, including an early olive processing facility, have been excavated and studied (Galili and Weinstein-Evron 1985). Earlier sites are also known from marine contexts, but they are more rare. Petroleum geologists discovered Mousterian artifacts in 17 m of water north of Cherbourg, France (Scuvée and Verague 1988). This site, Fermanville, has produced 2,500 pieces of chipped stone (including tools and debitage) indicating Middle Paleolithic (Mousterian of Acheulean Tradition) artifacts in possible terrestrial sediments. Other early marine submerged site representatives include hand axes indicating Lower Paleolithic age reported from Table Bay, South Africa (Werz and Flemming 2001).

Turning to projects in North America, there are several examples of marine inundated prehistoric archaeology along the Pacific and Atlantic coasts and in the Gulfs of Mexico and California. Pacific Coast projects include the use of marine remote sensing tools for paleolandscape reconstruction (Josenhans et al. 1995, 1997), testing with grab samples and coring in Hecate Strait (Fedje and Josenhans 1999) and in the Gulf of California (Gusick and Davis 2010a, 2010b), subbottom profiling and water dredge excavations in Middle Holocene age deposits at Montague Harbour in British Columbia (Easton and Moore 1991), and geoarchaeological studies focused on predictive modeling off of the Oregon coast (Davis et al. 2009) and the Northern Channel Islands (Garrison 2000). Additionally, over 2,000 mortars and other ground stone artifacts have been found offshore in Southern California since 1915 (Masters 1983, 1996).

Research in the Gulf of Mexico and off the Atlantic coast has focused on subbottom profiling and side scan sonar to reconstruct channel configurations and to identify anomalies for further testing; and coring or excavating to test sediment packages in order to locate paleo- and archaic-age sites (*inter alia* Adovasio and Hemmings 2009; Blanton and Margolin 1994; Evans et al. 2007; Faught 2002, 2004; Fillon 2006; Garrison 2006; Merwin 2006). The methods used in marine contexts have also been successfully applied to underwater research in the Great Lakes (O'Shea and Meadows 2009) and in the Damariscotta River (Leach and Belknap 2007).

The methodological approaches used by North American researchers revolve around geoarchaeologically based reconstructions of evolving Late Pleistocene and Early Holocene coastal paleolandscapes and paleoenvironments. By effectively combining environmental reconstructions with bathymetric surveys and local settlement patterns, these researchers have delineated survey areas with high archaeological potential. As will be discussed below, many of these projects show that mapping and reconstructing the locations of paleodrainage and paleolandscape features, and seeking out preserved sediment beds, are effective tools in predicting where to look for archaeological sites in local settings.

Principles and Methods

In the 1960s, oceanographers J.O. Emery and M. Edwards of the Woods Hole Oceanographic Institute realized the great potential for marine inundated prehistoric archaeological research along the Eastern seaboard, and they theorized about the kinds of data that would be needed to find submerged sites (Emery and Edwards 1966). They proposed four guidelines that are still useful today, (1) determine the local sea level history, (2) assess site preservation potentials, (3) assess relevant cultural time periods of local human occupation, and (4) know the functional range of sites which might be expected (Stright 1990, p. 439).

Recent research has expanded on these principles and added various technologies that allow for more refined predictive modeling of archaeological site locations. Advancements have also been made with the excavation of prehistoric sites in a marine inundated context. While some methods are borrowed from shipwreck archaeology, many are unique to marine inundated prehistoric archaeology, and certainly resemble modified versions of terrestrial archaeological methods. Although there is not yet a textbook on field methods in marine inundated prehistoric archaeology, the methods that will be described below have proven effective in locating submerged prehistoric archaeological material in various marine contexts throughout North America.

Paleolandscapes

Reconstructing the paleolandscape underwater is integral for identifying locales with high archaeological potential. Determining morphological characteristics such as river channels, bedrock depressions, or complex topographic features may indicate biologically productive areas such as riparian environments, estuaries, rocky headlands, or rocky intertidal habitats. Navigation charts can be effective for identifying general areas for survey in deeper water. Faught (2002) digitized the recorded depth points from a navigation chart to reconstruct the PaleoAucilla channel system, which was then refined with subbottom profiler data. For their work on the Florida Middle Grounds in the Gulf of Mexico, Adovasio and Hemmings (2009) focused their survey efforts on relict embayments and possible paleoshorelines in the 40–120 m depth range, which they located by using a sea depth chart and knowledge of previous research conducted in the region (Faught 2002).

Though navigation charts may work for identifying larger formations or general survey areas, identifying smaller landforms and features, and specific potential locations for sites, demands more precise and abundant data. Areas with a slight increase or decrease in relief, which may not be indicated on a navigation chart, can signal the presence of smaller landscape features that may have been central to prehistoric economic and habitation activity. Features such as steep slopes, smaller rock outcrops, or shell middens are usually integral to the economy of coastal hunter-gatherer groups and may be too small to identify without high-resolution bathymetry.

A great example of finding and sampling potential paleolandscapes comes from British Columbia. Building on the knowledge that favorable Late Pleistocene age terrestrial environmental contexts remained under the immediate waters of Haida Gwaii, British Columbia, Fedje and colleagues have employed swath bathymetric data (very high resolution bathymetric data) to model the drowned landscape in Hecate Strait and then incorporated high-resolution subbottom profiling and side scan sonar surveys to locate submerged terrestrial landforms for core sampling (Fedje and Josenhans 2000; Josenhans et al. 1995, 1997) (Fig. 2.1). This approach has also proven effective along Florida's Gulf coast, where numerous researchers rely on side scan sonar and subbottom profiler images to select survey locations that appear analogous to the settings of local terrestrial prehistoric sites (Adovasio and Hemmings 2009; Faught 2002, 2004) or to select specific features for coring (Evans et al. 2007).

While these methods of remotely sensed data collection are extremely effective and efficient, they require specialized equipment and can be expensive. More economical approaches have proven to be effective, but also more time consuming. Gusick and Davis (2010b; see also Faught and Gusick 2011) reconstructed a submerged landscape in the southern Gulf of California by gathering bathymetric data in a nearshore context using a Garmin GPS 76 receiver and a consumer fathometer. These data were imported into ArcGIS and were used to build a sea floor digital elevation model (DEM) that was merged with terrestrial elevation data in order to reconstruct the paleolandscape at 12,000 cal BP. This model was detailed enough to identify a paleoriver channel, steep slope areas with rock shelters, and areas of concentrated positive relief (Fig. 2.2).

On the northwestern coast of North America, Davis et al. (2009, p. 344) used available bathymetric data, hydrological projections, estimates of surficial geology, and solar insulation to develop a predictive model with ArcGIS that quantified

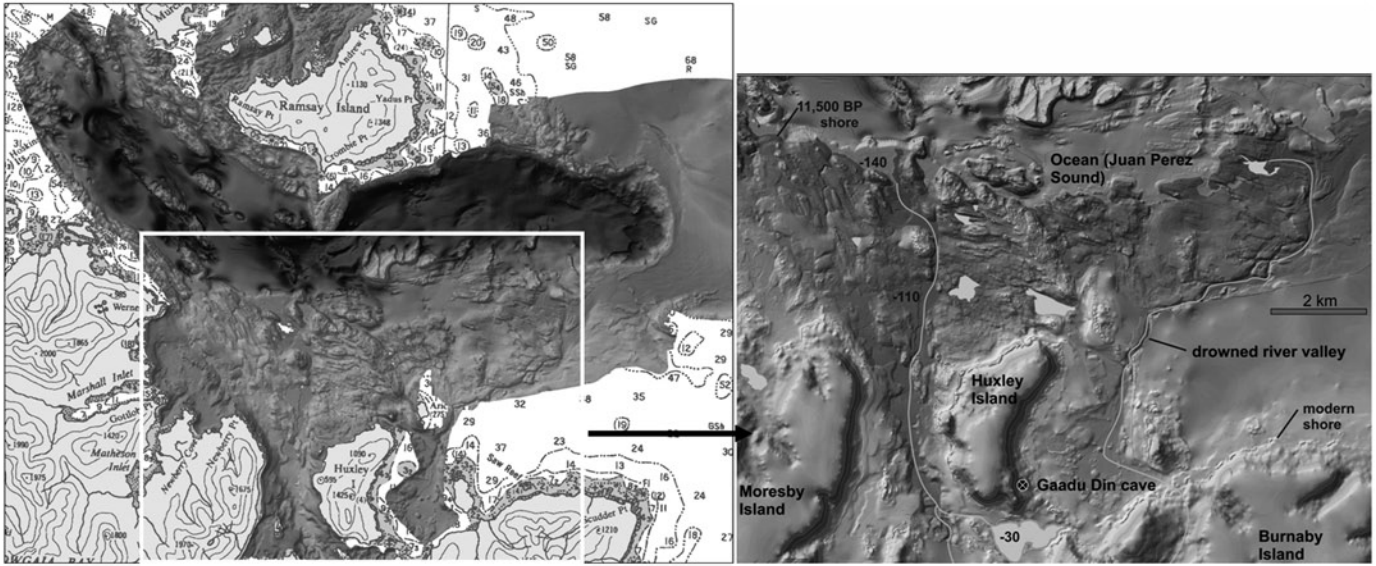

Fig. 2.1 *Left image* shows large area of glacially overdeepened basin with end moraine to east and river delta(s) to south (Heiner Josenhans, Geological Survey of Canada). *Right image* is detail (50 m contour) of area in white box showing model of Huxley Island environs at ca. 11,500 BP. The landscapes surrounding and between Moresby Island, Huxley Island, and Burnaby Island up to Juan Perez Sound were subaerial during prehistoric times. Today, only the three islands are subaerial landmasses (Daryl Fedje and Patrick Bartier, Parks Canada)

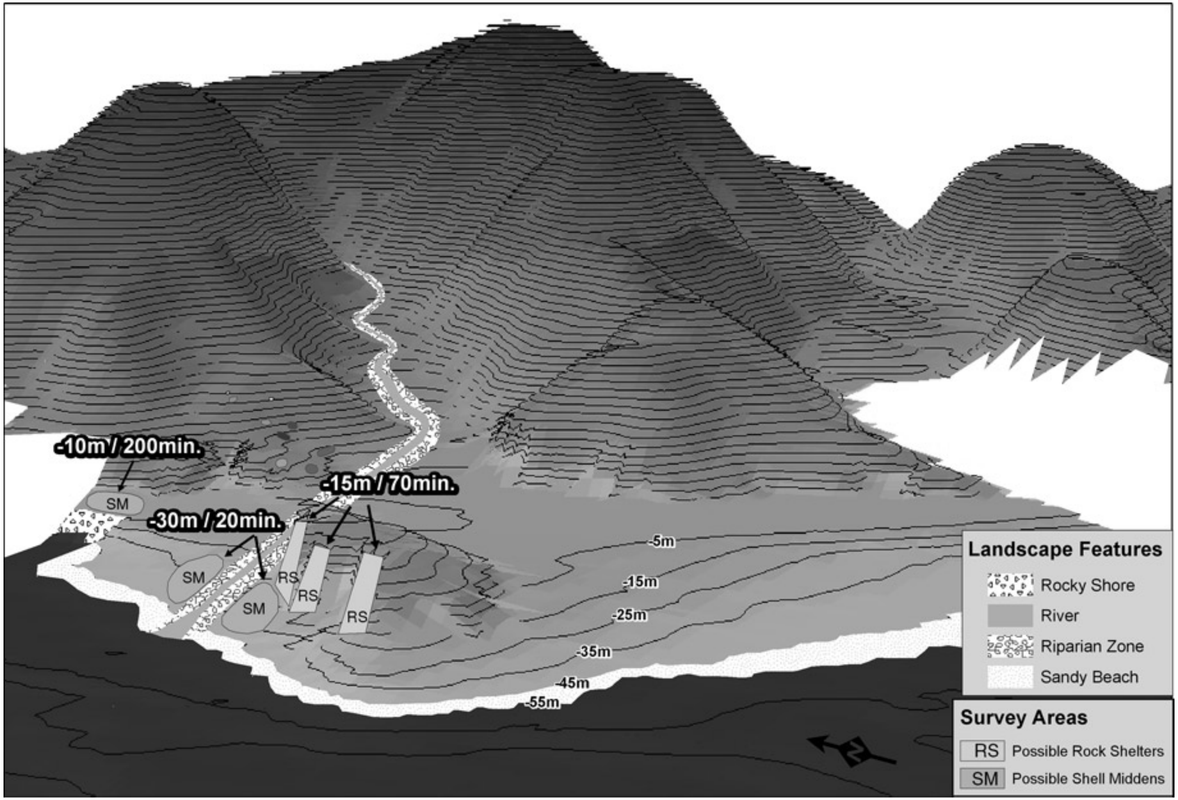

Fig. 2.2 Paleolandscape model depicting a section of landscape in Baja California at 12,000 BP. Survey areas depicted are currently submerged. Each area includes depth below current sea level and the time that a SCUBA diver would be able to remain at each depth.

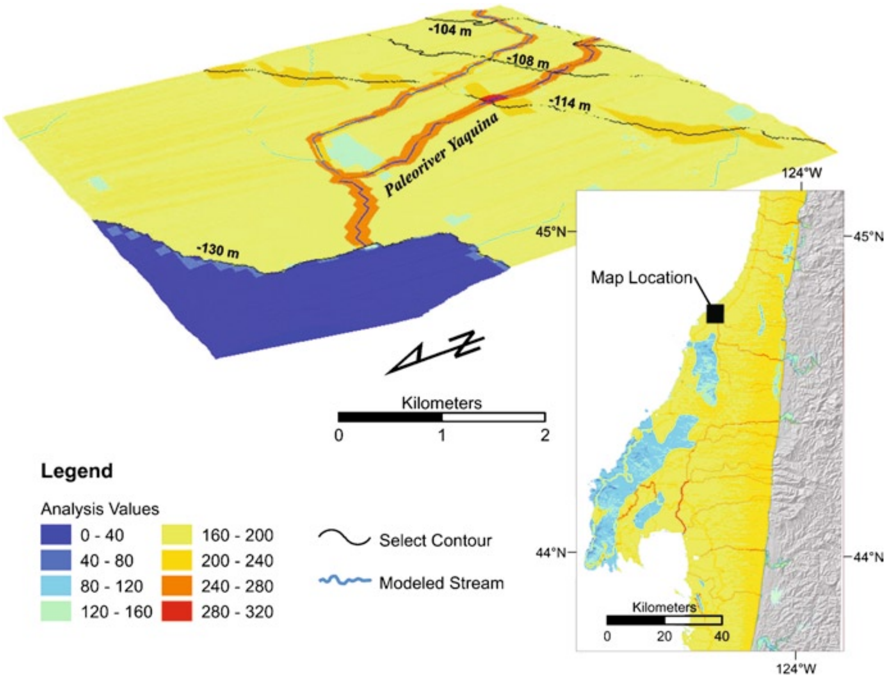

Fig. 2.3 GIS-based model developed by Davis et al. (2009) to predict the location of submerged late Pleistocene-aged sites (15,500–13,500 cal BP) on the central Oregon continental shelf

submerged areas on the paleolandscape with the highest resource potential for early foraging populations (Fig. 2.3). Though both of these methods produced only predictive models and did not provide a high-resolution sea floor map, they did provide a reasonably accurate model of the sea floor and were effective in narrowing down areas that warranted further study on an otherwise enormous submerged paleolandscape.

Sea Level History

Although a paleolandscape model provides the morphology with which to consider past environments and geological formations, the local sea level history must be considered in order to accurately define the chronology of prograding paleolandscapes. Many coastal Pleistocene shorelines were inundated by eustatic sea level rise (Fairbanks 1989; Peltier 2002), and their depths can be mapped by following a generalized regional sea level curve; however, coastlines directly affected by glaciation typically present a complex interplay between tectonic, eustatic, and isostatic change and may show a drastic departure from a generalized sea level curve (Stright 1995). This situation has been well documented for Pacific coastlines in

Haida Gwaii on the northern Northwest coast of North America. Much of this landscape was greatly affected by glaciation, resulting in “significant difference in the timing and limits of sea-level position” (Fedje and Christensen 1999, p. 637; Clague 1983; Josenhans et al. 1997). Additionally, McLaren et al. (2007, p. 2) have identified shorelines in Haida Gwaii that were “isostatically depressed as a result of glacial loading during the last glacial maximum, resulting in Late Pleistocene sea levels that were higher than today, leaving relict shorelines inland” rather than deeply submerged. This research illustrates the necessity of using local geologic history to determine if factors such as ice loading, uplift, or tectonic activity may have played a significant role in regional sea level history.

Culture Histories, Adaptation to Environments, and Behavioral Regularities

While paleolandscape models can provide researchers with means of identifying landforms that are considered integral to general prehistoric economy and habitation, knowledge of local cultural histories will elucidate population dynamics, chronologies and settlement patterns, adaptive behaviors, and diagnostic artifacts that are archaeologically sensitive in a regional context. Population dynamics refers to the abundance, or lack thereof, of sites of different time periods relevant to offshore settings, and the research on settlement patterns refers both to modeling missing resource or habitation zones, as well as adding to local understanding of the archaeological record.

Understanding local cultural systems and specific adaptations to both environmental and social pressures will provide insight into the types of material that can be expected to occur in preserved archaeological sites within various regions. Of course, one typical assumption regarding sites on a coastal landscape is that they will progressively show more faunal evidence of coastal adaptations the closer they are to the shoreline; however, not all sites located on submerged coastal landscapes will necessarily present clear indications of marine exploitation. While many pre-8,000 cal BP Pacific coastal sites yield the remains of marine resources (Erlandson 1994; Erlandson and Colten 1991; Glassow 2006; Glassow et al. 2008; Kennett 2005; Rick et al. 2001, 2005), contemporaneous sites in the Southeast, both terrestrial and submerged, have only produced evidence of terrestrial subsistence (*inter alia* Clausen et al. 1979; Driskell 1996; Dunbar et al. 1988; Webb 2006). Therefore, marine inundated prehistoric archaeology demands that archaeologists be knowledgeable about the local or regional prehistory, thus enabling them to know what they are looking for; what they are finding; and where to integrate the findings into local prehistoric reconstructions, settlement patterns, and chronologies.

Current underwater research in North America is shaped around knowing local human behavioral patterns that can provide defined guidelines for identifying locales considered high-potential for submerged cultural remains in the context of local cultural behaviors. Settlement patterning in the Northeast suggests that prehistoric groups exploited and processed eastern oyster (*Crassostrea virginica*), leaving traces of this activity close to natural oyster bioherms. Current archaeological investigation in the Damariscotta River in Maine focuses on identifying and sampling relict oyster bioherms, which have been preserved in marine sediment, in an attempt to locate cultural shell middens (Leach and Daniel 2006). Another inventive use of local cultural knowledge, though not in a marine setting, is found in research conducted in the Great Lakes. O'Shea and Meadows (2009) have identified potential caribou drive lanes (stone structures used for caribou hunting) that have been submerged beneath Lake Huron. These types of linear stone structures have previously been identified in a terrestrial setting and are associated with prehistoric and ethnographic caribou hunting. By framing their research around a local cultural activity that occurs on a specific type of landscape and leaves definite, identifiable evidence, they were able to narrow their search area and identify a unique submerged cultural site.

Preservation Potential and Processes

Even armed with an accurate paleolandscape model that presents features known to be important within the local culture history, the probability that archaeological remains may be preserved must be predicted and assessed. There are, of course, numerous factors in a marine context that can be detrimental to the preservation of submerged remains; however, there are contexts in which preservation potential can be considered favorable (Flemming 1983; Stright 1995). An ideal study area must exhibit a morphology that is not only biologically productive and attractive for habitation but also shows physical constraints that allow for preservation and accessibility (Fedje and Christensen 1999, p. 650). For instance, coastal caves and rockshelters have proven to be ideal locations for early mobile hunter-gatherer occupation (Erlandson 1993; Erlandson et al. 1996; Dixon et al. 1997; Fujita and Poyatos de Paz 1998; Gruhn and Bryan 2002; Fedje et al. 2004) and these recesses may provide protection from wave and tidal action in a submerged environment (Inman 1983). Regions in which structural contexts result in shallow bays can limit the amount of site disturbance from tidal action or storm surges, and supplementary protection from wave energy is also found on the leeward side of coastal islands and within archipelagos (Flemming 1983, p. 138). Coastlines with gently sloping continental shelves, particularly in locales with reduced wave action, would have been quickly inundated during sea level rise, promoting rapid sedimentation and therefore protection of archaeological sites from environmental elements. In fact, the anaerobic environment that can exist in the seabed is favorable for preservation of organic material (Dean et al. 1995, p. 31; Muckelroy 1978, p. 52).

Underwater research efforts in North America reflect the importance of identifying areas with high preservation potential. The protected bays within the archipelagos along the northern Northwest Coast have been the focus of dedicated paleolandscape modeling and archaeological sampling, resulting in the identification of submerged cultural material (Easton and Moore 1991; Fedje and Josenhans 2000; Fedje and Christensen 1999; Josenhans et al. 1995). Projects in the Gulfs of Mexico and California have benefited from the gently sloping bathymetry of the continental shelves in many areas of these regions and from the reduced wave energy typical of gulf contexts (Adovasio and Hemmings 2009; Evans et al. 2007; Faught and Gusick 2011; Gusick and Davis 2010b). Additionally, Faught's (2002) work in the Gulf of Mexico relies, in part, on identifying submerged karst features, as these are known from local terrestrial settings to contain preserved archaeological evidence.

Even in regions with numerous conditions favorable for preservation, geologic, hydrologic, and oceanographic changes that have occurred over the past 15,000 years may have greatly affected the preservation of archaeological material. For instance, while the geomorphology of eastern Pacific coastal environments, with rocky shores and deep basins, provides enclaves and rockshelters that can act to protect archaeological remains, the formidable wave action in this area of the world can erode away sea cliffs and cut terraces (Inman 1983), possibly destroying evidence of prehistoric occupation. In areas with reduced wave action such as the Gulfs of Mexico and California, site preservation may be more probable than those areas exposed to the open ocean, but the frequent hurricanes that occur in these regions may destroy or alter the location of submerged remains.

An additional consideration is sedimentation rates. Although sedimentation can aid in preservation, the amount of sediment that accumulated during marine transgression can be massive, resulting in deeply buried terrestrial surfaces. Punke and Davis (2006, p. 336) have identified Pleistocene landforms in the Pacific Northwest that are buried beneath the 28 m of fine- to course-grained sediment that has been deposited over the last 10,000 years. The depth of sediment covering a terrestrial surface can be difficult to determine without obtaining sediment core samples; however, images generated from a subbottom profiler can provide an indication of sediment cover. Use of this remote sensing equipment will be discussed below.

Survey Methods

The processes of narrowing down targeted features to those most favorable for investigation considering the paleolandscape, paleoenvironment, sea level history, cultural history, and preservation potential aid in determining general areas considered to have high-potential for preserved archaeological remains. This information is important when developing an effective underwater survey design, as location and depth of targets will determine the type of survey necessary for efficacious investigation. Additionally, marine inundated prehistoric archaeology can be time-consuming and costly; therefore, developing a survey design focusing first on those areas considered to have high-potential for archaeological remains can greatly increase productivity and maximize time and expenses.

Remote Sensing Survey: Sound Underwater Imagery

Searching submerged landscapes for prehistoric sites and artifacts is more than a challenge. Areas to survey are extremely large; and discovery of small objects (i.e., stone, bone, or wood artifacts) is akin to finding little needles in gigantic haystacks. Few sites will be exposed for surface collection, although they do exist (Faught 2002, 2004). Consequently, it is timely that digital mapping of large areas of the sea floor bottom, and remote probing of the sediment beds below, is currently possible because of technological advancements in remotely sensed sound underwater imagery and precise, integrated DGPS locational controls.

Four instruments based on sound underwater imagery form the basic tools to reconstruct sea floor morphology. They are differentiated by the frequency of sound beamed out and complexity of the return signal processing equipment. Images collected from these instruments can be used to model the local paleolandscape and focus additional research on higher potential areas (Table 2.1).

Subbottom profiling is surely the most important remote sensing device for prehistorians interested in submerged sites because it can inform on bottom morphology, sediment cover depths, and paleochannel configurations. Subbottom profiling, in the sense of sound propagation (dynamite early on) and study of

Table 2.1 Remote sensing technologies

Technology	Common uses	Comments
Subbottom profiler	Identify infilled-channels Determine marine sediment cover Identify buried features	Range: 0.9–34 kHz Chirp systems scan multiple frequency returns Uses low frequency seismic sound waves to penetrate sediment beds to create images Can indicate changing sediment density
Fathometer	Determine sea floor morphology (low-resolution)	Range: 50–200 kHz Use in conjunction with GPS to reconstruct large areas of seafloor gross morphology
Multibeam sonar	Determine sea floor morphology (high-resolution)	Uses multiple sound beams Creates detailed sea floor map
Side scan sonar	Identify surficial features	Range: 100–1,200 kHz 100–300 kHz is for wide swath, low precision 400–1,200 kHz is for narrow swath, high precision Uses sound waves to reconstruct images of the bottom, including objects and texture Good for exposed paleolandscape settings Good in fresh water rivers

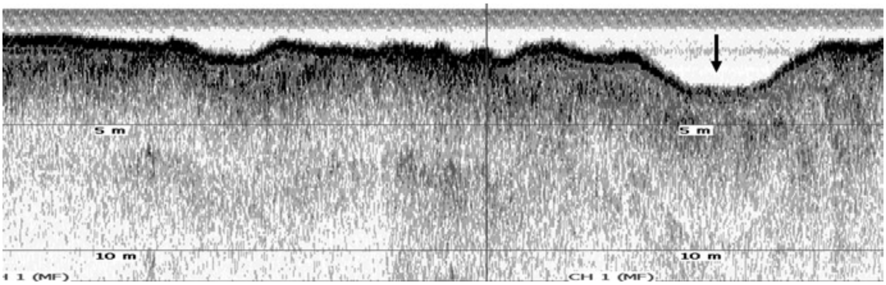

Fig. 2.4 Subbottom profiler image showing reconstruction of part of the PaleoAucilla. Depression indicated by *arrow* on *right* is the sediment infilled paleoriver channel

reflective images, has been used since the 1930s to study geologic strata in marine contexts (Schlee 1978). More recent archaeological uses include collection of subbottom data to map channel systems in order to identify high probability areas for archaeological sites. Pearson et al. (1986) reconstructed a portion of the PaleoSabine, and Faught and Donoghue (1997) used subbottom data and early GIS technology to reconstruct a detailed portion of the PaleoAucilla and PaleoOklochoknee River channel system of the Big Bend of Florida (Fig. 2.4). Additional research in the Gulf of Mexico used subbottom data to identify an in-filled paleoriver channel east of the Florida Middle Grounds (Adovasio and Hemmings 2009). Off the Pacific Coast, Easton (1993) used a subbottom device at Montague Harbour, and Josenhans et al. (1995, 1997) used high-resolution subbottom profiler surveys to confirm submerged channel-ways identified by multibeam sonar in Hecate Strait.

In addition to interest in channel systems, subbottom profiler data is used to locate positive relief features that may be shell middens or early (nearshore) mounds. Faught (2008) identified one positive relief feature with a subbottom profiler in Tampa Bay, but diver investigation showed it to be a remnant bed of Sangamon-aged marine shell. The feature was a “pile of shell,” but was not cultural. On the other hand, Evans et al. (2007) are testing possible shell midden features identified with a subbottom device in the northwestern Gulf of Mexico. Initial sampling indicates that the features are indeed middens that contain brackish shell of the appropriate age to have been culturally deposited when the landscape was subaerial.

Other sonar devices that are effective in mapping seafloor morphology are multibeam sonars (Swath echosounders) and fathometers. These echosounders are designed to measure bathymetry and can be very effective in identifying larger sea floor features. Fathometers show depths to sea floor from a single, narrow sound beam, while multibeam sonars determine fine precision bathymetry over large swaths of seabed. Data from the multibeam can be used to create quasi-photographic, but three-dimensionally manipulable reconstructions of seabed morphology akin to DEMs. The lower cost fathometer option will not be as precise, but when used in conjunction with GPS data, a lower resolution model can indicate gross morphology (Gusick and Davis 2010b). Fedje and Josenhans (1999) employed

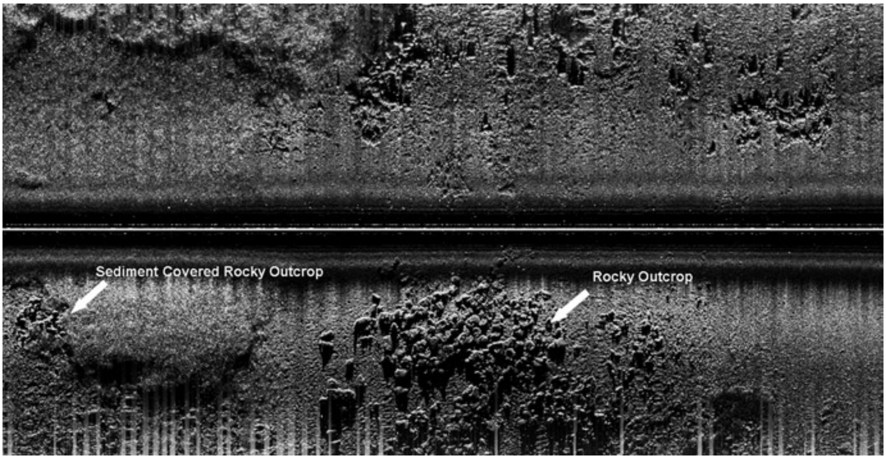

Fig. 2.5 Side scan image collected from Gulf of Mexico. Rocky outcrop in *bottom center* of image. *Bottom left* is rock outcrop covered in sediment. During diver investigation, these areas yielded cultural material

high-resolution multibeam data to illustrate the drowned paleolandscape in Hecate Strait, and from these data were able to identify paleo-beaches, -terraces, and -fluvial confluences.

Finally, we get to the side scan sonar. While regularly used in shipwreck archaeology, side scan sonar technology is useful to prehistorians where paleolandscape features are exposed or recognizable on the bottom. They can be useful in riverine settings, in finding lag deposits, raw material outcrops, or possibly caves. For instance, Faught (2002) used side scan sonar equipment in a drowned karst setting to locate rock outcrops in the Big Bend area. The resulting diver investigation confirmed that a portion of these rock outcrops yielded cultural material (especially those near Paleofluvial features, cf. Fig. 2.5). In other applications, Adavasio and Hemmings (2009) used side scan sonar to identify near-shore sand ridges in association with the Late Glacial Maximum Coast, and Gusick and Davis (2010a) used the technology to identify possible fish weirs and relic beach features in the Gulf of California.

On the Seafloor Bottom: Surveying, Testing, and Sampling

Once the "haystack" has been sorted out and high probability targets for study have been identified, direct observations in the field are most important. Virtual visits to underwater settings with sufficient visibility are possible with a remotely operated vehicle (ROV). Use of this equipment is well known in shipwreck investigations, but their full utility in submerged prehistoric site investigation is only now being determined. Current archaeological applications include underwater video documentation and collection of more recognizable images of features identified by subbottom or side scan operations (Adovasio and Hemmings 2009).

Features derived from the sonar equipment can be difficult to positively identify; therefore, collecting clear ROV images aids in determining if a feature should be investigated more thoroughly with a dive operation. This kind of technology is important to be developed for working in water deeper than 60 ft., as the amount of time a diver can remain at these depths is limited.

Although virtual site visits are possible, direct diver survey remains the most effective method for obtaining samples, for investigating targets more thoroughly, and for positively identifying cultural material. With SCUBA, divers breathe compressed air from a tank, or supplied from the surface with hoses. Experienced divers can dive deeper and stay longer by breathing mixtures of gases (increased oxygen, helium, or nitrogen mixtures), but these are not for the novice. In general, diving in depths less than 30 ft., is particularly easy and not time restricted, but the time a diver can remain underwater gets shorter with increasing depth and there are severe time restrictions on SCUBA diving deeper than 100 ft. It is at these greater depths that gas mixtures or closed-circuit rebreathers (CCR) are useful.

Fundamentally, the time underwater is always limited when compared with the way terrestrial archaeologists would spend getting to know their site. If a site is deeply submerged, an underwater archaeologist may only be able to work 3 h/day at the site. Prehistorians accustomed to ample time to draw strata and observe in the field should internalize this fact and learn to embrace and communicate specific and attainable goals for each season and each dive.

Effective sampling at a submerged archaeological site is another task that tends to be a bit more challenging than at a terrestrial site. Massive infield gridding, as often done on land, is a luxury underwater. It is often the case that sampling underwater takes place from central datum points from which collection transects can be sampled at regular intervals. Artifacts or other objects can be recorded by distance and bearing measures. Likewise, collection areas can be quadrilateral, but taking the time to set up a grid with actual pins on the bottom may not be the most efficient use of bottom dive time.

Coring remains the most useful way to collect sedimentary data and can be done relatively easily in an underwater context. Pearson et al. (1986) used a dense pattern core sampling project to test features and strata located with seismic records in order to identify terrestrial landforms in an area of the PaleoSabine River in the Gulf of Mexico. They were successful in identifying a probable midden at a considerable depth. Once a site can be identified, increased numbers of cores in tight patterns can be useful to determine the extent of sediment beds or boundaries of a site; however, cores are not usually effective in finding artifacts, and therefore in identifying sites, simply because the sample area is so small. That being said, Easton (1993, p. 9) collected a series of core samples from throughout the basin in Montague Harbour, British Columbia, that were effective in identifying stratified midden deposits as well as a "depositional sequence of basal clays, terrestrial soils, and marine sands." Additionally, Gagliano et al. (1982) used geoarchaeological point count methods to identify anthropogenic sediment characteristics at known terrestrial sites. These data were then used to identify submerged sites by comparing characteristics within sediment from cores collected from probable inundated anthropogenic deposits.

Another approach to subsurface testing, if the paleolandscape is not buried too deeply with marine sediment, is hand fanning. Equivalent to shovel testing terrestrially, divers can take samples at predetermined intervals by hand fanning up to a meter or more into unconsolidated sediments and collecting specimens (Muckelroy 1978, p. 28). Faught (2002, 2004) used hand fanning to good effect in a drowned karst environment in Florida, and Gusick and Davis (2010b) report its effectiveness in Baja California.

Once a site has been identified in a submerged setting by previous coring and/or hand fanning techniques, there are multiple devices for controlled excavation (Table 2.2). For small excavations, both airlift and hydraulic dredges have proven effective (Fig. 2.6). The effluent ends of these dredges can be brought to the surface for screening, or screened underwater (Fig. 2.7). Easton and Moore (1991) used an airlift device to excavate 1-m test units in a submerged deposit in Montague Harbour, and hydraulic dredges have frequently been used to dig test pits and excavate identified sites in various locales in the Gulf of Mexico (Dunbar 2006; Faught and Latvis 2001).

Table 2.2 Sampling technologies

Technology	Common uses	Comments
Core tube Vibra-cores Piston cores Hand-pounded	Sediment sampling Feature testing Site boundary testing	Can be diver-operated (see Bonem and Pershouse 1981; Jones et al. 1992; Horlings 2009 for inexpensive and portable versions designed to utilize pressure from a SCUBA tank) Usually small diameter, 3 in. or less common Not great for finding artifacts Can collect intact deposits
Hand fanning	Subsurface testing	Move a fair amount of unconsolidated sediment Not good for sites with significant marine sediment cover Can recover artifacts *in situ*
Induction dredge	Site excavation Marine sediment removal	Diver-operated Uses hydraulic action Good for shallow depths (less than 20 ft.). Gasoline pump, dredge head, and hoses are heavy, cumbersome and loud Can excavate large areas
Air lift dredge	Site excavation Marine sediment removal	Diver-operated Uses compressed air released at the hose opening Works well in deeper water, but needs high pressure compressor Lightweight in water Can excavate large areas
Industrial dredges	Sediment sampling	Not diver-operated
Hydraulic	Site sampling	Cumbersome and cannot be diver-operated. Hydraulic dredges powered by gasoline (or diesel) engines
Clamshell Bucket		Clam shell and bucket dredges are heavy pieces of equipment typically used in industrial dredging projects

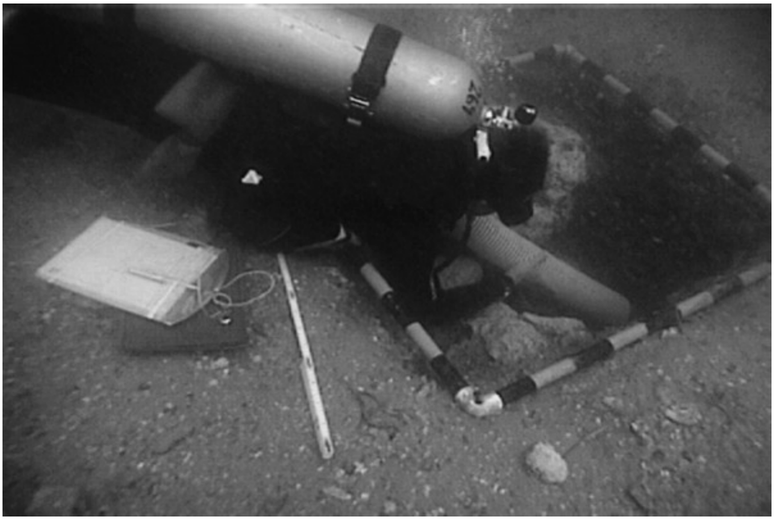

Fig. 2.6 Underwater excavation unit showing retention of unit wall. Excavation accomplished with use of hydraulic dredge

Industrial strength excavation devices include a bucket dredger, a grab dredger (clam shell dredge), and various types of induction dredges with large diesel engines and turning digger heads to loosen sediments. Bucket and clam dredges can collect several cubic meters at a time and can be effective for larger samples to determine if a controlled site excavation is necessary. Although dredging methods may seem less than desirable since they homogenize their sample volumes, they can be very useful for removing large units of sediment, and they can sample enough material to actually find artifacts. For instance, Fedje and Josenhans (1999) conducted sampling with an industrial-sized dredge on a terrestrial landform submerged 55 m off Hecate Strait. The sample material was screened on deck and led to the recovery of a stone tool.

After Collection

Maintaining the inundated state in which an artifact was discovered will prevent desiccation, thereby reducing salt crystallization, which is extremely detrimental to the stability of artifacts. Faught (1996) discusses the deterioration of chipped stone from marine environments and emphasizes the need to flush artifact materials with fresh water for long periods to completely remove any salt. The mantra "keep it wet" is important for preservation of organic materials or stabilization of lithic materials. It is best to keep the material submerged in water that is continually refreshed. The only exception to this is in the case of material for radiocarbon dating. These items should be desiccated as soon as possible, as prolonged immersion enables organic growth, and chemicals to prevent such growth have potential problems with radiocarbon calculations.

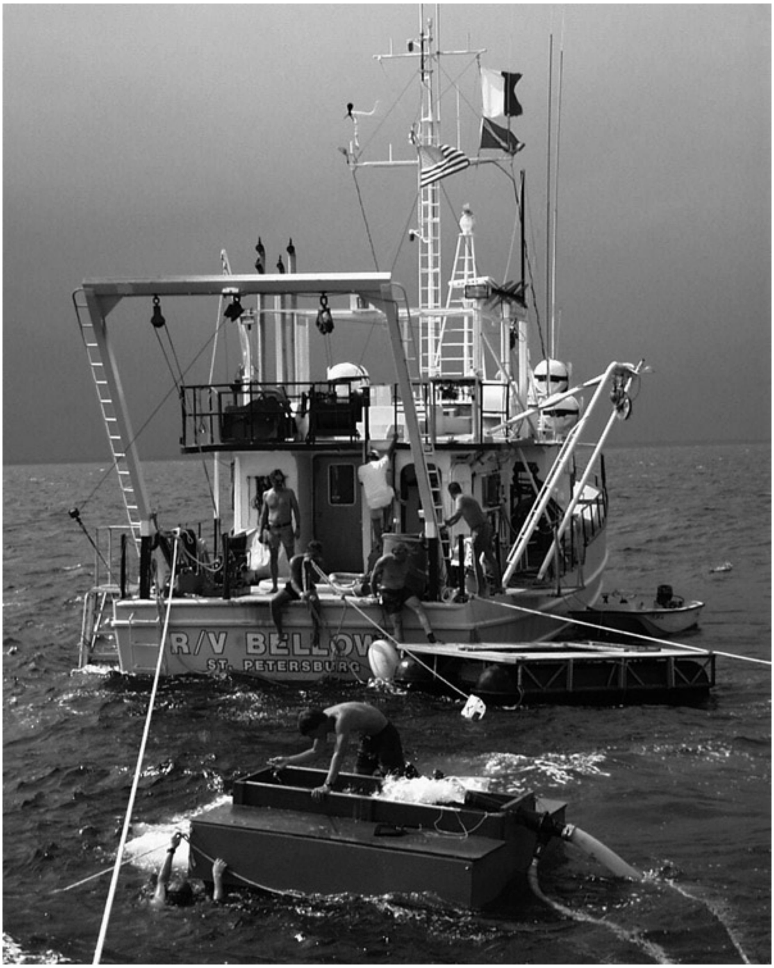

Fig. 2.7 Image showing effluent end of hydraulic dredge dumping into a screen being monitored topside

Conclusions

Most important to underwater exploration in the New World, the examples listed throughout this paper illustrate the utility of employing systematic approaches to the location and sampling of offshore archaeological sites (see Flemming 1983; Geddes et al. 1983; Kraft et al. 1983; Masters 1983). The accomplishments to date in methodological development and research into submerged environments are extremely promising. By effectively combining information on environmental reconstructions with bathymetric surveys and knowledge of coastal settlement patterns, innovative archaeologists have developed and will continue to develop newer and more effective methods for the study of submerged sites within their paleolandscape context. Our attempt to bring these efforts to light and to help move prehistoric marine archaeology into mainstream archaeological research is only part of what will undoubtedly be a long process. Strengthening the role of underwater archaeology as part of early coastal sites research would not only be extremely advantageous for research into the initial human migration into the New World but would also benefit any archaeologist investigating an ancient landscape that has been partially or fully submerged, no matter the time period of interest.

While we do feel it is important for archaeologists working in a coastal environment to consider the seascape when developing project methods, there are areas in which the cost and time of conducting underwater studies may exceed the expected outcomes. Yet, there are thousands of miles of inundated coastline surrounding North America that do have the potential to yield prehistoric archaeological sites, but are largely unexplored. The inundation of these coastlines should not be a barrier that prevents researchers from collecting data that may help to evaluate major issues within archaeology. Indeed, coastal landscapes and the resources they provide have influenced some of the most significant developments in human history. Our ability to explore more fully these developments has been expanded through dedicated research focused on coastal landscapes. While much of this research has been terrestrially based, underwater paleocoastal research is rapidly becoming a viable and integral field in Anthropology. Our ability to more fully understand the behaviors of early maritime peoples, including the timing and nature of the peopling of the New World, may very well depend on locating data that has been submerged for the last 15,000 years.

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Chapter 3
Early Environments and Archaeology of Coastal British Columbia

**Quentin Mackie, Daryl Fedje, Duncan McLaren,
Nicole Smith, and Iain McKechnie**

Introduction

Coastal British Columbia is largely a rugged fjord-land archipelago. It has not always been so – over time, the coastline has changed configuration dramatically and the fauna and flora have seen multiple successions and extirpations. Through this, for the last 11,000 RCYBP years at least, resilient people made their living from the ocean and the land, shrugging off or taking advantage of environmental change. Similarly, archaeologists have worked the nooks and crannies of the coast for decades, surveying in the dense forest and digging in the deep middens, subject to similar environmental conditions as those they study and making quiet progress in regional culture histories. In more recent years, this area has been thrust to the forefront of research into the First Peopling of the American continents. As the Clovis First model began to be questioned, alternate modes and routes for the arrival of humans were brought in from the sidelines, including the hypothesized west coast route (e.g. Fladmark 1979). Not much research had been focused on this route, perhaps as Easton (1992) suggests, because of the terrestrial mindset of many archaeologists. Perhaps also, the prospects of finding sites on the deeply drowned landscapes or in the rugged, heavily forested hinterland was prohibitively daunting and led to a pessimistic outlook on success. In the last decade, this pessimism has slowly turned to a more optimistic outlook, as advances in remote sensing technology, radiocarbon dating, benthic sampling, and archaeological survey methods have demonstrated that the ancient land is knowable, had people on it, and that their archaeological record is recoverable (e.g. Erlandson 2001; Erlandson et al. 2005, 2007, 2008; Faught 2004; Fedje et al. 2004a). In this chapter, we review the environmental and archaeological data from the terminal Pleistocene and early Holocene. We then describe some recent advances in methods for finding early archaeological sites, including case studies showing successes and prospects for the future. We then turn attention to three difficulties archaeologists may need to address if they are to further advance knowledge of the Pleistocene BC

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coast: the heterogeneous and dynamic nature of the coast must be appreciated; appropriate ethnographic analogies must be developed; and a humanistic appreciation of the processes by which people first arrive on a landscape must be employed.

Review of Palaeoenvironment

Archaeologists need to be very sensitive to the dynamic environment of post-glacial Pleistocene and early Holocene coastal British Columbia. Without a fine-grained understanding of the dramatic yet subregionally specific environmental changes, it would be difficult or impossible to find and interpret sites dating to this earliest period of human occupations. The following sections review some of the more significant palaeoenvironmental events and trends, with case studies to illustrate smaller areas within the BC Coast.

Sea-Level History

Unlike un-glaciated regions such as the California and Oregon coast where late Pleistocene shorelines are deeply drowned beneath modern sea levels (see “Global eustatic” curve in Fig. 3.1), the glacially influenced NW Coast offers an array of opportunities to locate late Pleistocene archaeological sites and target the adaptation of humans at relatively narrow temporal windows.

Sea-level histories are very localized phenomena on the Northwest Coast as a result of tectonic change associated with proximity to tectonic plate boundaries, the isostatic effects from the various ice loading and unloading events on an area with highly variable crustal thicknesses, and global eustatic change (Clague et al. 1982, 1983; Riddihough 1982; Fairbanks 1989; Fedje et al. 2005b). The net results of these processes are significantly different histories, even in areas of relatively close proximity (Fig. 3.1, Table 3.1). Table 3.1 provides a general history of shoreline position through time for select areas of the B.C. coast. These positions are known from a variety of sediment basin cores, both marine and terrestrial (Fig. 3.2) and from sections and basal peats. Working from this, we can obtain a preliminary understanding of the logistical constraints to investigating aspects of the early human use of the coast, illustrated through the following three case studies.

Case Studies

Haida Gwaii

The sea-level history of the region around Haida Gwaii is the most refined record for the BC Coast. Work in northern Hecate Strait on the eastern side of Haida Gwaii shows that the strait was open and ice-free before 14,380 RCYBP and that sea levels,

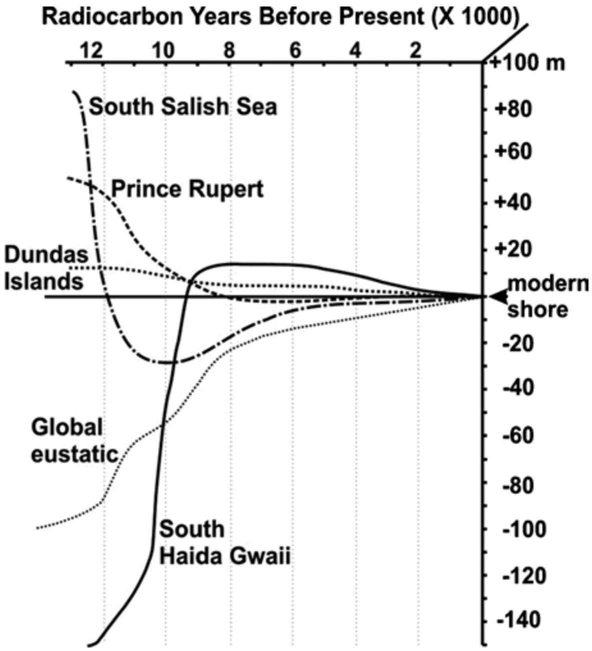

Fig. 3.1 Selected BC sea-level histories South Salish Sea (Fedje et al. 2009), Prince Rupert and Southern Haida Gwaii (Fedje et al. 2005b), Dundas Islands (McLaren 2008)

specifically in that area, were lower than 30 m below modern from at least 14,330–12,860 RCYBP (Lacourse et al. 2005). At 12,500 RCYBP, relative sea levels in southeastern Haida Gwaii and adjacent Hecate Strait were 150 m below modern (Fedje et al. 2005b). Levels in this area began to rise slowly ca. 12,000 RCYBP and sharply after ca. 11,000 RCYBP reaching a transgressive maximum 15 m above modern at 8,900 RCYBP. Relative sea levels remained at 15–14 m above modern until 5,000 RCYBP and have fallen slowly since that time (Fig. 3.3).

This relative sea-level history provides the basic framework for investigating shoreline occupation sites from late glacial through to Holocene time. By combining high-resolution sea floor mapping with air photo or lidar-derived terrestrial data, models can be prepared and palaeo-landforms assessed as to archaeological potential and logistical constraints.

Fraser Valley – Stave Lake

The lower Fraser River drainage area on the southwestern mainland of BC was almost completely covered by glacial ice at the height of the Vashon Stade of the Fraser Glacial period, approximately15,500–15,000 radiocarbon years ago (Armstrong 1981). The advance of glaciers during the Vashon Stade began 17,000 radiocarbon years ago, after a short 1,000 year interglacial period, forcing most

Table 3.1 Shoreline position relative to modern for select locations

		Radiocarbon years ago (×1,000)														
		14.5	13.5	13.0	12.5	12.0	11.5	11.0	10.5	10.0	9.0	8.0	7.0	6.0	5.0	
		Calendar years ago (×1,000)														
See Fig. 3.1	Region	17.4	16.0	15.3	14.6	13.9	13.4	12.9	12.5	11.4	10.2	8.9	7.8	6.8	5.7	References
1	Haida Gwaii	Below **−30^{1}**	Below **−30^{1}**	Below **−30^{1}**	**−150**	**−150**	**−130**	**−120**	**−100**	**−50**	**+14**	**+15**	**+15**	**+15**	**+14**	Fedje et al. (2005a, b); Lacourse et al. (2005)
2	Dundas Islands				**+14**	**+13**	+12	+11	**+10**	**+10**	+9	+8	+7	+7	**+6**	McLaren (2008)
3	Prince Rupert				**+50**	+40	+30	+25	+20	+15	**+5**	**0**	<0	<0	**<0**	Clague et al. (1982); Fedje et al. (2005b)
4	Alert Bay	Ice	**+30^{2}**	**+55**	**>+17**		**+53**								**+3**	Hebda (1983); Howes (1983); Stafford and Christensen (2009)
5	Barkley Sound	Ice		Above **+25^{3}**		**−46**	**−46**	**−45**	**−44**	**−42**	−27	−18	−11	**−4**	**+2**	Clague et al. (1982); Dalimore et al. (2008); Friele and Hutchinson (1993)
6	N. Salish Sea	Ice				**+150**	**+100**	**+50**	**0**	**−2**	**−2**	**0**	+3	**+2**	+1	Hutchinson et al. (2004)
7	S. Salish Sea	Ice			**+75**	**0**	**−4**			**−30**			**−4**	**−8**	**−6**	Fedje et al. (2009); James et al. (2009)
8	Fraser Lowlands	Ice		**+200**	**+180**	**+80**	**+60**	**+20**	**+18**	**+16**	0	**−12**	**−5**	−2	**0**	Clague et al. (1982); James et al. (2002)
9	Global Eustatic	**−105**	**−100**	**−95**	**−90**	**−75**	**−65**	**−60**	**−55**	**−50**	**−35**	**−25**	**−18**	**−8**	**−2**	Bard et al. (1996); Stanford et al. (2006)

Bold numbers indicate data points constrained by ^{14}C dates. Other data points are interpolated. Shell dates have been for local marine reservoir effect (Southon and Fedje 2003; James et al. 2009). *1* data from northern Hecate Strait; *2* data point from 50 km northwest of Alert Bay; *3* data point from 50 km northwest of Barkley Sound

Fig. 3.2 Use of Livingstone core sampler from canoe-based platform, 2001. Sediment cores provide a number of palaeoenvironmental proxies, including vegetation, climate, and sea-level history. Q. Mackie photo

plants and animals, including Pleistocene megafauna, from the region (Lian and Hickin 1992). By 13,000 RCYBP, ice had receded to the eastern Fraser Valley, but still existed in the mountain valleys of the southern Coast Mountains (Armstrong 1981). Rapid deglaciation was complemented by rapidly rising sea levels during the post-Vashon submergence. Stratigraphic marine deposits demonstrate that sea levels occurring around 13,000 RCYBP were 175 m higher than today (Mathewes et al. 1970). During this period, the Stave Watershed would have been much like a fjord (Fig. 3.4) (Gilbert and Deslodges 1992). Following the post-Vashon submergence, a rapid drop in sea levels occurred. By 12,000 RCYBP, sea levels had dropped to about 80 m above current sea level and the rate of marine regression became slower

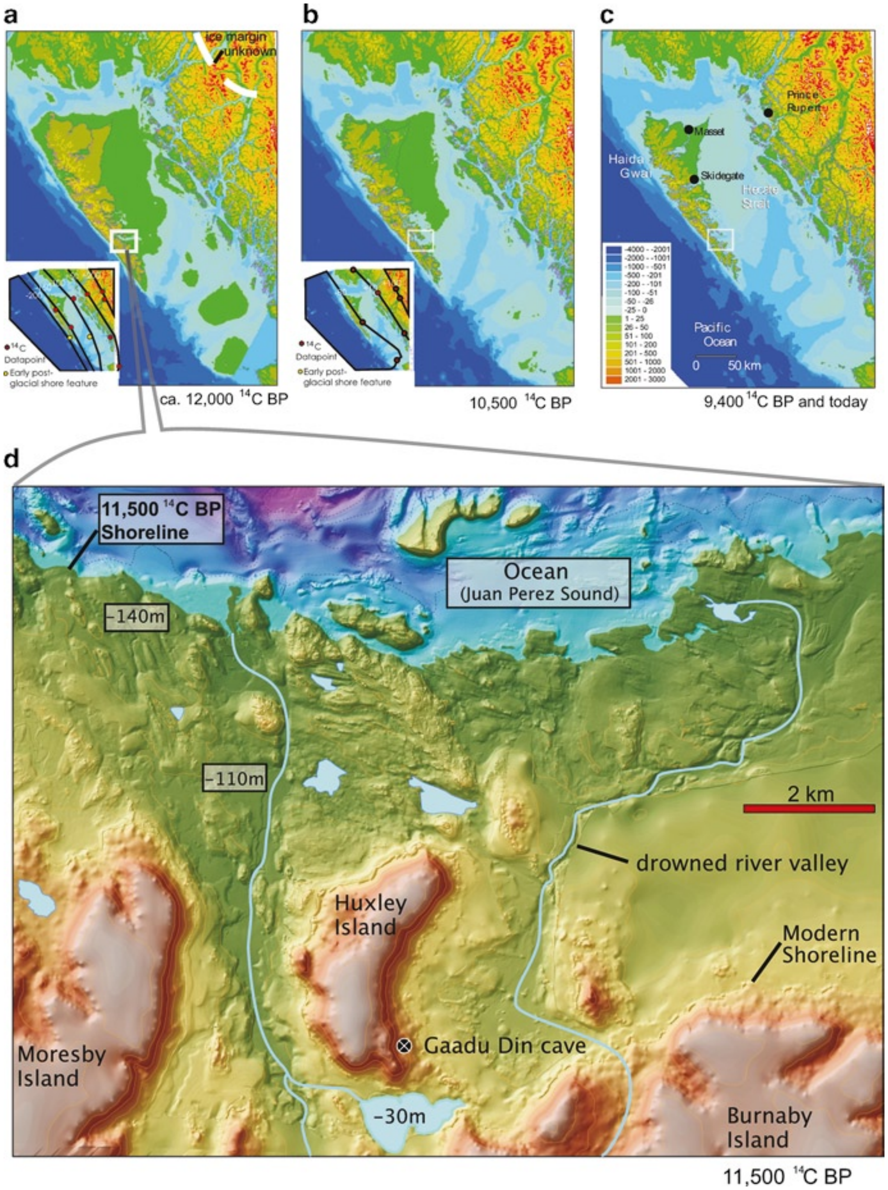

Fig. 3.3 Image of topography and bathymetry of the north coast of British Columbia at ca. 12,000–9,400 RCYBP (**a**–**c**) and detail of southern Juan Perez Sound at 11,500 RCYBP (**d**) combining high-resolution multi-beam image with conventional terrestrial and hydrographic data. The image shows palaeo-river channels and associated fluvial features (terraces, gravel bars, deltas, and lake basins) as well as geological features such as drumlins and eskers. Images prepared by Patrick Bartier and Daryl Fedje of Parks Canada

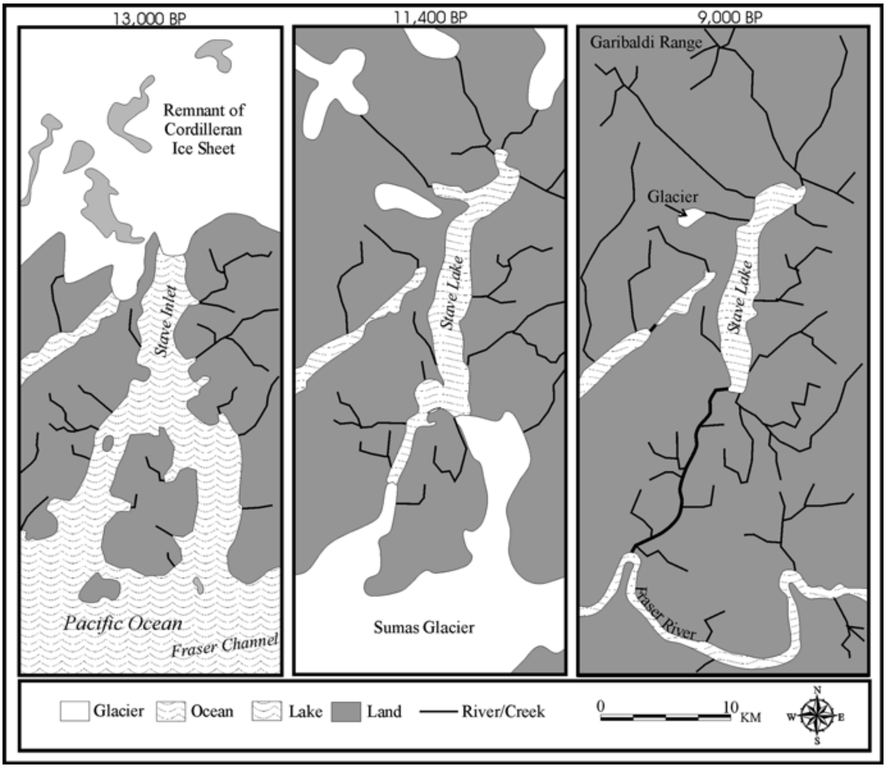

Fig. 3.4 Change in the physical landscape of the Stave Lake region from late Pleistocene through Holocene periods. Time periods are in radiocarbon (^{14}C) years. Prepared by D. McLaren

(James et al. 2002). Between 12,000 and 11,500 RCYBP, sea levels regressed to 60 m above present sea levels. Stave Lake would have been transformed from a fjord to a lake during this period. A minor glacial event occurred in the central Fraser Valley area after 11,500 RCYBP: the Sumas glaciation (Fig. 3.4). This glacial event has been traced as a glacial advance in the Fraser lowlands to its limit a few kilometers west of the Stave River between 11,500 and 11,200 RCYBP (Saunders et al. 1987; cf. Souch 1989). The lowlands of the Fraser Valley were filled at this time by fluvial, deltaic, marine, lacustrine, and outwash sediments (Clague et al. 1983). Following the retreat of Sumas ice, drainage patterns reoriented and became similar to present flows. Sea levels did not stabilize at this point but continued to regress until they reached approximately 12 m below present-day sea level around 8,000 RCYBP, at which time isostatic rebound as a result of glaciation finally ceased (Mathewes et al. 1970). As the Fraser Delta had not yet formed, the mouth of the Fraser River was further east than it is today, being located approximately where the Pitt and Fraser now meet. Changing ice, sea, and lake levels of this area provide an example of the different geomorphic factors affecting early archaeological site locations.

Barkley Sound

Until recently, late Pleistocene sea-level histories for western Vancouver Island had been poorly constrained temporally and spatially. However, recent work has provided a significantly refined perspective on the sea-level history and coastal morphology for this period. Before 12,000 RCYBP, sea levels for central western Vancouver Island were more than 21 m above modern (Gutsell et al. 2004) and rapidly fell to 46 m below modern at 12,000 RCYBP (Dallimore et al. 2008). Sea level stayed more or less stable for approximately 2,000 years, then rose rapidly to near modern at about 6,500 RCYBP and to the mid-Holocene high stand of about 4 m above modern (Friele and Hutchinson 1993). This dramatic fluctuation is illustrated in Fig. 3.5. The observed period of sea-level stability between 12,000 and 10,000 RCYBP provides a welcome framework for investigating the potential presence of late Pleistocene archaeological sites. Combined with high-resolution sea floor mapping, areas with potential for archaeological deposits can be identified and targeted for underwater sampling. Particularly interesting landforms for investigation are level landforms near protected shorelines and along travel corridors such as drowned river terraces and palaeo deltas (Fig. 3.6). Areas with little lateral distance to modern and ancient shorelines also have the potential for occupation on constrained, stable, flat areas above the mid-Holocene marine high stand, such as bluff-edges. Such places would have been attractive at many different sea levels. However, no archaeological sites have currently been identified on western Vancouver Island which date to before 5,000 RCYBP. This is not surprising as palaeo-shorelines dating between 12,000 and 6,000 RCYBP are drowned at depths to ca. 46 m below modern and there has been no subtidal testing nor systematic testing of elevated bluffs.

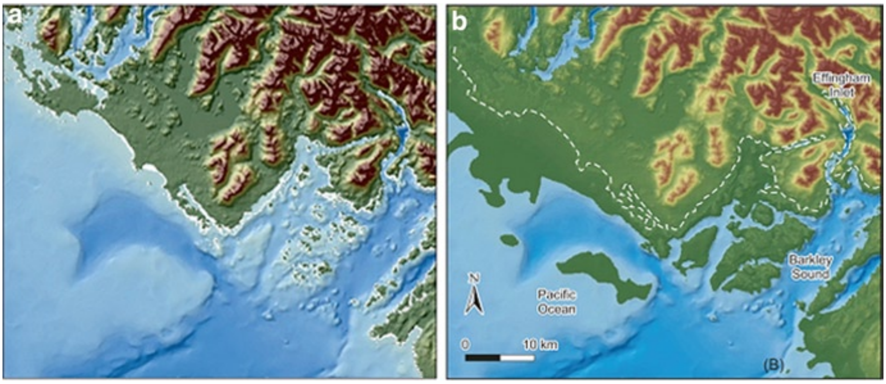

Fig. 3.5 (**a**) Image of modern topography and bathymetry of Barkley Sound and (**b**) Late Pleistocene shoreline at 11,000 RCYBP when relative sea level was 46 m below modern for a period of 2,000 years. Dashed line outlines the modern shoreline (images obtained with permission from A. Dallimore, Royal Roads University)

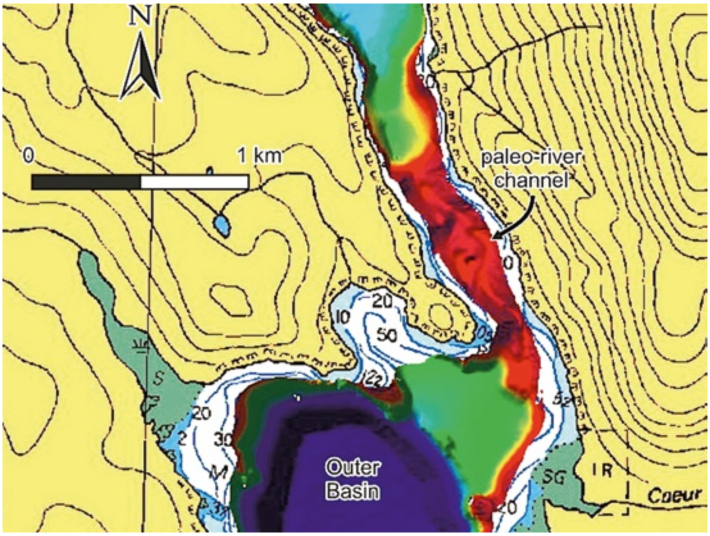

Fig. 3.6 Multibeam image showing high resolution bathymetry of the palaeo-river and palaeo-delta in Effingham Inlet dating to the sea level low stand of −45 m between 12,000 and 10,000 RCYBP. Image obtained with permission from A. Dallimore, Royal Roads University

Deglaciation and Early Post-Glacial Vegetational History

On the outer north coast of British Columbia, lowland deglaciation commenced by 16,000 RCYBP and ice-free areas extended to the east side of the Hecate Plain before 14,400 RCYBP (more than 200 km east of the west coast of Haida Gwaii); however, some cirque and higher elevation piedmont glaciers continued to be active until ca. 12,500 RCYBP (Mathewes 1989; Barrie et al. 2005; Lacourse et al. 2005). The outer southern British Columbia coast was largely ice-free from at least 18,000–16,300 RCYBP (Al-Suwaidi et al. 2006), but a late Fraser glacial advance pushed from the BC mainland across Vancouver Island to the Continental Shelf shortly thereafter. The outer coast remained ice-covered until at least 14,500 RCYBP with rapid retreat underway at 14,000 RCYBP with the west coast and lowland areas of the inner coast (east side of Vancouver Island) ice-free by ca. 13,000 RCYBP (Cosma et al. 2008; Hebda 1983; Stafford and Christensen 2009; Brown and Hebda 2002).

During early post-glacial time, there were rapid shifts in vegetation along the coast of British Columbia. At present, there is no direct or continuous evidence for botanical refugia during the last glacial maximum. The northern BC coast was characterized by herb and shrub tundra-like plant communities from at least 15,000 to 13,500 RCYBP (Mathewes 1989; Lacourse et al. 2005). The development of open pine parklands and woodlands on the west coast of Haida Gwaii by 13,000 RCYBP may support the presence of a nearby biological refugium. Notably, a pine stump, still rooted in a peaty soil and dated to 12,200 RCYBP, was recovered from a drowned fluvial terrace at 143 m water depth off eastern Haida Gwaii (Fedje and

Josenhans 2000; Lacourse et al. 2003), and numerous other drowned soils were discovered using the IKU dredge (Fig. 3.7), producing a diverse record of plant macrofossils (Fig. 3.8). Spruce was present on the outer north coast by 11,500 and closed spruce forests had become established by ca. 11,000 RCYBP. During Younger Dryas-age time, there appears to have been a shift to a cooler and more open climate-vegetation regime (Lacourse and Mathewes 2005). After 10,000 RCYBP, the climate ameliorated and closed mixed conifer forests expanded and rose to elevations significantly higher than modern (Lacourse et al. 2005; Pellatt and Mathewes 1997).

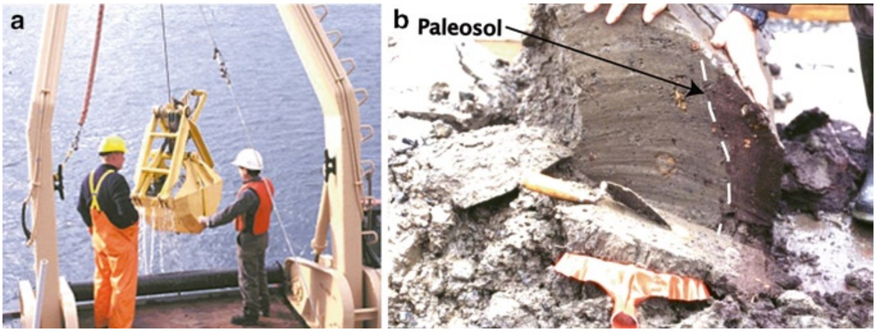

Fig. 3.7 IKU sampling (**a**) and intact terrestrial soils overlain by recent marine sediments (**b** – *dark* matrix to right of *arrow*) recovered from 143 m water depth in Juan Perez Sound. An outer tree ring from a rooted lodgepole pine stump and a willow twig from the associated soil were both dated to 12,200 RCYBP. J. McSporran photos

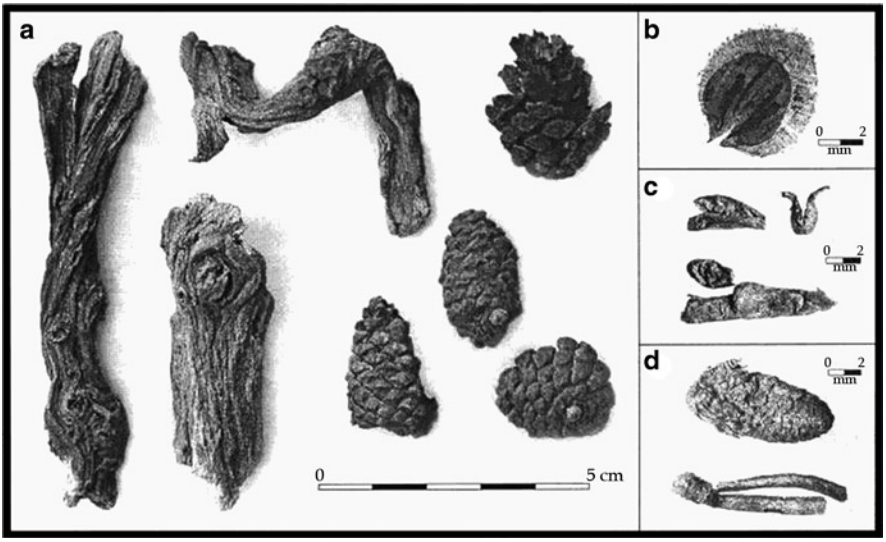

Fig. 3.8 Plant macrofossils dating to 12,200 RCYBP recovered from a drowned forest soil now 143 m below sea level in Juan Perez Sound, southeast Haida Gwaii: (**a**) willow twigs and pine cones, (**b**) cow parsnip fruit, (**c**) willow buds, and (**d**) pine cone and needles. R. Mathewes image

On the south coast of BC, late-glacial advances (16,000–14,000 RCYBP) preclude the very early post-glacial vegetation community history seen on the outer north coast. On the outer south coast, there was a rapid shift from tundra to open pine woodlands between 13,500 and 13,000 RCYBP (Hebda 1983; Brown and Hebda 2002). Subsequent shifts in plant communities were strongly influenced by east-west trending precipitation gradients. Open pine woodlands endured until ca. 12,500 RCYBP before being replaced by a mixed conifer forest that was pine-dominated until ca. 10,500–10,000 RCYBP and then by one characterized by low pine counts and abundant alder and by the arrival of Douglas fir (Brown and Hebda 2002; Walker and Pellat 2003).

Palaeontological Data

The early post-glacial palaeontological record for the British Columbia Coast remains sparse; however, recent work in Haida Gwaii, northern Vancouver Island, and the Salish Sea (Gulf of Georgia) is providing significant new data, some of which suggests a very different fauna, at least on the terrestrial side, to that of more recent times. Table 3.2 portrays current knowledge of fauna from late glacial to earliest Holocene time. The table only provides detail on medium-to-large mammals and general bird, fish, and shellfish categories for reasons of space. The pre-Holocene record is largely non-archaeological with most data coming from karst caves, marly wetlands and marine clays.

The very early post-glacial record for terrestrial fauna is limited to a single brown bear, dated to 14,400 RCYBP from a cave on the west coast of Haida Gwaii (Ramsey et al. 2004). At about 12,000 RCYBP the record becomes more extensive with brown bear, black bear, caribou, deer, fox, birds, salmon, and other anadramous fish from karst caves on Haida Gwaii (Fig. 3.9a, b); shortface bear, brown bear, black bear, goat, and marten from northern Vancouver Island caves; and bison, ground sloth, shortface bear, black bear, sea lions, salmon, and marine fish from wetlands and marine clays in the southern Vancouver Island – Salish Sea area (Al-Suwaidi et al. 2006; Fedje et al. 2001; Fedje and Sumpter 2008; Steffen et al. 2008; Wilson et al. 2009; Harington et al. 2004). By ca. 10,000 RCYBP, a number of species had been extirpated from the outer coast and the "modern" coastal fauna is in place. The extirpations and "modern" fauna development were likely largely driven by environmental change from tundra and open woodlands to dense coniferous forest.

Although there are only scattered data relating to the maritime fauna of early post-glacial time, a number of marine cores (Dallimore et al. 2008; Pellatt et al. 2001; Barrie et al. 1993; Hetherington et al. 2003) show evidence of a highly productive marine system as does the presence of mammals, such as sea lions and brown bears, which had a substantial focus on maritime foods. Brown bears are especially relevant as these omnivores have many of the same resource requirements as humans, are abundant in early post-glacial assemblages, and all the dated BC coastal specimens have stable isotope signatures (^{13}C, ^{15}N) that demonstrate a mixed marine and terrestrial diet (Fedje et al. 2004a, b; Fedje and Sumpter 2007, 2008; Steffen et al. 2008). Their presence implies a highly productive terrestrial and marine environment.

Table 3.2 Dated pleistocene/holocene transition fauna for different regions of coastal British Columbia

Region	^{14}CBP (×1,000)	Shortface bear	Brown bear	Black bear	Ground sloth	Bison	Elk	Caribou	Deer	Mtn. goat	Fox	River otter	Sea lion	Seal	Sea otter	Bird	Salmon	Other fish	Shellfish	References
Haida Gwaii	14–13		X																X	Barrie et al. (1993); Fedje et al. (2005c); Fedje and Sumpter (2007); Ramsey et al. (2004); Wigen (2005)
	13–12		X																X	
	12–11		X	X				X	X		X					X	X	X	X	
	11–10		X	X				X								X	X	X	X	
	10–9			X								X	X	X	X	X	X	X	X	
W Vancouver Island	13–12									X										Al-Suwaidi et al. (2006); Nagorsen et al. (1995)
	12–11																			
	11–10																			
	10–9			X																
NE Vancouver Island	13–12		X							X									X	Howes (1982); Nagorsen and Keddie (2000); Stafford (2009); Steffen et al. (2008)
	12–11	X	X																X	
	11–10																		X	
	10–9			X															X	
SE Vancouver Island	13–12																			Harington et al. (2004); Wilson et al. (2009)
	12–11					X							X			X	X	X	X	
	11–10																			
	10–9																			
Gulf Islands	13–12																			Wilson et al. (2009)
	12–11	X			X	X													X	
	11–10					X													X	
	10–9																			
Fraser Lowlands	13–12													X						Harington 1996; Harington et al. (2004); James et al. (2002)
	12–11																		X	
	11–10																		X	
	10–9																			

Fig. 3.9 Brown bear skull (**a**) dated to 11,870 RCYBP and sockeye salmon vertebrae (**b**) dated to 11,255 RCYBP from Gaadu Din 1 cave; California mussel shell (**c**) dated to 9,400 RCYBP from Kilgii Gwaay. D. Fedje photo

Early post-glacial archaeological faunal assemblages are rare, but it is noteworthy that a fully developed maritime adaptation is evident from the 9,450 RCYBP Kilgii Gwaay site in southern Haida Gwaii (Fedje et al. 2005c). The Kilgii Gwaay fauna is dominated by marine fish (15 species), birds (12 species), and mammals (5 species). Black bear is the only non-maritime mammal and the few birds that are not fully marine are migratory species (ducks, geese), and raven. At Richardson Island, 17 taxa of fish are known from highly fragmented, calcined hearth remains, mostly dating to before 9,100 RCYBP; rockfish, salmon, herring, dogfish, sculpin, and a variety of other minor taxa from diverse environments are present, attesting to a productive and diverse marine ecosystem (Steffen 2006).

Over 3,000 salmonid remains have been recovered from Gaadu Din 1 Cave, dating from 11,500 to 10,500 RCYBP. Representative examples of these tested positive for sockeye DNA, although other species cannot be ruled out from the remainder of the assemblage. These are thought to have been deposited by brown and black bears using the cave as an autumn lair while fishing in streams such as the palaeo-lake and river system known from nearby Section Cove (Fedje 2008). Salmon, always a touchstone species in Northwest Coast archaeology, are clearly present in the terminal Pleistocene. Recent studies emphasize salmon's ability to colonize streams quickly and efficiently after glacial retreat. Within only 28 years, coho, sockeye, and pink salmon had colonized a creek in newly deglaciated Glacier Bay, Alaska. Maximum escapements during this time were recorded at <100, 500, and 15,700 fish per year, respectively (Milner et al. 2008:416). Other aquatic indicators such as invertebrate populations also rose steadily, stabilizing after only 20 years. Dolly Varden was the first colonizing species. It appears that streams can become productive environments in surprisingly short order, as the presence of Dolly Varden and sockeye salmon in Juan Perez Sound in the early post-glacial confirms. To the south, hake and herring are present almost as soon as organic materials appear in the Saanich Inlet core record, as early as 11,000 RCYBP (Tunnicliffe et al. 2001).

For many years, there has been speculation about one or more glacial refugia on the Northwest Coast. Numerous genetic and taxonomic studies on modern populations as diverse as brown bear, black bear, stickleback, *Nebria* sp. beetles, pine marten, and short-tailed weasel show phylogeographies consistent with at least one large, productive refugium during the LGM, perhaps on the submerged Hecate lowlands (Reimchen and Byun 2005) or in one or more of the five areas in nearby southeast Alaska identified as possible refugia (Carrara et al. 2007). Coast deer are suggested to have survived in multiple cryptic refugia (Latch et al. 2009). Smith et al. (2001) show that genetic diversity of Haida Gwaii Coho salmon is consistent with survival in fluvial refugia through the LGM. Similar suggestions have been made regarding Chum salmon (Kondzela et al. 1994). Continued research on the refugia question is essential for understanding early human occupation.

In summary, there may have been at least one productive refugium for large land mammals and anadramous fish on the BC coast during the LGM. Even if there was no refugium, the evidence points to a well-developed marine and terrestrial ecology developing rapidly in the post-glacial period, a process Milner et al. (2007) show occurs at a decadal scale. The requirement for source populations from which to colonize dictates that either there was a refugium or that the area was accessible from points north and/or south. While heterogeneously distributed through time and space in the terminal Pleistocene, there were large areas of productive grasslands and parklands, supporting bison, caribou, deer, ground sloth, and three species of bear, fronted by a diversity of marine habitats which included salmon-bearing waters and streams.

Sea Core Data

The palaeo-marine history of the Northwest Coast has been investigated from a variety of ship and shore-based sediment cores. Coring of sediments from high-energy coastal settings provides relatively coarse-grained temporal records, which best document major transitions between glacial and post-glacial conditions, whereas sediment cores recovered from anoxic inlet basins have provided sub-annual temporal resolution of past climatic conditions (Dallimore et al. 2005, 2008). These include cores from Hecate Strait and Cook Bank (Barrie and Conway 1999; Lacourse et al. 2005), from Effingham Inlet on the west coast of Vancouver

Island (Dallimore et al. 2008) and Saanich Inlet on southeastern Vancouver Island (Tunnicliffe et al. 2001). These provide the proxy data (fossils and isotopes) to calculate primary productivity – in some cases showing considerable annual or decadal fluctuations in the marine environment.

Archaeological Data

Having reviewed the palaeoenvironmental data, we now turn to the archaeological evidence which places humans on this landscape. The modern political boundary of BC forms a poor unit of analysis of course. It is worth mentioning that to the North, sites in central Alaska reach back 12,000 RCYBP (Hamilton and Goebel 1999), as does Paisley Cave in Oregon (Gilbert et al. 2008) and Monte Verde in central Chile (Dillehay et al. 2008). To the east of the Rocky Mountains, Clovis occupations in the "Ice free Corridor" dating to less than 11,000 RCYBP may be the basal archaeological culture type (Fladmark et al. 1988; Fedje et al. 1995; Waters and Stafford 2007). Pleistocene archaeology is not well represented in the Cordillera, perhaps because of the late deglaciation of valley bottoms and an absence of focused surveys in upland locations. The following are some brief summaries of the more important terminal Pleistocene archaeological sites from the BC coast and adjacent areas.

Late Pleistocene Sites (Pre 10,000 RCYBP)

On-Your-Knees Cave

At On-Your-Knees Cave (49-PET-408) on Prince of Wales Island in Southeastern Alaska, a single date of 10,300 RCYBP on a surface-collected bone tool pushes the occupation range of this site into the terminal Pleistocene, although most use of this karst cave (Fig. 3.10-1) is concentrated in the period from 9,500 to 8,500 RCYBP. A small lithic assemblage underlying the main occupation layer may also be of pre-Holocene age (Dixon 2001).

K1 Cave

K1 Cave (FgUc-6) is an extensive karst cave system, at elevations from 10 to 60 m above sea level, on the west coast of Haida Gwaii (Fig. 3.10-2). Excavations in a small chamber, currently some 60 m in from open air, produced a large faunal assemblage and two spearpoint bases (Fedje et al. 2004a, b). One point (Fig. 3.11a) was recovered from a layer constrained by dates of 10,660 ± 40 and 10,525 ± 50 RCYBP and the other (Fig. 3.11b) by dates of 10,960 ± 35 and 10,510 ± 35 RCYBP. None of the fauna shows evidence of human modification and there is no evidence that

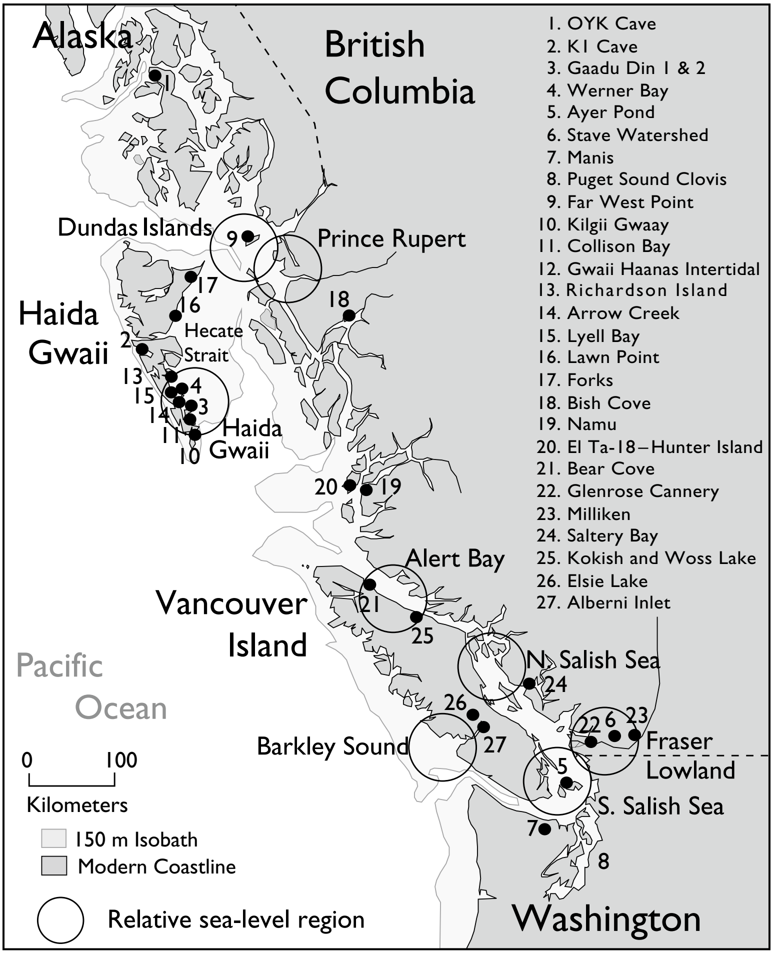

Fig. 3.10 Locations of archaeological sites and regions referred to in text

people were active in this cavern (in the dark zone and no charcoal concentrations or lithic detritus). The faunal assemblage is consistent with that of a bear den and lair. It is likely that people were hunting at or near the cave mouth and the points were carried into the cavern in the bodies of wounded bears (McLaren et al. 2005).

Gaadu Din 1

Gaadu Din 1 (1693T) is a karst cave at 40–60 m elevation on Huxley Island, southeast Haida Gwaii (Fig. 3.10-3). Excavations in a small cavern about 10 m from open air produced a substantial palaeontological assemblage and a small number of cultural

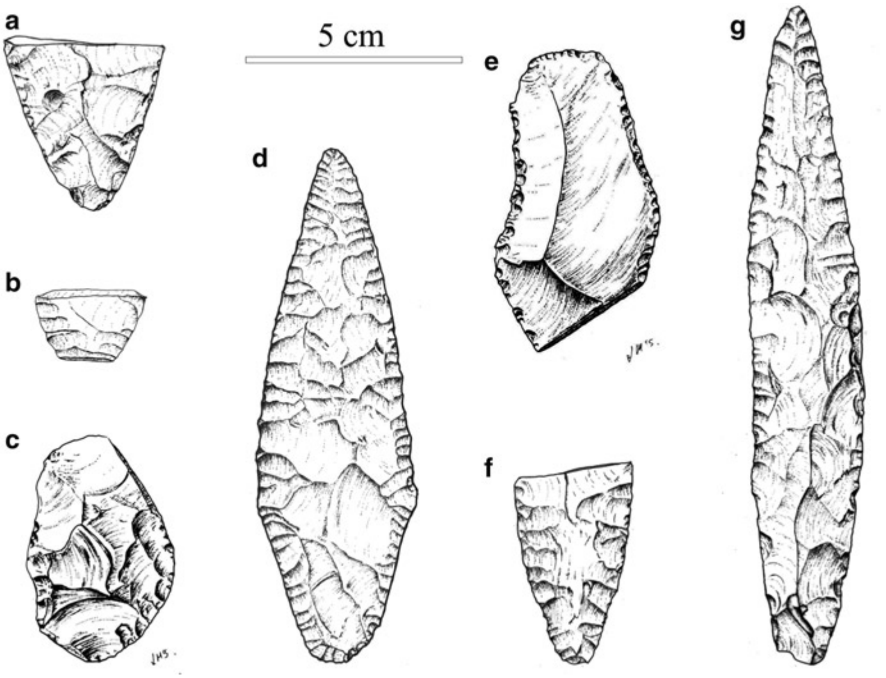

Fig. 3.11 Artefacts from K1 Cave (**a**, **b**), Gaadu Din 2 cave (**c**, **d**), and Gaadu Din 1 Cave (**e**–**g**). Drawings by J. McSporran

artefacts (Fedje 2008). The archaeological assemblage includes a bone point fragment directly dated to 10,150 ± 25 RCYBP, a spearpoint (Fig. 3.11g) associated with a charcoal date of 9,980 ± 30, an undated spearpoint base (Fig. 3.11f), and flake tools (Fig. 3.11e) associated with dates of 10,550 ± 25 and 10,615 ± 30 RCYBP.

Gaadu Din 2

Gaadu Din 2 (1906T) is a small karst cave at 100 m above sea level, about 300 m north of Gaadu Din 1 (Fedje and Smith 2009). Excavations were conducted a few metres inside the cave. Faunal remains were limited to a small number of fish bones and one poorly preserved black bear bone. Archaeological evidence includes hearths, dating to 10,280, 10,210, and 9,500 RCYBP, and a small lithic assemblage. Four bifacial tools were recovered, including a complete spearpoint (Fig. 3.11d) and biface (Fig. 3.11c) dating to 10,220 ± 30 and 10,295 ± 25 RCYBP, respectively, as well as two point fragments from a hearth dating to 10,210 ± 20 RCYBP (three dates). At least eleven biface resharpening flakes were also recovered from hearth matrices.

Werner Bay

A single stone tool was recovered from 53 m below sea level in Werner Bay (Fig. 3.10-4). This site was discovered by bucket dredge sampling of a terrace identified from a swath bathymetry-derived model of a submerged terrestrial landscape off the east coast of Moresby Island (Josenhans et al. 1997). Based on sea level history, this location was last subaerial at 10,200 RCYBP.

Stave Lake Pleistocene Sites

The former shoreline of Stave Lake (Fig. 3.10-6) was inundated by hydroelectric facilities at Stave Falls in 1910. Since 1997, during periods of low water, archaeological survey crews identified 56 surface scatters of stone tools left as lag deposits following reservoir operation-related erosion (McLaren et al. 1997, 2008; McLaren and Owens 2000). Projectile points from 23 of these lithic scatters were identified as having similar attributes to those associated with the late Pleistocene and early Holocene stemmed and foliate point traditions of the northern Northwest Coast, southern Plateau, and Great Basin regions of western North America (McLaren 2003; McLaren and Steffen 2008). Preliminary subsurface testing was conducted at 15 of the 56 archaeological sites in the area between 2002 and 2007 (McLaren et al. 2008). A total of 28 radiocarbon dates have been run on plant macrofossils and charcoal collected from these subsurface tests. Two sites were found to have dates associated with archaeological remains older than 10,000 RCYBP. During test excavations at the Cardinalis Creek Mouth Site (DhRn-29), a chert biface preform and multiple flakes were found. Two separate samples of charcoal collected directly under the biface preform were dated to 10,370±40 and 10,150±40 RCYBP (McLaren et al. 2008). At the Devil's Point Site (DhRn-16), a small test excavation was placed into a cut bank to recover a large flake tool. Two charcoal flecks found directly overlying this artefact were dated to 10,290±50 and 10,210±60 RCYBP.

Manis

The Manis site (Fig. 3.10-7) features *Mammut americanum* (mastodon) bones excavated from beneath peat bog deposits (Gustafson et al. 1979). One of the mastodon ribs has a bone or antler point embedded in it, around which the rib has healed. The point has never been extracted. One flaked cobble spall was also found in association with the bones. Radiocarbon samples on associated materials returned dates of 12,000 and 11,850 RCYBP. Some archaeologists have questioned whether the point is of human manufacture (Carlson 1990; Dixon 1999; Grayson and Meltzer 2002). The association of the cobble spall with the mastodon remains is unclearly reported and the illustration of the spall is poor, according to Grayson and Meltzer (2002). Overall, the site is poorly reported; the nature of the site stratigraphy in relation to the bones and radiocarbon dates is uncertain (Dixon 1999), and there is therefore reasonable doubt about whether this site is indeed of cultural origin. Nonetheless, while it was long a temporal outlier on the Northwest Coast, recent, less equivocal finds are putting humans on the landscape at similar times and hence reducing scepticism about this site.

Ayer Pond

There are a number of locations in the southern Salish Sea and the Victoria-Saanich Peninsula area where bison and other large game species have been recovered from wetlands (Wilson et al. 2009; Kenady et al. 2007, 2011). Three individual bison are known from Saanich-Victoria and nine from Orcas Island. At Ayer Pond (45-SJ-454.1) on Orcas Island (Fig. 3.10-5), there is evidence suggesting human involvement in a partially articulated bison (Kenady et al. 2007, 2011). While there were no tools associated with the 11,760 ± 70 RCYBP bison, green bone fractures, percussion impact scars, cut marks, and bone representation "skewed towards less meaty cranial and distal limb elements" suggests human agency (Wilson et al. 2009) during firmly pre-Clovis times.

Puget Sound Clovis

In the Puget Sound area around Seattle (Fig. 3.10-8), eight fluted projectile points assigned to the Clovis archaeological culture have been found in undated contexts. Two of these are found within the general Salish Sea area: one from Bellingham and another from Whidbey Island (Croes et al. 2008:108), suggesting that people were present in northern Puget Sound ca. 11,000 RCYBP. The Puget lowlands offer relatively easy travel from the Salish Sea to the Columbia River and from there into the intermontane areas of Washington State, where the East Wenatchee (Richey-Roberts) Clovis site, 150 km east of Seattle and east of the Cascade/Coast range, is well documented (Gramly 1993).

Early Holocene Sites (10,000–7,000 RCYBP)

An increasing number of early Holocene sites have recently been identified in coastal British Columbia. Many of these sites have been discovered with landforms associated with ancient shorelines which provide additional context for understanding maritime adaptations. In this section, we catalogue the main known sites within the period 10,000–7,000 RCYBP.

On-Your-Knees Cave (49-PET-408)

Apart from the bone tool mentioned above, most use of this karst cave (Fig. 3.10-1) is concentrated in the period 9,200–8,500 RCYBP. The lithic assemblage includes both bifacial and microblade technology, including those made of exotic materials such as obsidian from sources on nearby Suemez Island and distant Mount Edziza (Lee 2001). Notably, the skeletal remains of a young man were found, dating to 9,200 RCYBP, after a marine reservoir correction was applied to account for a $\Delta^{13}C$ value of −12.1. Such a value indicates a lifetime diet strongly focused on marine foods, despite this site's apparent function as a bear hunting locale. DNA analysis shows that this individual represents the oldest known member of the ancient Haplotype D sublineage and of the Y-Chromosome haplogroup Q-M3 (Kemp et al. 2007), suggesting he belonged to an early, founding population of Asian origin.

Far West Point

A focused programme of palaeoenvironmental reconstruction and archaeological survey on the Dundas Archipelago (Fig. 3.10-9) resulted in a number of sites located on higher sea levels (McLaren 2008). One undated site contained a microblade fragment; otherwise diagnostic lithic artefacts are absent. The Far West Point site (GcTr-6) has shell midden deposits dating between 6,000 and 7,000 RCYBP, which show strong focus on a diverse suite of marine species, especially barnacle, rockfish, greenling, herring, ducks, and pinnipeds. A worked whale bone tool was dated to 7,300 RCYBP. Most intriguingly, a black, organic-rich (microscopic traces of urchin, mussel, clam, fish, and sea mammal) layer below the shell midden returned a date on charcoal of 9,690 RCYBP, although a confirmatory date has not yet been obtained (McLaren 2008:244). Other Dundas Archipelago shell midden deposits dating to between 6,000 and 7,000 RCYBP are noted by Martindale et al. (2009).

Kilgii Gwaay

Situated on a small island in southernmost Haida Gwaii (Fig. 3.10-10), the Kilgii Gwaay site (1325T) includes a water-saturated component and a shell-rich component, both of which are located in the modern intertidal zone (Fedje et al. 2001, 2005c). This site is securely dated to 9,450 RCYBP by 18 radiocarbon samples which are consistent with its position relative to sea-level history. A large faunal assemblage shows a marine emphasis (31 marine – maritime species) on sea mussel, rockfish, lingcod, alcids, albatross, harbour seal, and sea otter, although black bear is an important component of the mammal assemblage (Fedje et al. 2005c; McLaren et al. 2005). The abundant stone tools are almost exclusively unifacial (Fig. 3.12c, d) and the assemblage includes many distinctive discoidal cores (Fig. 3.12a, b). Organic technology includes three-strand twine (Fig. 3.12e), withes wrapped with split spruce root (Fig. 3.12f), and wooden wedges (Fig. 3.12g) and hafts. Overall, this site shows a notable fluency with marine resources and implies the use of capable watercraft and exploitation of many different ecological niches.

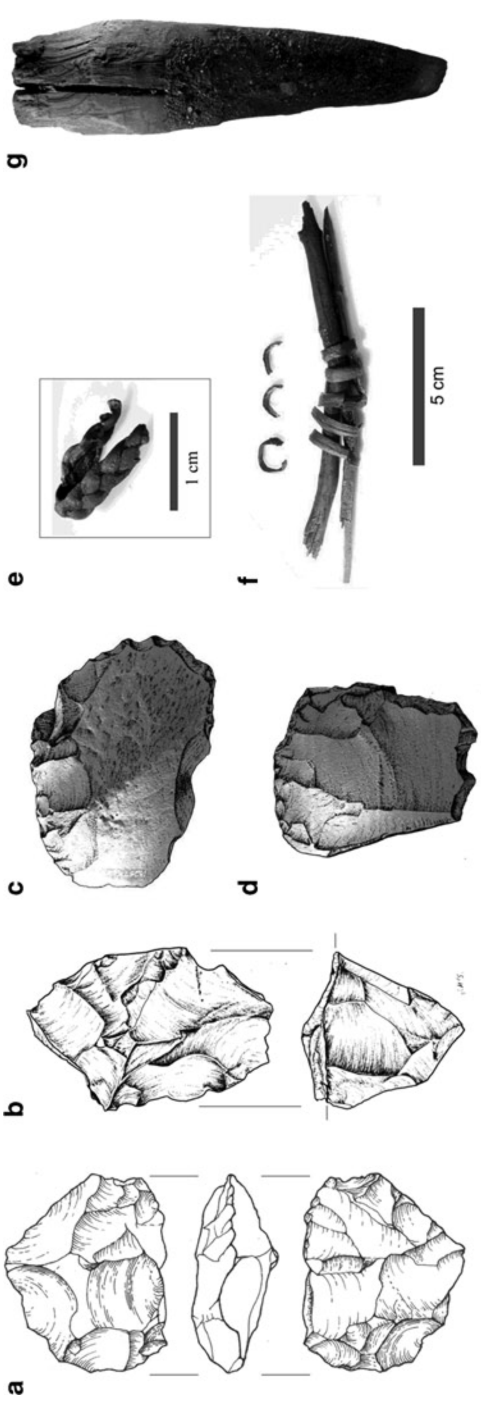

Fig. 3.12 Artefacts from Kilgii Gwaay site: discoidal cores (**a**, **b**), unifaces (**c**, **d**), braided twine (**e**), wrapped withes (**f**), and wooden wedge (**g**). Illustrations by J. Cohen (**a**), J. McSporran (**b–d**), D. Fedje (**e–g**)

Collison Bay

The Collison Bay site (1720T) is about 20 km north of Kilgii Gwaay (Fig. 3.10-11), with which it shares many similarities. Collison Bay is an intertidal site with numerous water-worn artefacts on the surface. Excavations show sharp, pristine lithics in a possible palaeosol about 50 cm below the beach surface. These strongly resemble the Kilgii Gwaay assemblage in typology, raw material, and depositional context. No radiocarbon dates of these buried sediments have been obtained, but technological and sea-level affinities allow confident assignment to 9,450 RCYBP.

Gwaii Haanas Intertidal Sites

In addition to Kilgii Gwaay and Collison Bay, there are over 100 other intertidal archaeological sites known from the Gwaii Haanas archipelago of southern Haida Gwaii (Fig. 3.10-12). These range from one to hundreds of stone tools, usually in a deflated lag surface. Some of these intertidal sites may contain intact, in situ cultural layers beneath the current beach surface, though this has not been demonstrated. The large sample size allows analysis of site location relative to coastal resources and to late Holocene sites. A study by Mackie and Sumpter (2005) reveals that sites were located in markedly different places than in later times.

Richardson Island Site

Richardson Island (1127T) is the most thoroughly investigated of the Haida Gwaii early Holocene sites which sit on raised marine landforms (Fig. 3.10-13). The first occupation was on a supratidal marine berm at 9,300 RCYBP. Rapid sea level rise in effect “pushed” this berm uphill, creating deep and finely stratified deposits until the 8,900 RCYBP marine maximum. Between 9,300 and 8,750 RCYBP, the lithic assemblage is dominated by bifacial and unifacial tools of the Kinggi Complex, including discoidal and unidirectional core reduction strategies (Fedje et al. 2011b; Storey 2008). Bone only survives as fragmented calcined pieces in hearths, from which Steffen (2006) identified 17 fish taxa as well as bird and mammal. Microblades are introduced at 8,750 RCYBP and appear to develop in situ as a period of experimentation has been observed following their appearance (Smith 2004; Mackie et al. 2008). The location of the site on a small island central to North Darwin Sound combined with the site contents allows the confident assessment of maritime-focused way of life, although the numerous bifacial spearpoints were probably used for winter bear hunting.

Arrow Creek

Arrow Creek 1 (766T) is situated on a raised alluvial fan at 14–16 m above the modern tidal limit 200 m upstream from where the creek currently flows into

Matheson Inlet on the east coast of Moresby Island, Haida Gwaii (Fig. 3.10-14). The main occupations at this site date between 5,500 and 8,200 RCYBP, although a few scattered stone tools were recovered from a layer dating to 8,880 RCYBP (Fedje et al. 1996; Fedje and Christensen 1999). There were no faunal remains or clearly defined features encountered in the excavated area. The ca. 900 lithics from the excavations include 12 microblade cores and 93 microblades as well as a number of unifacial stone tools and reduction detritus. No bifacial artefacts or biface reduction flakes were present. Arrow Creek 2 (925T) is situated at 0–3 m above high tide. At this site, a number of stone tools were recovered from estuarine deposits dating between 9,500 and 9,200 RCYBP. A barnacle attached to a flake tool was dated to 9,120 RCYBP (marine reservoir corrected) and a stone wall (possibly part of a stone wall fish trap) was associated with a date of 9,010 RCYBP.

Lyell Bay

In the Lyell Bay area of southern Haida Gwaii (Fig. 3.10-15), two raised beach sites (14–16 m above high tide) were investigated (Fedje and Christensen 1999). At both sites, testing was limited to a 1 m^2 unit, excavated to about 2 m depth and a few shallow 50 cm square tests. No faunal remains were recovered from either site. The Lyell Bay South site (1354T) dated from 8,450 to 6,600 RCYBP. The Lyell Bay East site (1355T) dated from 8,800 to 5,000 RCYBP. At both sites, lithic artefacts (n=610 and 274, respectively) included microblades, spokeshaves, cobble choppers, and multidirectional cores as well as flake and core tools. Stone tool technology was largely unifacial with only a single biface thinning flake from the basal levels of Lyell Bay South and a single biface fragment from the basal level of Lyell Bay East.

Lawn Point

Lawn Point (FiTx-3) is a raised beach site located on the east coast of Graham Island, Haida Gwaii (Fig. 3.10-16). The site exhibits six components, the lower five of which are characterized by pebble tools, flake tools, pebble cores, microblade cores, and microblades (Fladmark 1986, 1989). No bifacial tools or biface reduction detritus were observed at this site. Components two through four appear to be of mid-Holocene age (of these, only component 4 is dated – 5,750 RCYBP). Component 5 dates to 7,200 RCYBP. Component 7 is undated, but, based on local sea-level history, likely dates between ca. 9,000 and 8,000 RCYBP (Fedje et al. 2005b).

Forks (GaTw-9)

This subsurface lithic scatter is located at the base of the eastern flank of Argonaut Hill in the Hecate lowlands (Fig. 3.10-17) and is known from small test excavations only (Sanders 2009). Twenty-eight artefacts were recovered from the setting on a terrace edge above the +16 m Holocene marine high-stand and associated wave-cut bank. A series of radiocarbon dates shows first occupation by at least 7,140 ± 20 RCYBP. The tool assemblage includes a variety of chopper and spall tools and flakes made from diverse but locally available raw materials.

Bish Cove FlTe-35

Very little is known about the early Holocene human occupation of the mainland coast between the Namu area and the Dundas Archipelago, a distance of about 300 km. Bish Cove is a small site on Douglas Channel near Kitimat situated at 38–45 m above sea level (Fig. 3.10-18). Several microblades and a biface fragment were found at this site, which is suggestive of early Holocene occupation (Streeter 2006). This is in agreement with preliminary sea-level history; the shoreline would have been 35 m above present 9,300 RCYBP (Fedje et al. 2005b). The cultural material is found in association with and above beach sands, though no radiocarbon dates have been run (Streeter 2009, personal communication). Mixed biface-microblade assemblages at Namu, Richardson Island, and On-Your-Knees Cave are all of early Holocene age. Taken together, this small, poorly known site is suggested to date to before 9,000 RCYBP and points the way to the likely location of similar sites in the poorly known archaeological area of Douglas Channel, Gardner Canal, and surrounding archipelago.

Namu

The site of Namu (ElSx-1) on the central BC coast (Fig. 3.10-19) contains an essentially continuous cultural occupation spanning much of the Holocene (Carlson 1996). It consists of extensive shell midden deposits, post-dating 6,000 RCYBP (Cannon 2003), underlain by early Holocene black greasy silts from which was recovered a basal date of 9,700 RCYBP (Carlson 1996). No fauna preserve in the lowest levels, but these do contain a rich lithic assemblage dominated by pebble tools and microblades (Rahemtulla 2006). The site is situated on the outer fringe of the BC mainland.

ElTa-18 – Hunter Island

This shell midden site is located in a narrow inlet on Hunter Island, some 20 km west of Namu (Fig. 3.10-20). Charcoal from near the base of the cultural deposits (as determined and sampled from percussion coring) was dated to 9,940 RCYBP (Cannon 2000). It has only been subject to preliminary percussion core and auger testing.

Bear Cove

Bear Cove (EeSu-8) is a shoreline shell midden site on northeast Vancouver Island (Fig. 3.10-21) which has an early Holocene component dating to 8,200 RCYBP (Carlson 1979, 2003). The site has been divided into three temporal components spanning the past 8,200 years, but only a single date has been obtained from the earliest period. Similar to Namu, the earliest component is embedded in a greasy, black silt and does not contain preserved faunal remains. The early component artefact assemblage is characterized by cobble, core and unifacial flake tools, and leaf-shaped bifacial points.

Glenrose Cannery

The Glenrose Cannery site (DgRr-6) is on the Fraser River and now lies some 20 km from the eastern shore of the Salish Sea (Fig. 3.10-22), but when first occupied about 8,150 RCYBP, it would have been adjacent to salt water as the Fraser delta had not yet formed (Matson 1996:111). The earliest Old Cordilleran component includes leaf-shaped and stemmed bifaces, cobble tools, and suggestions of a well-developed bone and antler industry, including barbed points, antler wedges, and an anthropomorphic antler haft. The faunal remains assigned to this component include 28% salmon, though whether these belong to the 8,000-year-old deposits or more recent ones is unresolved (Matson 1996:117).

Stave Lake Holocene Sites

DhRn-29, one of the Stave Watershed sites (Fig. 3.10-6) described above with dates older than 10,000 RCYBP, also has produced a number of early Holocene dates between 8,900 and 9,270 RCYBP. McLaren also reports on four other sites with dates between 10,000 and 7,000 RCYBP: DhRn-16 (8,990±46 RCYBP), DhRn-21 (8,702±43 RCYBP), DhRo-11 (9,075±45 RCYBP), and DhRo-53 (7,748±43 and 7,222±59 RCYBP) (McLaren et al. 2008). Cultural material from these early Holocene test excavations consisted of flakes and shattered flakes with the exception of DhRo-53 where microblades were also found. These sites are among the numerous sites exposed by reservoir draw-down (Fig. 3.13). Despite the generally deflated nature of the reservoir, intact subsurface cultural remains from across the Holocene have been found in a number of locations (McLaren 2003; McLaren et al. 2008).

Milliken

The Milliken site (DjRi-3) is located in the Fraser Canyon approximately 125 km inland from its current mouth (Fig. 3.10-23). Almost 18 m of river gravels containing cultural deposits are exposed, the bottom-most component of

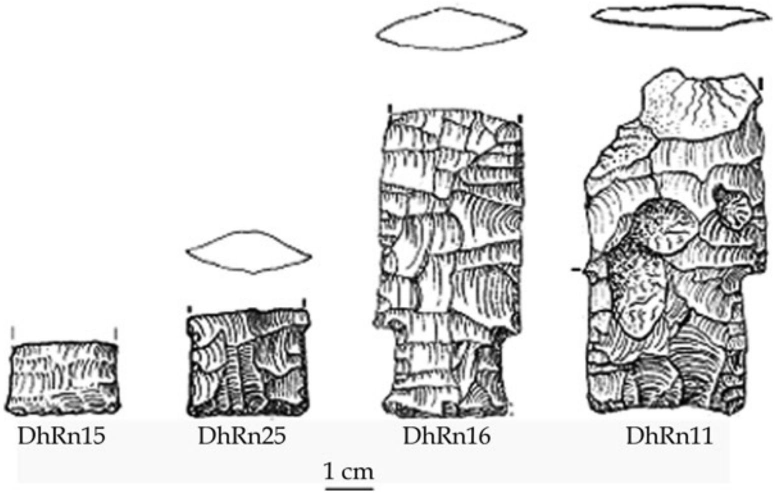

Fig. 3.13 Examples of surface-collected stemmed projectile point fragments from the Stave area. Drawings by D. McLaren

which represents the Milliken phase (Borden 1975). Dates from this phase range between 7,050 and 9,080 RCYBP (Mitchell and Pokotylo 1996). The early lithic component is essentially indistinguishable from that at Glenrose, being largely composed of pebble tools, with diagnostic leaf-shaped bifaces (Matson 1996). The location of this site in the lower Fraser Canyon strongly suggests that it functioned as a salmon procurement and processing station, a notion reinforced by some late summer seasonality indicators such as carbonized wild cherry pits and by the presence of numerous stake molds throughout the sequence, including the lowest component (Mitchell and Pokotylo 1996:73). These may be the remains of fish drying racks, although Mitchell and Pokotylo (1996:79) note that most of the lithic evidence is consistent with hunting and that there is no direct evidence for salmon procurement during this time. Nonetheless, the site is comparable in many ways to contemporaneous sites at the Columbia River Dalles, whose functions unequivocally included salmon fishing camps (Butler and O'Connor 2004), probably acquired by some form of dip-netting based on the canyon setting.

Methods for Finding Early Coastal Sites

As a consequence of low visibility and accessibility, thirty-plus years of archaeological investigations on the BC Coast have yielded only a small number of serendipitous instances where early Holocene site locations have been found (e.g. Namu, Arrow Creek, and Bear Cove). These sites are located in proximity to late Holocene components and were not the result of focused research programmes aimed at identifying early Holocene sites, a similar pattern to the more general conclusions of Hall and McCarthy (2002). A suite of imaging and remote sensing techniques, however, is revolutionizing the way archaeologists model for, and locate, late Pleistocene and early Holocene archaeological sites above and below the present shore line.

Imaging Tools and Remote Sensing Techniques

Off-the-Shelf Maps

The best "off-the-shelf" maps for British Columbia are the TRIM series of 1:20,000 topographic sheets with 20-m contours and marine charts, typically at 1:20,000 scale, for intertidal and subtidal data. While useful for planning purposes, the TRIM maps are very coarse, especially vertically, for accurate targeting of archaeological potential zones. Similarly, nautical charts, while ranging in scale, have very poor vertical resolution. While searching along the modern coastline is fairly straightforward with existing tools, for reasons explained above, site reconnaissance above and below the coastal strip is hampered by uncertain inherent potential and unknown survivorship, making higher resolution topography a valuable tool for narrowing search zones.

High-Resolution Photogrammetric Contour Mapping

One relatively simple and proven method for obtaining higher resolution topography (though one that is perhaps underexploited) is the derivation of 1 or 2-m contour interval maps from existing air photos. This method was successfully applied by Fedje and Christensen (1999) in Haida Gwaii and McLaren (2008) in the Dundas Archipelago. In both cases, sites dating to greater than 9,000 RCYBP old were found. McLaren's research with 2-m intervals and use of a marine regression model based on his own sea level curve is notable in that, despite substantial work on the inner coast of northern British Columbia, previous work had found no sites older than 5,000 RCYBP.

Lidar

Light distancing and ranging (Lidar) is a remote sensing tool analogous to swath bathymetry which has seen some recent application in archaeology worldwide. In Lidar, an aircraft-borne instrument emits laser pulses at frequencies up to 50,000 Hz. The time taken for the laser pulse to reflect back to the instrument is proportional to the distance between the instrument and the reflecting surface. The aircraft then flies overlapping transects recording three-dimensional data based on the laser probes.

Sophisticated inertial sensors and Differential GPS mean the pitch, yaw, and other movements of the plane can be accurately measured and a stable datum can be precisely retrofitted to the flight line. The dense rainforest of the Northwest Coast means that almost all the laser returns are of vegetation, primarily the top of the forest canopy. However, in even a very dense forest, there is some sky visible from the forest floor, and even the smallest patch of sky is a potential path for the laser pulse to penetrate through the canopy and to the ground surface. Thus, a small percentage of the "cloud" of X–Y–Z laser-derived points are of the ground surface and these can be algorithmically extracted from those points which measure vegetation. The result is a "bare earth" model of the landform with trees digitally removed. This DEM, which typically has vertical resolution better than 50 cm, has great potential for leading archaeologists to zones of high archaeological potential (Mackie et al. 2007; Eldridge and Anaya-Hernandez 2004; Sanders 2009). Unlike photogrammetry, Lidar can be easily (though expensively) obtained for large regions.

Multi-Beam Swath Bathymetry

Multibeam swath bathymetry is an essential tool for continental shelf research and has been applied in various archaeological applications in recent years. A ship-mounted instrument emits a fan-shaped pattern of sonar pulses to the sea floor. As the ship runs "swaths" (transects) back and forth, a highly detailed set of measurements is built up. Inertial sensors and differential GPS aboard the ship allow for incidental movements to be accounted for, leaving highly accurate positional data for the instrument. The result is data at sub-metre resolution to most depths relevant to Pleistocene archaeology, from which derived DEMs can reveal intact terrestrial landforms which are now deeply drowned. From these, archaeologists can assess both the inherent potential of the landform and the likely visibility of any ensuing archaeological remains. For the former, use of appropriate ethnographic analogies and ethnological generalizations is essential; for the latter, then applying sidescan sonar or seismic tracks to determine benthic sedimentation regimes is a useful adjunct to the multibeam DEM. Through these means, it is possible to build a map of archaeological potential zones for the seafloor. Testing of these zones can take several forms, including dredge sampling, ROV and/or submersible visits, and SCUBA. Multi-beam bathymetry has guided underwater archaeological research around Haida Gwaii starting in the late 1990s (e.g. Fedje and Josenhans 2000). Currently, the data sets and expertise are in place to investigate the seafloor near Gaadu Din 1 and 2, which has been assessed for potential using multi-beam, sidescan, and seismic sensing, as well as direct assessment by SCUBA, ROV, and submersible, laying the groundwork for recovery of sediments to the surface.

Applications on the Northwest Coast

The Northwest Coast poses significant problems in the visibility of the early archaeological record and data recovery, which demand new reconnaissance and modelling tools to overcome. By combining detailed palaeoenvironmental knowledge with high-resolution imagery and remote sensing techniques, archaeologists can successfully target those landforms with the highest potential for early sites.

Assessing the archaeological potential of a landform includes two basic components: *inherent potential* (the likelihood of people using the landform *and* depositing material culture) and *archaeological visibility* (the likelihood of material remains surviving site formation processes into the present and/or the material remains not being too deeply buried or drowned (Fedje et al. 2004a)). If conventional inland reconnaissance does not consider palaeoenvironmental history, it will disproportionately take place in zones of uncertain or low archaeological potential for early Holocene or late Pleistocene sites. But once the palaeoenvironmental history (and particularly sea-level history for coastal BC) is considered, the inherent potential of surviving landforms can be identified. The inherent potential and archaeological visibility assessments may be further refined through the use of imaging and remote sensing techniques allowing archaeologists to better examine and evaluate drowned locations and those stranded on inland terraces or obscured by vegetation.

We now have the methods to target locations on the coast for particular time periods. Shoreline sites dating to the late Pleistocene, for example, are deeply drowned in some locations such as Haida Gwaii (to −150 m), Barkley Sound (to −46 m), and the Salish Sea (to −25 m). While the deepest sites in Haida Gwaii are mostly out of reach to SCUBA, those in Barkley Sound and certainly the Salish Sea (Gulf and San Juan Islands) are more accessible to dive teams and ROVs. Swath bathymetry highlights those locations with inherent archaeological potential such as lake shores, river valleys, and deltas, while sidescan and seismic transects can distinguish lag surfaces from ones deeply buried by marine sedimentation. In Haida Gwaii, however, several early Holocene sites dating to a brief window around 9,500 RCYBP are presently in the intertidal zone and often visible as intertidal lithic scatters or intact deposits accessible through shovel testing or excavation. (See case study below for discussion of submerged site investigation in Haida Gwaii).

In other parts of BC such as the Dundas Islands, Prince Rupert, the northern Salish Sea, and the Fraser lowlands, late Pleistocene shoreline sites will be stranded on raised coastal features which may be readily visible using Lidar and photogrammetric contour mapping allowing for targeted ground reconnaissance. For areas such as Haida Gwaii where the earliest archaeological sites are drowned, the task becomes to look for geologically stable inland features that would have been attractive to people during early post-glacial time. These include caves, palaeo-lake shores, and lookout sites on high promontories, and while often difficult to locate during ground reconnaissance, are again much more visible using remote sensing techniques and targeted ground reconnaissance.

Case Study 1: Locating and Sampling Submerged Archaeological Sites

In those areas where sea level has risen during likely windows of human occupation, much of the archaeological record is now drowned to depths of over 100 m. Such depths are challenging to work at under any circumstances, but especially when target sites, most likely to be campsites consisting of hearths and stone tools, are small, at least by the standards of underwater archaeology. As such, they are difficult or impossible to locate solely by remote means such as sidescan sonar, which is very effective for locating larger and protruding targets like shipwrecks. This constraint means that an initial stage of underwater reconnaissance is to create an archaeological potential model of the seafloor, taking into account both components of archaeological visibility noted above. The most appropriate tools are high-resolution swath bathymetry to create a sub-metre DEM, sidescan sonar that can reveal details of benthic texture, and seismic sub-bottom profilers that can show deeper sedimentation patterns. With these tools working together, then a potential model based on topography and sediments is possible. Zones of high potential can then be tested using SCUBA, remote vehicles, clamshell bucket dredge sampling, and similar means. By carefully preparing the potential model, the "haystack" is made smaller. The "needles" subsequently become easier to find, although these imaging tools are very unlikely to directly detect the Pleistocene material remains.

Use of an IKU sampler (Fig. 3.7), operated from the surface and targeted towards submerged zones of high potential (Fig. 3.3d), has been successful in recovering a single flake tool from a river terrace at 53 m depth (Fedje and Josenhans 2000). This one positive test should be considered in the context of over 100 negative tests, conducted in 1998 and 1999. Empirically, then, success rate is <1% using the IKU device. More abstractly, we can crudely simulate the effect of dropping the IKU bucket onto the two best known, and two of the largest, of the 9,500 RCYBP intertidal lithic sites: Kilgii Gwaay and Collison Bay. These are good analogues for submerged sites as they both were occupied during a time of rapid sea level rise, comparable to more deeply drowned sites. Both are located on highly attractive landforms consisting of (now intertidal) near-shore terraces with southern exposure. Perhaps most importantly, both sites are protected from high wave energies at present, and thus during past marine transgression. Indeed, the intact subsurface deposits at Kilgii Gwaay and Collison Bay make them exemplars of the kinds of conditions which may permit sites to survive both transgression and 10,000 years of being drowned at depths up to 15 m. Inherent potential and visibility are thus high at both sites.

Table 3.3 gives the basic parameters of these sites. Accurate figures for site area and count of artefacts for all 112 known intertidal lithic sites are not available, but experience suggests these two sites are at the high end for artefact density and for modelling potential. Kilgii Gwaay measures about 3,200 m^2 and about 1,800 lithics have been recovered from the surface of this site. Rounding the size of the IKU to 0.5 m^2 means that, on average, one artefact would be recovered for every 3.5 grab samples. For Collison Bay, the comparable figure is one artefact for every

Table 3.3 The probability of encountering submerged archaeological deposits using a 50 × 100-cm IKU grab sampling device based on known intertidal sites in southern Haida Gwaii (ca. 9,500 RCYBP)

	Kilgii Gwaay	Collison Bay
Site area in square metres	3,200.00	1,600.00
Number of artefacts on surface	1,800.00	195.00
Artefacts per square metre surface	0.56	0.12
Artefacts per IKU (0.5 m^2) grab	0.28	0.06
Number of grabs for 1 artefact	*3.56*	*16.41*

16.4 grab samples. These figures neither take into account the vertical penetration of the IKU, which may be up to 1 m in ideal conditions, nor does it take into account several other features of these sites. At Kilgii Gwaay, a large area of the central site is the surface of an ancient pond on which very few artefacts were found, meaning grabs accurately targeted to this central area would almost certainly be negative. At both Kilgii and Collison, significant portions of the site, including some of the most artefact-rich, are covered by very large cobbles and small boulders, which would defeat the IKU by defeating closure of the bucket, preventing retrieval of fine sediments and associated artefacts. These conditions might well be shared by drowned sites as well. Drowned sites may also be covered with marine sediments of unknown depth, which would reduce the efficacy of the grab sampling programme. For example, of the ca. 100 IKU tests in Juan Perez Sound, over one half of the tests recovered only marine sediment or a single cobble that prevented closure of the bucket. Furthermore, with increasing depths, the accuracy of the IKU drop can vary within uncertain limits – while the ship can be positioned accurately to a few metres relative to the seafloor potential model, currents and dredge bucket “flutter” means that the actual accuracy of the bucket on the bottom may be on the order of a 10 m radius. All things considered, while crude, our calculations suggest that, at best, an order of 5–10 grab samples per submarine target is probably necessary to have a statistically likely chance of recovering artefacts. This translates into approximately 10–20 grab sample attempts, and thus one half to one day of ship time per target.

On other continental shelves, such as the North Sea, Australia, and the Gulf of Mexico, archaeologists have created more systematic models of site survivorship through marine transgressions. Ward and Larcombe (2008:67), for example, tabulate 18 geomorphological settings and evaluate the likely impact of marine transgression and subsequent current and tidal actions on associated archaeological sites. They further evaluate existing and potential anthropogenic impacts on the sea floor, such as trawling, dredging, aggregate extraction, and windfarms, resulting in a “general preservation rating” (2008:78) for select areas of the drowned North Sea plain. Their criteria (and the more detailed ones in Dix et al. 2008:146–195) could readily be modified for use on the Northwest Coast, where similar anthropogenic disturbances are starting to result in impact assessments of drowned archaeological resources. Nutley (2005) has tabulated an interesting suite of factors affecting Southeast Australian sites inundated during the Holocene. Nutley points out that stone wall fishtraps and wooden fishweirs in mature fluvial settings may be viable targets for underwater archaeology due to their size and the necessary low-energy riverine or shoreflat ecological settings they occupy, while lithic sites are resistant to decay but not to translocation. Numerous mid-to-late Holocene wood stake and stone wall fishweirs are known from the Northwest Coast (Eldridge and Acheson 1992; Moss et al. 1990; Moss and Erlandson 1998), so application of Nutley's principles of preservation may well be transferable. Fedje et al. (1996:129) observed a stone wall in a ca. 9,010 estuarine setting that may be an example of such a feature. Nutley (2005:16) also discusses the impact of tsunamis and cyclonic storm-surges on coastal sites, referring to empirical data collected after the 1998 and 1999 cyclone seasons and the 2004 Indian Ocean tsunami. In the Gulf of Mexico, Faught (2004) and Stright (1986, 1990), among others, have formulated post-hoc criteria for survivorship of palaeoindian archaeological sites on the sea floor. More empirically, as discussed below, in southern Haida Gwaii, over 100 early Holocene archaeological sites are known from the intertidal zone (Mackie and Sumpter 2005). Each one is a lesson in the conditions by which archaeological sites survive transgressive and submarine processes and are now undergoing regressive ones. Additionally, the lower layers of raised beach sites such as Richardson Island were in the middle to upper intertidal zone for several thousand years of the high stand. Protected by a gravel blanket, numerous delicate hearth features and pristine lithics survived partial inundation. Together, such sites could form the basis for an inductive model balancing inherent potential with site visibility (Mackie and Fedje 2008). Many of these studies on inundational and submarine site formation processes are brought together and discussed in terms of overall continental shelf characteristics by Bailey and Flemming (2008). Taken together, there is an emerging, rich literature on the question of drowned archaeological site visibility, which is moving underwater archaeological method beyond those applicable to shipwrecks; coastal British Columbia has considerable, unrealized potential to generate and test these ideas.

Case Study 2: Locating and Sampling Terrestrial Archaeological Sites

High-resolution topographic tools such as photogrammetric contours and Lidar are important for finding and assessing remnant Pleistocene and early Holocene geomorphology in areas that are currently subaerial. As described above, there was rapid and significant environmental change across the Pleistocene-Holocene boundary and leading towards the present. Changing sea level means most zones of potential are either drowned or stranded inland. Modern vegetation cover is typically a very dense temperate rainforest with a thick humic layer obscuring mineral soils and earlier buried soil horizons from times of different vegetational regimes. The wet rainforest soils are acidic and even shell components will degrade over time, leaving little other than stone, charcoal, ash, and calcined bone. It is not uncommon for there to be more than 50–100 cm of recent organic overburden woven together with dense root matting. Millennia of terrestrial erosional processes have obscured the clarity of any

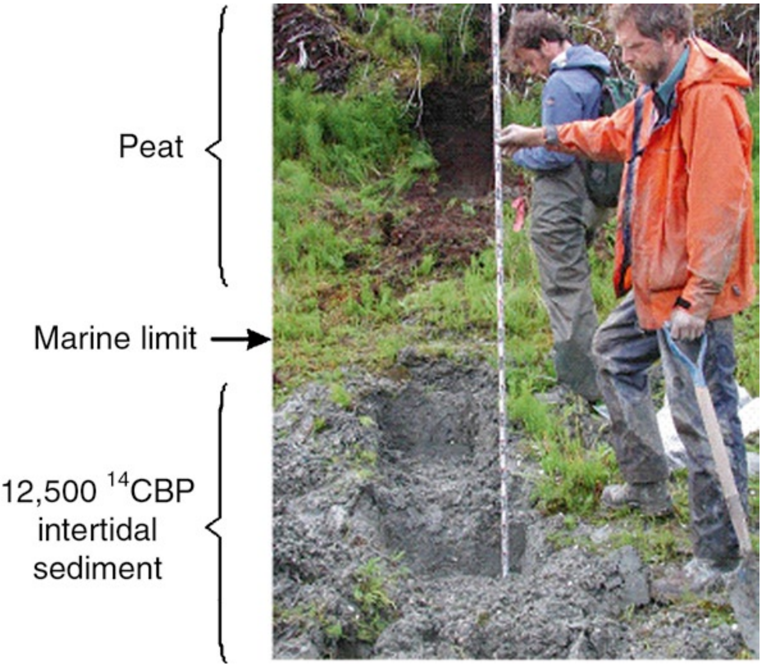

Fig. 3.14 Almost 2 m of peat overlies an early post-glacial beach in a raised marine section, at 50 m above modern sea level, near Prince Rupert. Q. Mackie photo

palaeo-coastal landforms, especially when viewed from ground level. Peat development of up to 2 m (Fig. 3.14) through the Holocene obscures many zones which are attractive to humans, such as beaches and the margins of small lakes or other lowlands. Soil exposures are usually small and isolated, meaning that site reconnaissance must rely largely on shovel testing and augers, supplemented with opportunistic inspection of tree-throws and creek channels. Overall, it is difficult to get an extensive view of surface or subsurface zones of potential. Under such circumstances, accurate knowledge and modelling of the terrestrial surface is essential, and it may be best to couple this to a high resolution sea-level history. One goal would be to target palaeo-marine features that are now stranded in the forest, especially those with very high potential for human occupation, such as tombolos, berms, spits, and sheltered embayments with fresh water access. Another goal might be to model for inland "magnets" which are on neither the modern or palaeo coast, yet which would be stable landform features drawing people in from the coast to knowable locales. Such inland features include promontories, which afford a lookout or view, and karst landscapes, which afford the potential for limestone caves with their attendant resources, such as denning bears. River terraces and lake shores can also be modelled.

Recent research in the Dundas Island Group exemplifies the palaeo-marine approach (McLaren 2008). This archipelago has a very different sea-level history from Haida Gwaii, despite a separation of less than 100 km. The difference results from the Dundas Islands being closer to the Cordilleran Ice sheet: whereas Haida Gwaii was isostatically forebulged upwards during the late Pleistocene, thus accounting for the lower relative sea levels, the mainland to the east was isostatically depressed, thus raising relative late Pleistocene sea level (Barrie and Conway 2002; Clague 1984; Fedje et al. 2005b; Hetherington et al. 2004). The Dundas Islands, partway between these two areas, is situated in a type of sea level "hinge" where it was hypothesized that limited sea level change occurred during the late Pleistocene (Fedje et al. 2004b; McLaren 2008). A research programme employing isolation lake basin and peat coring was employed on the Dundas Islands to test the possibility that this area was like a sea level hinge (Fedje et al. 2004b; McLaren 2008). Based on biostratigraphic changes in diatom frequencies and supporting proxy indicators, this research resulted in the identification of a gentle regression in sea level from 13 m above sea level to present sea level since 12,385 RCYBP (Fig. 3.15).

Selected areas within the archipelago were chosen for the creation of high-resolution (2-m contour interval) topographic maps, derived from existing aerial photography. This relatively cheap method allowed the sea-level curve to be

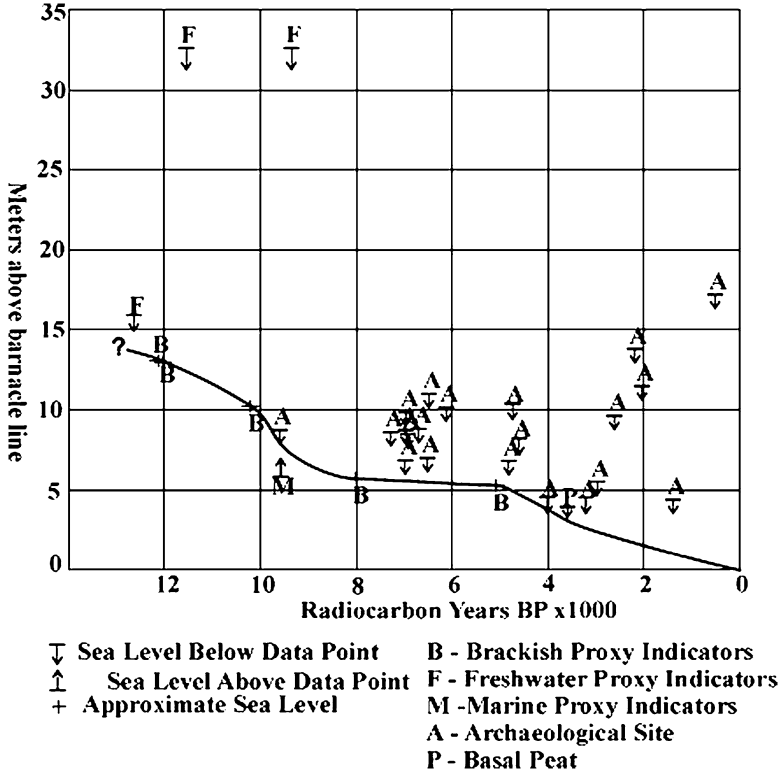

Fig. 3.15 Dundas Islands Sea level curve based on palaeoenvironmental proxy indicators from lake, peat cores and archaeological samples (modified from McLaren 2008)

coupled to a fine-grained knowledge of the land surface, and targeting of suitable elevations, some of them well inland, was made possible (McLaren 2008; Martindale et al. 2009). Among the archaeological sites found were several shell middens in raised beach contexts dating to the middle Holocene and, in particular, the site at Far West Point with basal dates to 9,690 RCYBP (McLaren 2008). The elevations of all radiocarbon samples from archaeological sites provided proxy data allowing for refinement of the sea-level curve created from lake coring.

Prior to this study, the earliest known archaeological sites on the northern coast of British Columbia, including the well-researched Prince Rupert harbour and Skeena River subregions, were about 5,000 RCYBP, which demonstrates the utility of the palaeoenvironmental and cartographic background approach used by McLaren. A similar programme in Haida Gwaii was also successful in using 1 m photogrammetric contours to identify raised beach sites on raised marine terraces, such as the Lyell Bay sites noted above (Fedje and Christensen 1999). The method is therefore conceptually simple, but requires interdisciplinary work.

More recently, Lidar data have become available for some areas on the coast. The Lidar bare-earth models, with their sub-metre vertical resolution, surpass the photogrammetric method in accuracy and readily allow for the creation of sun-shaded digital elevation models which greatly help in visualization of the landform and detection of features of interest. A proposal and pilot project to use Lidar-derived DEMs to find promontory sites which overlook the ancient coastal plain (Mackie et al. 2007) was implemented by Sanders (2009). Argonaut Hill is a large, heavily forested glacial outwash remnant 130 m high near the northeastern coast of Haida Gwaii. While no lookout sites were found in a brief survey, the ancillary Lidar modelling of early Holocene coastlines along the base of Argonaut Hill did result in the quick and efficient discovery of several lithic sites. From one of these, the Forks site (Figs. 3.10-17 and 3.16), date samples ranging from 3,925 to 7,140 RCYBP were recovered. This small study demonstrated that Lidar was a very effective tool at leading archaeologists directly to palaeo-coastal landforms of interest underneath dense forest canopies situated over a kilometre from modern shorelines.

Lidar can also be used to detect developed surficial karst (Mackie et al. 2007; Langendoen and Baichtal 2004; Montané 2002) even under dense forest canopy, which would in many cases lead researchers directly to areas of very high potential for karst caves and any associated archaeological materials. Because of the expense, Lidar data only exist for selected areas of the BC Coast (notably, NW Haida Gwaii and some areas around southern Vancouver Island; large Lidar datasets for southeast Alaska and Puget Sound are available). With demonstrated utility across multiple resource management sectors, Lidar will likely be flown pre-emptively for many more areas, as it has already been in the NE sector of the Province (Eldridge and Anaya-Hernandez 2004). Other remote sensing technologies, such as the use of thermal imaging to detect cave exurgences, may also come to the foreground in the near future, enabling archaeologists to carefully target those specific inland terrain features with the very highest archaeological potential (Fedje et al. 2004a).

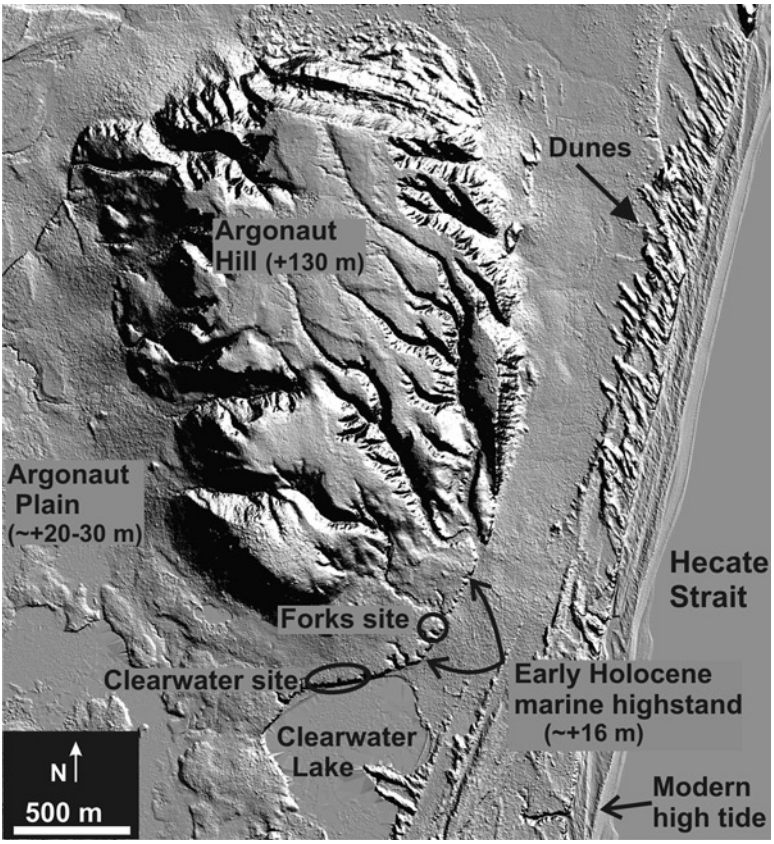

Fig. 3.16 Lidar-derived bare earth model of Argonaut Hill and environs. Lidar image from Terra Imaging

Discussion

Using the above methods, high-resolution imagery can efficiently lead archaeologists to landforms of the highest potential classes, such as stranded beach ridges, terrestrial promontories, developed karst and sinkholes, and both raised and drowned palaeo-river terraces. Since few early sites are now known, the first application of these technologies will likely continue to be "high grading" for the best combination of inherent potential and likely archaeological visibility. As more sites are found, then these methods can expand in utility to include explaining site location in micro-environmental terms and set in motion a virtuous circle of modelling and ground-truthing of models for the Pleistocene-Holocene transition. In this, we are optimistic that the archaeological record of the Pleistocene Northwest Coast can, indeed, be empirically investigated. By extension, empirical evidence concerning the coastal route of the first peopling of the Americas can and, we think will, be found.

The modelling tools and emerging environmental and archaeological data which form the basis of this chapter suggest that the time is right for intelligent selection of high potential zones on the coast for intensive archaeological reconnaissance.

In a broader context, we perceive three topics that influence how archaeologists think about this topic: the finer-grained nature of the "coastal plain", the mode and tempo of the "first peopling" process, and the use of appropriate ethnographic analogies. These orienting constructs strongly influence how and where future researchers will focus their attention and thereby these are crucial for determining their likely success or failure. We will discuss each of these in turn.

The Coastal Plain

Some themes are common when archaeologists who study First Peopling processes invoke the environmental characteristics of coastlines. As summarized by Westley and Dix (2006), these include:

1. Coasts provide more equable climatic conditions than inland areas (e.g. Fladmark 1979).
2. Coasts provide more stable habitats than inland areas (e.g. Yesner 1980; Stringer 2000).
3. Coastal environments are relatively uniform along the length of a coastline (e.g. Stringer 2000; Mannino and Thomas 2002).
4. Coasts have a diverse, and often more productive, array of resources compared to inland routes due to their ecotone (boundary between two ecosystems, hence combining characteristics of each) status (e.g. Bailey and Parkington 1988; Flemming et al. 2003).
5. The restricted topography of coasts (i.e. the presence of the sea) focuses migration routes and simplifies navigation (e.g. Mithen and Reed 2002; Kelly 2003).

However, they go on to note, "it is now apparent that coastlines may have been characterized by periods of intense spatial and temporal instability that would almost certainly have been perceivable by past humans" (Westley and Dix 2006:24) and more nuanced appreciation of coastlines is needed.

Indeed, the early post-glacial coastline of the Northwest Coast area has variously been described as a *highway* (Erlandson et al. 2007); a *corridor* (Dixon 2001:295); a *plain* (Hetherington et al. 2003; Schalk et al. 2007; Bailey and Flemming 2008:2158 – "an extensive coastal plain"); and a single large *megapatch* from Alaska to Chile (Dixon 2001). The implication is that its over-riding characteristics are low-relief, easy transportation, linearity, homogeneity, and productivity. It may have been all or none of these at all times, or sequentially. The terminology used – corridor, highway, etc. – is important because it structures how archaeologists think about the environment and its affordances for people and animals, which in turn influences how they create ethnographic analogies and settlement models and thereby how ancient sites now in difficult or obscure modern settings might be found.

In the following section, we divide the BC palaeo-coast into different subregions and environment types.

The outer coast of British Columbia appears to have been open and relatively ice-free from ca. 18,000 to 16,000 RCYBP, partially closed from 16,000 to 14,000 RCYBP as Fraser ice overran Vancouver Island to the Continental Shelf, and permanently open by 13,500 RCYBP. The outer coast was not, however, a homogeneous environment, physically or biologically, with the possible exception of the extreme seaward fringe and adjacent marine environment. Even this coastal strip was, at least intermittently, hilly and interrupted by rocky headlands and fjords. Before 12,000 RCYBP, relative sea levels were much higher than present on the south coast, the consequence of which would have been a largely steep, rocky, indented coastline with "plain"-type areas being limited to discontinuous fluvial/outwash deltas. At the same time, the Hecate Lowlands saw much lower sea levels than present and a large (perhaps about 7,000 km^2) area of low-relief, temperate tundra formed to the east of Haida Gwaii, effectively joining those islands to the mainland. However, vegetation communities may have been more homogeneous at this time than at any later time. The north coast was dominated by tundra and parkland or open woodland plants, the central coast by pine-Mountain hemlock parkland (Stolze et al. 2007), and the south coast communities would have been similarly open (Brown and Hebda 2002). Thus, during these early times, there may have been narrow terrestrial lowlands connecting some of the larger flat regions, while other lowlands may have been relatively isolated from each other by rugged terrain and the associated rocky headlands with fewer margins for those paddling in canoes. Nonetheless, the open nature of the terrestrial vegetation may have counterbalanced this medium-scale patchiness and allowed people and animals to roam across the lowlands, and perhaps to follow well-defined passes or coastal strips from one area to another. In summary, the "coastal plain" of British Columbia during this period was broken into areas of favourable and less favourable terrestrial conditions and favourable and less favourable coastal conditions, forming a mosaic of large and small heterogenous environmental settings for early human arrivals.

Between 12,000 and 10,000 RCYBP, areas inland of the shore would have been subject to rapid shifts in vegetation communities including the development of closed coniferous forests by 11,500 BP in the environs of Haida Gwaii and northern Vancouver Island (Lacourse et al. 2005; Lacourse 2005; Hebda 1983). More xeric conditions on the southeast coast of Vancouver Island limited development of closed forests (Pellatt et al. 2001). Hence, this is a period of increased patchiness of vegetation during which large ecologically homogenous habitat zones were broken up, including those favoured by species such as brown and short-faced bear, caribou, and bison (Table 3.2). At the same time, rising sea levels eliminated most of the Hecate lowlands, isolating Haida Gwaii from the mainland and leading to the extirpation of Brown bear from those islands. Simultaneously, the lowlands in the Salish Sea area were emerging from the ocean, creating a window of large, exposed rolling hills and open parklands from which such species as bison, ground sloth are known. Between these areas, sea levels were roughly similar to modern on the central coast, producing a coastal archipelago with exposed lowlands to the west backed by steep fjords and protected island archipelagos to the east. To the south, the Puget lowlands may have facilitated the movement of Clovis people (Croes et al. 2008) in, or out, of this region. Overall, the "coastal plain" is time-transgressive, appearing early in northern regions and more recently to the south.

The effect of the younger Dryas is poorly understood and may be similarly subregionally specific (Fedje et al. 2011a). Colder weather may have led to greater snowfalls during this time, and though there is little evidence for increased glaciation, winter-time travel and subsistence were likely more difficult for humans and animals alike. On Haida Gwaii, there is evidence for the extirpation of coastal deer around the 10,900 RCYBP onset of the Younger Dryas, perhaps due to heavier snow cover than these small ungulates can cope with. Brown bear disappear from Haida Gwaii around 10,200 RCYBP, perhaps reflecting reduced habitat from rising sea levels and forest infill. In other areas, the Pleistocene faunal record is not as well known.

It is important to consider that early post-glacial biotic communities may not have any modern analogues (Mathewes 1991; Stewart and Lister 2001; Williams et al. 2001). Plant communities were dynamic with changes relating to varied dispersal rates, a highly dynamic climate, and rapidly changing edaphic settings. Glacial advances and retreats, sea-level shifts, and rapidly changing plant communities would have created both opportunities for expansion and bottlenecks to survival for a variety of terrestrial fauna. A "temperate tundra" with mild winters and a long growing season may have been exceptionally productive. Rising sea levels in some areas release iron and organic nutrients into the near-shore waters, promoting algae growth and the development of rich intertidal invertebrate communities. It is worth noting that in areas of falling or stable sea levels, deltas are likely to form where rivers meet the ocean, while during rising sea levels estuaries are more likely.

It remains unclear whether or not there were biotic refugia along the BC coast. The early post-glacial record of bear in Haida Gwaii including a date of over 14,000 RCYBP (Ramsey et al. 2004) suggests either bears survived in a necessarily large and productive coastal refugium during the LGM, or that they were able to enter the heartland of the NWC very soon after the ice retreated. Both scenarios are of interest for archaeologists, since bears make a good ecological analogue for humans.

In sum, the "coastal plain" needs to be understood at various temporal and spatial scales. At the broadest scale, it probably was a long linear zone of lower-relief and moderate climate flanking the west coast of British Columbia. At medium scales, the early North Coast was very different from the early South Coast, and the nature of these two zones slowly switched over time. At somewhat finer scales, the configuration of the coastline – its "involution index" (Mackie 2001) – may be extremely important, as may be the locational penalties and benefits (Fedje et al. 2004a; Wobst 1974). At finer scales still, impassable headlands, sheltered archipelagoes, productive estuaries, migration bottlenecks, dens of short-faced bears, and the like probably structured the daily life of people, from which the process of first peopling is assumed to flow. In the following section, we outline some considerations about the reconstruction of the daily life of these early inhabitants.

Ethnographic Analogy

The archaeology and anthropology of the Northwest Coast are dominated by the well-known, massive, detailed works of Franz Boas and his students, and other early ethnographers working in a Boasian idiom of historical particularism. While there are obvious benefits to having these source data, it has arguably created a certain naivite in coastal archaeologists when it comes to ways of life in the deeper past. The overarching narrative of Northwest Coast archaeology, for better or worse, has been one of progressive cultural evolution to the ethnographically described pattern of "complex hunter-gatherers", with large dugout canoes, monumental art and architecture, private ownership of resources, social stratification, and so forth. Under this narrative, the founding archaeological cultures are too easily conceived of as an impoverished default condition: complex hunter-gatherers stripped of their complex trappings. In reality, the way of life may have been qualitatively different and the ethnographic record may be of little or no use, or even be counterproductive. For example, Mackie and Sumpter (2005) find early Holocene and late Holocene site locations in Haida Gwaii are almost mutually exclusive, with co-occurrence in only 18 instances in a sample of 454 such sites. Since coastal configuration was the same then as now (e.g. protected inlets versus exposed coasts), many of the fundamental resource suites are known to be similar. Moreover, since many of the most important tool technologies from the early Holocene sites differ substantially from late Holocene sites, there must have been non-trivial cultural differences to account for such different choices in appropriate settlement sites. That is, it was not just a situation of fewer Haida with lower population densities, smaller houses, and no totem poles or slaves living a "lightweight" version of traditional Haida life, but of a people with similar problems and prospects enjoying a very different lifeway. With this in mind, it is necessary to look further afield for appropriate ethnographic analogies.

Since the early Holocene archaeological record in Haida Gwaii and elsewhere is strongly suggestive of complete fluency with marine resources and the marine transportation environment, the search for analogies can be narrower. One candidate group is the Yamana (Yahgan) of southern Tierra del Fuego. Living at low population densities, highly mobile, yet utterly focused on marine resources, Yamana life (e.g., Gusinde 1961[1931]) may form a useful framework for the Pleistocene-Holocene transition on the Northwest Coast. While certainly the historical context of observations about Yamana life must be considered (e.g., Yesner 2004; Mackie 2001), even the historic Yamana offer insight into alternative maritime lifeways. For example, the much-derided Yamana canoe, made of sewn bark and noted to be extremely leaky and somewhat wobbly, was nonetheless capable of transporting 6–10 people or a fully-grown sea lion carcass. In these boats, the Yamana routinely ventured through the "furious fifties" to the islands and islets of the continental shelf well south of Cape Horn, such as the 100 km voyage to the Diego Ramírez archipelago, where they hunted pinnipeds and other prey (Gusinde 1961:128). Cape Horn itself is part of an archipelago some 40 km separate from the major islands of the southern cone. The leakiness and flexibility of these canoes apparently allow them to conform slightly to the waves rather than batter or cut the sea. This comes at the cost of speed, as the canoes were slow even when paddled by more than the typical single person. Nonetheless, the impression given by Gusinde is of a craft built and handled in a way suitable for the meandering lifestyle that is the Yamana stereotype, but equal to more demanding tasks when necessary. Certainly, such a canoe would be adequate for making a living on the Northwest Coast, now or in the past.

Although not known to have practiced storage of food on the scale of ethnographic Northwest Coast peoples, the Yamana were certainly aware of the principles and practice of storage of both food and raw materials. For example, sea mammal intestines would be stuffed with blubber which could then be stored in the acidic water of bogs until needed. The energy density of such sausages must have been enormous. Gusinde (1961:337) also describes canoe-loads of blubber from beached whales being cut into slabs and stored in swamps, which would keep for months or even a year. This parallels the North European practice of storing dairy and adipose fats in the form of "bog butter" (MacAdam 1882; Cronin et al. 2007; Berstan et al. 2004). Slabs of bark from the southern elm were also cut and stored in swamps, allowing canoe manufacture and repair at any time of the year. The Yamana invested in fish weirs and other mass-capture devices, and a by-product of their way of life included quite large shell middens with visible tent platforms on the surface. The people were noted to be excellent swimmers, and one gets the impression of frequent diving in and out of canoes to collect subtidal shellfish and other marine invertebrates. They were familiar with all manner of bone and wood technologies and textiles, even if they chose a fairly "lightweight" (i.e. low investment, high flexibility) toolkit. Equally, the Pleistocene occupants of the Northwest Coast may have had skin boats (kayaks or umiaks), not a match for the late Holocene dugouts in speed, but perhaps just as seaworthy and capacious.

While the ancestral people to the Northwest Coast First Nations probably did not closely resemble the Yamana any more than they resemble their ethnographic descendents, the point remains that we must fully embrace a nuanced, global perspective on the use of ethnographic analogy. Yesner (2004) ably compares and contrasts the Yamana to the Aleuts, suggesting comparable levels of social and technological achievement, while Mackie (2001) makes some comparisons between Yamana and Tlingit. Both of these comparisons belie the ethnographic stereotype of the Fuegians as occupying the lowest evolutionary niche of any human group. Hence, sophisticated ethnographic analogy-building is needed on the Northwest Coast, and we would argue, also needed in other regions where continental shelf archaeologists may look to the Northwest Coast for their analogue maritime hunter-gatherer-fisher people.

First Peopling as a Process

Seeking to avoid naivete in ethnographic analogy and thinking about the graininess, scale, and temporal transgression of the BC palaeo-coast should be two important steps for furthering Northwest Coast archaeological research. However, a third point arises from these: what was the likely process by which the first people came to the coast, and what behavioural parameters can we reasonably deduce which aid with archaeological reconnaissance?

While the literature on modelling the first peopling of the Americas is large, the majority of this takes the form of continental scale analyses of the hypothesized interior route of entry. Fewer studies address the demographic, mobility, or other ecological circumstances of the coastal route, and very few or none adequately consider the various spatial and temporal scales at which human behaviour unfolds (Westley and Dix 2006), let alone take a humanistic view of the dramatic landscape alterations at the terminal Pleistocene (Leary 2009). And yet, the continental event of First Peopling is a conflation of a series of regional, subregional, and local events, and the process must therefore make sense at the human-scale of intentionality as well as in millennial terms. Balancing these multiple scales lies at the heart of dissatisfaction with such models as Blitzkrieg (Martin 1973). What kept people moving, and killing, through so many different ecological zones to get someplace distant they did not yet know existed? Attempts to reconcile the archaeological evidence with ethnographically plausible human models of behaviour, such as the "string-of-pearls" and "leapfrog" models, which may depend on human dispersal via transient exploration or estate settlement (e.g. Anderson and Gillam 2000; Beaton 1991; Surovell 2003; Whelan 2006), are also more hypothetical than empirical states of being. Just as we may lack analogues for the coastal plain and for its early inhabitants' way of life, so we lack, more generally, ethnography of the process of First Peopling. This process took place exclusively in prehistory (with the exception of the remote landmasses such as Antarctica) and the mode and tempo of first peopling can be difficult to intuit. For example, in the case of the Pacific, archaeologists have suggested both passive drift models of First Peopling (e.g. Montenegro et al. 2008) and active, ideologically driven seeking of new lands (e.g. Anderson 2006), and many intermediate behavioural and ecological scenarios have also been suggested. Further, other than as vessels of fertility (e.g. Surovell 2000), there are few systematic attempts to explicitly consider constraints and opportunities afforded to first peoples through such social factors as gender roles (e.g. Waguespeck 2007; Balme and Bowdler 2006). The strange lack of real people in the study of First Peopling allows the persistent image to remain of the small pack of large males with spears, chasing mammoth, as the agents of progress (Perry 2006). By facing up to the lack of ethnographic analogues, suitable caution can be drawn into otherwise optimistic or naïve models of human territorial expansion (see Lanata et al. 2008 for a cautious reworking of some continental models of demographic expansion).

Nonetheless the dilemma remains that the behaviour can only be deduced from archaeological sites, and finding such sites is dependent on understanding the process. So, while using the best practices in understanding environmental heterogeneity and ethnographic analogy, there must be a concerted effort to understand the process of first peopling. As Westley and Dix note, "the 'site-oriented' method presently provides more information about the products of colonization rather than the actual process" (2006:11). The authors rightly argue for a multi-scalar investigation of environmental heterogeneity, suggesting that dynamism may have kept people moving, or that stability may have allowed movement (2006:23). Another possibility exists, however, exemplifying the notion that we must understand the temporal and spatial scales and the ethnographic parallels when model-building: the possibility that environmental dynamism offers its own comforts and opportunities, and that stability itself produces ecological challenges.

For example, as discussed, a large number of sites in Haida Gwaii are known between 11,000 and 9,000 RCYBP a time of profound vegetational and faunal changes and rapid sea level rise. The latter change was on the order of 5 cm/year for two millennia: the camp in which a person was born would be in the lower intertidal zone when they died; their grandparents' camps would be fishing spots or reefs. Rising sea level, nibbling away at maturing forests, deposited large amounts of wood into the water, making that key resource essentially free and constantly exposing (then drowning) sources of suitable lithic raw material. Accepting that sea level change was an integral part of their world, not an external imposition (Leary 2009), changes the frame from *coping* to *dwelling*. The dynamic environment, on which there is evidence for sustained occupation and fluent use of many or all ecological niches, was arguably an *opportunity*, not a cost. People dealt very well with the dynamic environment for 2,000 years. Indeed, it is only after the onset of the early Holocene high stand that rapid adjustments to the stone tool technology are observed, perhaps precipitated by raw material shortage (Mackie et al. 2008; McLaren and Smith 2008). Regardless, many of the changes in the environment would have structured the daily life and perceptions of people – in short, their worldview – in a way that archaeologists would be well advised to consider when attempting to model processes for which there is little direct information, such as the first peopling of new land and sea. The diverse, dynamic coastal environment inhabited by these resourceful people was not primarily a "corridor", or a "highway", or a "route", any more than Beringia was a "bridge" and not a subcontinent. The ancient coast of BC was, above all, a place to be; a homeland of the senses for those who were not on the way elsewhere, least of all southern Argentina.

Conclusions

Working in archaeology on the BC coast has always presented many challenges including low archaeological visibility, dense vegetation, a deeply drowned landscape, terrestrial erosion processes, and acidic soils which dissolve organic remains in decades – not to mention difficult access by boat or plane only to many of the locales of most interest. During times of rapid environmental change, which are many especially in the early periods, coastal dwellers may follow the shorelines. This leads to their material remains becoming spread thinly across the landscape, and the likelihood of much of the archaeological record becoming drowned or stranded. Surrounded by numerous, huge late Holocene shell middens which are blessed by exceptional preservation and often found in sheltered, south-facing coves, it is no wonder that the archaeology of the early Holocene has lagged behind that of more recent times.

This late Holocene emphasis may be shifting as the Northwest Coast is recognized as a key link in the first peopling of the Americas debate. The various archaeological sites, many only described in grey literature, are now being placed in an ever-more detailed palaeoenvironment. As factors determining site location and visibility become better known, optimism rises that this is a time, place, and problem amenable to empirical investigation. From this, specific and interdisciplinary research programmes are planned and implemented, replacing the prior strategy of "getting lucky", although luck is certainly still a key constituent of success. Use of imaging tools such as multi-beam bathymetry, sidescan sonar, and Lidar can be coupled to local environmental histories, such as sea-level curves and cave fauna, to create micro-scale potential models and maps. With these in hand, sites have been found in challenging locations by deliberate survey (Fedje and Christensen 1999; McLaren 2008; Sanders 2009). There is therefore every expectation that the near future will continue to accelerate knowledge of the Pleistocene-Holocene BC Coast. The material cultural history of the descendent indigenous people – The Haida, the Tsimshian, Salish, and others – will become known. So too will the place of the Northwest Coast as both aboriginal homeland and connective seam between Beringia and North America.

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Chapter 4
Blessing the Salmon: Archaeological Evidences of the Transition to Intensive Fishing in the Final Paleolithic, Maritime Region, Russian Far East

Andrei V. Tabarev

Introduction

From the end of Pleistocene local cultures in the Russian Far East demonstrated technological complexity with a number of innovations reflecting the dynamic evolution of economic and social structures of their society. Among economic models, the intensive seasonal salmon-fishing takes a special place in research and analysis. Rich ethnographical data on the aboriginal cultures over the North Pacific basin (both Asian and American) gives us very interesting pictures of highly developed systems of salmon exploitation along with the ceremonial and ritual activities (for example, Kroeber 1925; Kroeber and Barrett 1960; Stewart 1997; Swezey and Heizer 1997; Watanabe 1972; etc.).

Aboriginals on the both coasts of the Northern Pacific used to bless the salmon and recognized it as the main food item. Legends and tales about salmon are strikingly similar among people all over the Northern Pacific. They believed that "red fish" was living in the World of Salmon, that there were several tribes of salmon in this world operated by chiefs and Masters of Salmon.

Biological investigations strongly point on the Far Eastern seas as the cradle of salmon. Six species of *Oncorhynchus* – *O.masou, O.tschawyscha, O.kisutch, O.gorbusha, O.keta* and *O.nerka* used to spawn in the coastal streams of Western Pacific and only five in Eastern. *O.masou* is recognized as the oldest species (Mother of Salmon) and it is absent on the North American coast

American specialists agree that the phenomenon of salmon-fishing has its roots in the very early period of the peopling of North America. Faunal remains were found on a number of archaeological sites along the Pacific coast of Alaska and British Columbia, and dated as early as 10,000 RCYBP (Carlson 2003; Matson and Coupland 1995; Vasilievsky 1998).

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What do we really know about the origin of salmon-fishing in the Far East? Do we have data to suggest that Far East was the first region in the Northern Pacific where ancient cultures flourished thanks to summer–autumn salmon fish harvesting?

During recent years the author of this chapter is trying to gather and to interpret various archaeological information, and to prove the high importance of salmon-fishing in development of ancient technologies (stone, clay, organic), in the origin of semisettled way of life and early complex societies, in the invention of water transport, in the intensity of distant migrations, in specific forms of art and rituals (Tabarev 2001, 2003, 2006, 2007).

Cultural Chronology of the Russian Far East

A huge territory of Northeast Asia called the "Russian Far East" includes several big geographical regions – the Amur Region (Middle Amur and Lower Amur River), Maritime Region (Primorye), and Sakhalin Island. Kamchatka Peninsula and Chukotka Peninsula usually are connected with the term "Extreme Northeast." The first archaeological investigations started in the Russian Far East about 130 years ago, and today specialists have a clearer panorama of prehistoric cultures and traditions from the Upper (Late) Paleolithic* sites to the early historic period.

* Upper Paleolithic sites are rare, and are presented by a small number of open and cave locations with pebble industries and small quantity of faunal remains. Anyway some of them gave pretty good materials for ^{14}C dating. For example, carbon dates from the levels with stone artifacts in Geographical Society Cave (Maritime Region) were recently dated by bones (*Pantera tigris, Crocuta spelaea* and *Mammoth primigenius*) as early as 40,000–38,000 RCYBP (Kuzmin 2005: 56–58).

The Final Paleolithic dates just after the LGM, 17,000–16,000 RCYBP and continues until 3,000 RCYBP. More than 15,000 years ago the inhabitants of the region adapted to a variety of natural landscapes – forests, mountains, lakes, river valleys, sea banks, plains, etc. (Tabarev 2007). The boundary between the Neolithic is complicated by the early appearance of pottery around 13,000 RCYBP. This has changed traditional points of view and the understanding of the Neolithic in its classic version (so-called "Neolithic Revolution"). The arrival of agriculture was relatively late (about 5,000–4,500 RCYBP) and the production of food was not the main strategy until the colonization of the Far East by Russian settlers during the nineteenth and early twentieth centuries.

Archaeological Materials

Specialists identify several original Final Paleolithic and Neolithic "cultures" in the Russian Far East – groups of sites with specific traits in lithic industry, dates and locations (Fig. 4.1).

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* Both terms are in use in Russian archaeological literature.

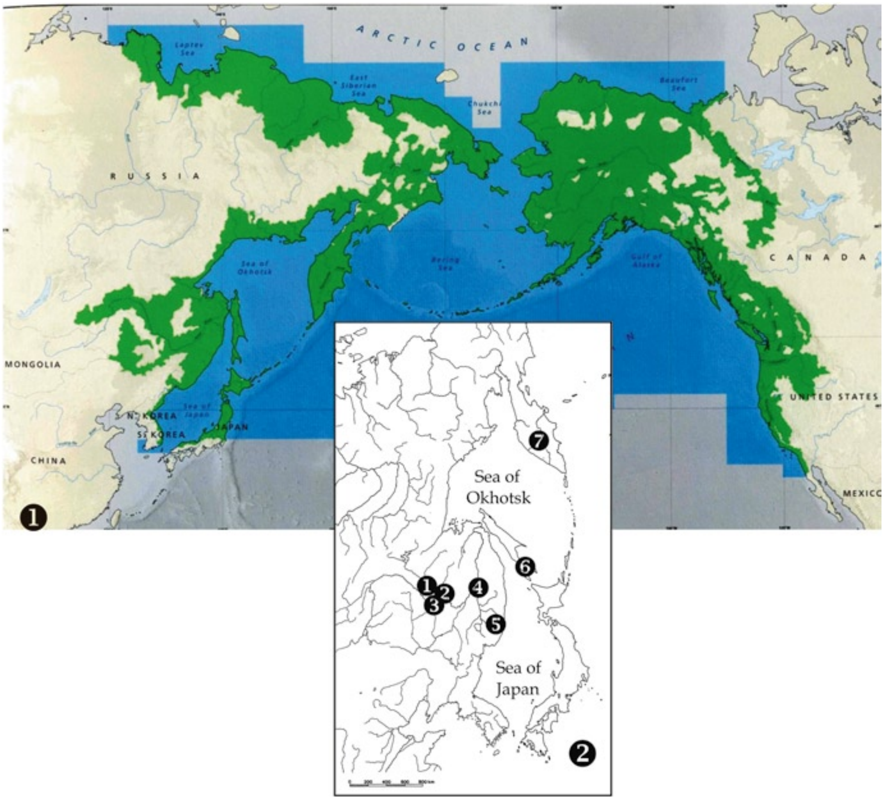

Fig. 4.1 *1* – Northern Pacific and the territory of salmon fish runs; *2* – Russian Far East, cultures and sites mentioned in the text (1 – Selemja culture, 2 – Gromatukha culture, 3 – Novopetrovka culture, 4 – Osipovka culture, 5 – Ustinovka culture, 6 – Ogon'ki culture, 7 – Ushki Lake site)

Selemja (Selemjinskaya) *culture* – (24,000–12,000 RCYBP) is the oldest culture (cultural tradition) in the region. Several groups of sites were investigated by archaeologists during the 1980s on the Selemja River and its tributaries. In spite of huge collections of stone artifacts and debitage there are just a few remains of possible dwelling constructions or shelters. Most of the sites represent seasonal camps on the river banks and may be interpreted as traces of complex hunting-fishing activities of the inhabitants. Among the stone implements, wood-working tools (adzes, axes), bifacial knives, and microblades for composite tools stand out (Tabarev 1997). According to stratigraphical and technological observation the Selemja culture may be divided into several cultural stages.

Gromatukha (Gromatukhinskaya) *culture* – (13,000–4,000 RCYBP). This culture got its name after the principle site (Gromatukha) excavated in late 1960s and recently during early 2000s. There are also a dozen known sites with similar materials in the Middle Amur Region tested with small-scale units and trenches. The

Gromatukha Site itself is multilevel and has a record of cultural evolution spanning several 1,000 years. In the lowest horizon the lithic industry is characterized by typical Final Paleolithic assemblage – wedge-shaped microcores, transverse burins, bifacial knives, points, end scrapers, and gravers. There are also lots of heavy wood-working tools – axes, adzes and chisels – with typical use-wear traces.

Unfortunately, there is no evidence of any dwellings or structures at the site. Many concentrations of debitage and preforms have been interpreted as flintknapping areas. These are associated with concentrations of charcoal, likely hearths. These characteristics indicate that people of Gromatukha culture were mobile foragers with a seasonal focus on fishing (salmon) occupying temporary camps with light surface dwelling constructions.

Detailed stratigraphical observation and analysis of the distribution of the archaeological materials done after the excavation places the limited number of primitive pottery sherds in the levels dated 13,000 RCYBP. If confirmed, Gromatukha may have one of the earliest examples of pottery-making in the Russian Far East. Additional fragments of pottery were found during recent stage of excavation and confirmed these conclusions. Pottery was apparently invented in northeast Asia and used by forest hunters and river fishers in the very end of the Pleistocene (13,000 RCYBP). Early pottery has been dated 12,500–11,000 RCYBP nearby in both the Upper and Lower Amur (Kuzmin 2003). Until 3,000–2,000 RCYBP it was not connected with a food production economy.

The development of semisettled way of life of the ancient people in the Far East likely appeared within the *Novopetrovka* (Novopetrovskaya) *culture*. This culture is one of the most interesting Neolithic ones in the Russian Far East. Three sites (Novopetrovka-I-III) with remains of subterranean dwellings were located and studied in late 1960s and early 2000s near the Novopetrovka village on Dunaika river (Amur tributary) close to Russian-Chinese border. All the dwellings are of rectangular configuration (usually not bigger than 7×6 m) with the sets of visible postholes around the walls and a fireplace in the middle. The dwellings have small depressions with stone tools and preforms, and empty ones were probably used for food storage. Novopetrovka sites (small villages) were sedentary or semisedentary settlements of hunters and fishers.

The Novopetrovka lithic industry is of special interest for technological analysis. It is absolutely different from the industry known for Gromatukha culture in terms of percussion but reflects similar type of activity (combination of hunting and fishing). People of Novopetrovka culture were making their tools (arrow and dart points, knives, drills and burins) on long prismatic blades (5–15 cm). The industry was based on the exploitation of big prismatic cores (up to 20 cm) by a pressure-flaking method. High quality raw material (chert, jasper, and other siliceous rocks) and special devices to fix cores in place were widely used by local craftsmen.

Broken and unbroken blades with retouch or burination number are several thousand. Retouch covers margins of blades both from ventral and dorsal sides but bifacial tools are exceptionally rare. There are almost no real bifaces and no bifacal preforms or tools. The historical roots of Novopetrovka culture (prismatic cores and blades) may be preliminary traced to a series of sites with eroded cultural levels (so-called Anansi Group) in the southern regions (China).

Few fragments of pottery with the presence of shell temper were found on the Novopetrovka sites. The relationship with Gromatukha pottery is unclear but it appears technologically different.

Osipovka (Osipovskaya) *culture* – (13,000–9,500 RCYBP) illustrates the Final Paleolithic – Early Neolithic of the Lower Amur Region (Derevianko and Medvedev 2006). Today about 20 Osipovka sites are known in the vicinity of Khabarovsk and Komsomolsk cities in the valleys of Amur and Ussuri rivers. They are spread out in a southwest to northeast direction for more than 450 km. Some of the sites were investigated within multiyear projects, while others were just tested with small-scale trenches and units between the 1960s and 1990s. In many cases, the Osipovka Final Paleolithic-Early Neolithic component is just one of several cultural levels represented at the sites demonstrating the importance of their location over time.

Osipovka stone tools and pottery are of very distinctive types and may be recognized even in surface surveys. The stone toolkit is represented by bifacial points (leaf-shaped, rhomboid, lance-shaped, almond-shaped and other configurations), wood-working instruments (adzes, chisels), end scrapers, knives on blade-like blanks and on bifaces, hammers, anvils, net weights etc. These tools reflect a complex hunting-fishing-gathering economy where intensive seasonal salmon-fishing played the central role (Popov and Tabarev 2008).

Ustinovka (Ustinovskaya) *culture* – (16,000–9,000 RCYBP) is known by the big series of sites with various lithic implements in the inland and coastal parts of the Maritime Region (Derevianko and Tabarev 2006; Gillam and Tabarev 2003, 2006; Tabarev 2001). The most informative is the set of seasonal sites and workshops in the Zerkal'naya River valley. According to the position of the sites all of them were located close to the river and tributary mouths in the middle-reach which are traditionally (even today) the best places for seasonal salmon-fishing.

The Ustinovka stone toolkit includes large quantity of wood-working implements – axes, adzes, chisels, drills, scrapers etc (Figs. 4.2–4.3). All of them may be successfully used in trap and weir construction along with the building of light dwellings (shelters) for fishers. The presence of small quantities of obsidian tools and debitage in the Zerkal'naya river basin confirm the flow (trade, exchange) of exotic materials between the interior and coast. The obsidian from Peaktusan volcano was transported from the modern Chinese-Korean frontier which is about 300 km away from the Zerkal'naya river basin (Gillam and Tabarev 2004).

Ogon'ki culture (19,000–13,000 RCYBP) model (tradition) was proposed on the base of excavations of Ogon'ki-5 Site on Sakhalin Island (Vasilevski 2003). This small camp with remains of dwellings was tightly connected with the local ecological context – coastal and riverine resources along with the wide options for hunting in the inland part of the island. The Ogon'ki toolkit includes implements on blades, bifaces, microblade, and blade cores. Obsidian from the Japanese islands of Hokkaido (Shirataki locality) was used for most of the tools and was regularly transported by land or by sea during several periods of habitation on the site.

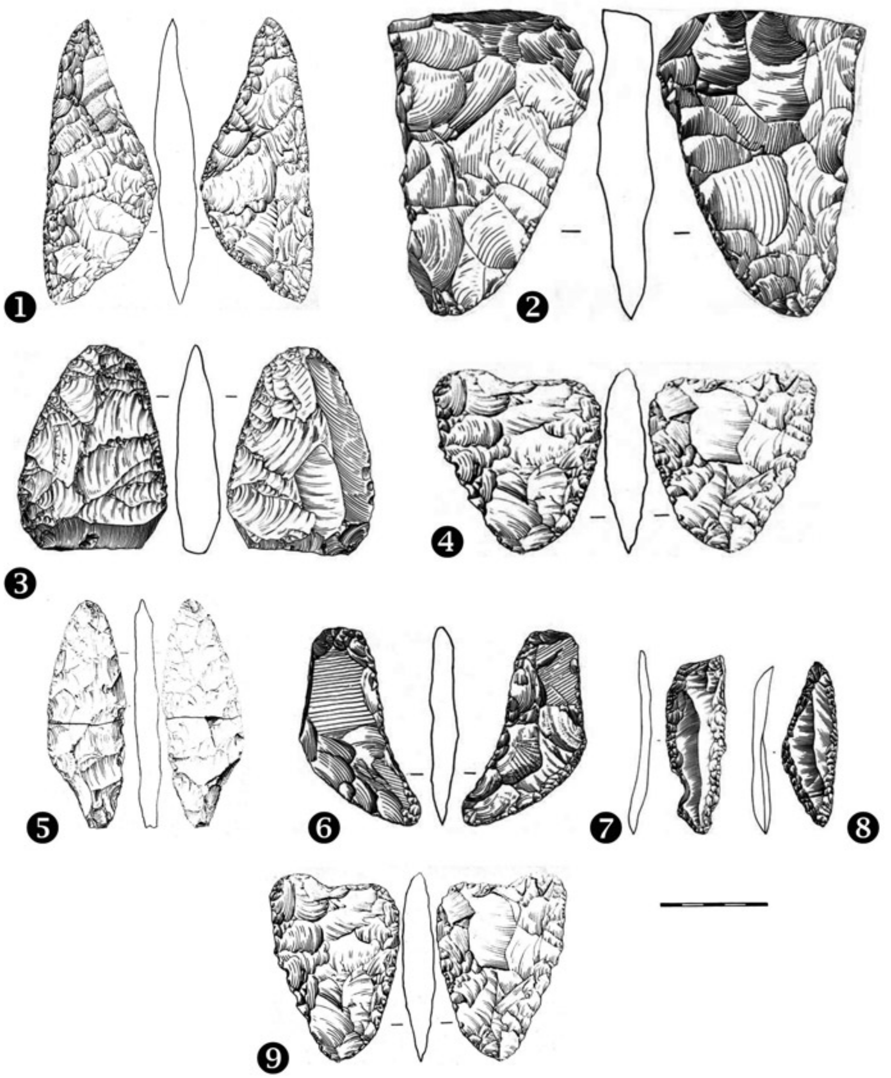

Fig. 4.2 Fishing knives of final Paleolithic cultures. *1–6, 9* – Ustinovka culture, Maritime region; *7–8* – Sokol Site, Sakhalin Island

Because of high soil acidity, about 99% of all the archaeological artifacts from the Final Paleolithic – Early Neolithic sites in the Russian Far East are stone and clay. Of course, great number of tools and examples of artwork were certainly produced from organic materials (wood, bone, antler, shells, fiber etc.). Only a handful of organic items are known and they likely represent a small portion of the original total.

Several examples of artifacts prepared with the use of marginal or facial retouch indicate the special importance of fish. Found all over the Far Eastern region

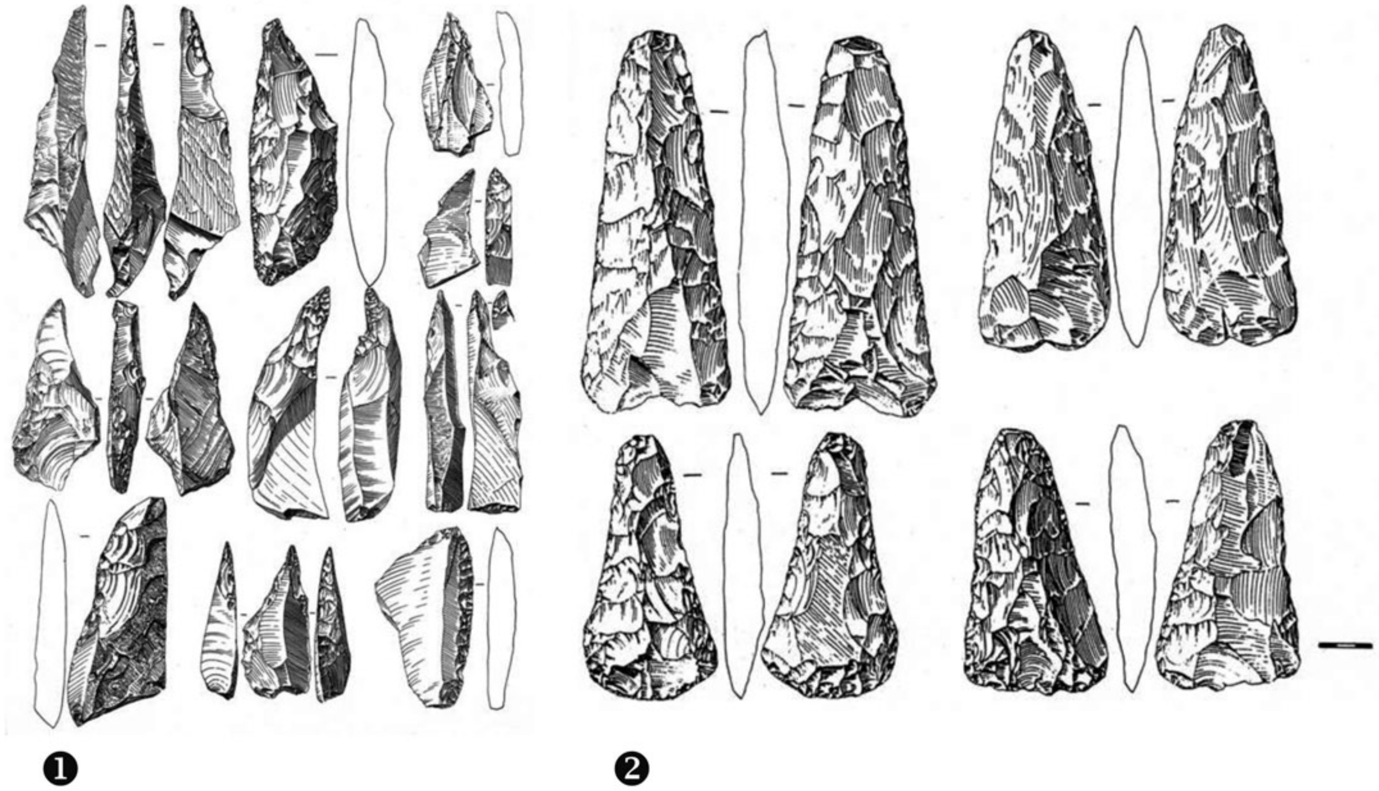

Fig. 4.3 Wood-working tools Ustinovka culture, Maritime region. *1* – Drills and gravers; *2* – axes and adzes

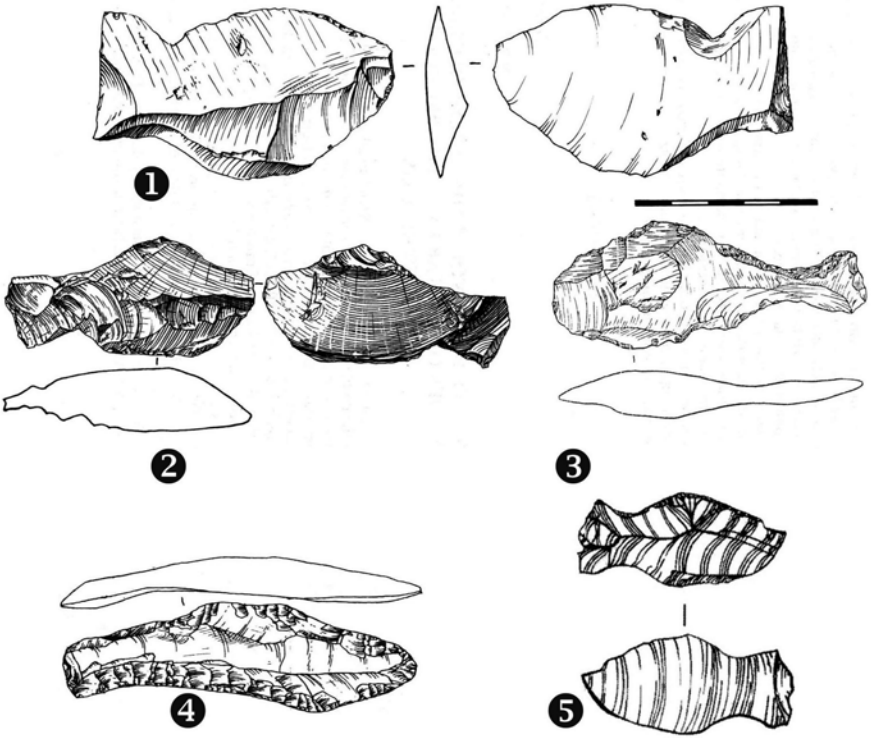

Fig. 4.4 Stone images of red fish. *1–3* – Ustinovka culture, Maritime region; *4* – Osipovka culture, Lower Amur region; *5* – Ogon'ki culture, Sakhalin Island

(Osipovka culture, Ustinovka culture, Ogon'ki culture), they represent the images of fish with typical traits of salmon (configuration, humps, color of raw material) (Fig. 4.4). Their sizes (not more than 5–7 cm long) point to the possible use as personal or family amulets, toys or details of clothes ornamentation (Tabarev 2006). Later, during the Neolithic period, fish elements occur as pottery decoration found on several sites with specific context (ritual centers-?) over the Lower Amur region. This type of pottery with extremely rich ornamentation could be for ritual use during seasonal ceremonies. Some suggest that the eyes of the faces painted on the vessels may represent salmon (Medvedev 2005) (Fig. 4.5 – *3–4*).

Discussion and Current Conclusions

During postglacial period many river mouths of rivers and small tributaries over the Northern Pacific were opening their territories for various species of fish, and among them salmon (five species) are of special interest and significance (Augerot

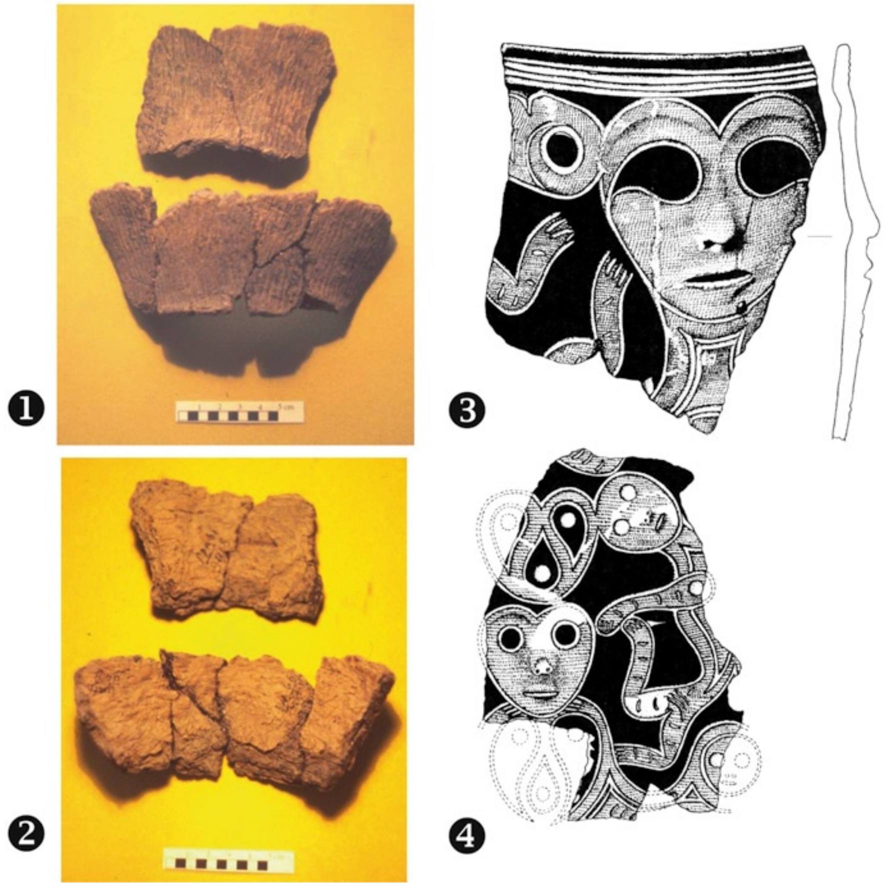

Fig. 4.5 Pottery from the Russian Far East. *1–2* – Earliest pottery, Gromatukha culture, Middle Amur region; *3–4* – Neolithic pottery with symbolical design, Lower Amur region

and Foley 2005). The change in Final Pleistocene environment after the LGM provided people in the Far Eastern region (Amur River valley, coastal zone of Maritime Region, and Sakhalin Island) with new sources of food including such outstanding option as annual salmon runs (Augerot and Foley 2005; Fobres et al. 1994). This type of seasonal activity had exceptional implications for human mobility, technological developments, and art/ritual reflections. "People of Salmon" may be archaeologically traced to the Final Paleolithic – Neolithic cultures (16,000–4,000 RCYBP) of this region and compare with similar cultures over the North Pacific Rim (Japan, Alaska, Northwest Coast, Northern California, etc.). Unfortunately, direct evidence for intensive salmon-fishing at the Pleistocene-Holocene boundary is absent due to the acidity of Far Eastern soils. Indirect evidence for the early development of salmon-fishing in the Russian Far East includes three components: (1) typical location of all the sites and its seasonal character, (2) specific tool-kit, and (3) evidence of ritual activities connected with the "red fish."

In spite of the technological differences in lithic industries which are known to archaeologists over the Far Eastern region for Final Paleolithic – Neolithic times its evolution may be well-correlated with the development of salmon-fishing activities. The Final Paleolithic is dominated by the use of wedge-shaped microcores, transversal burins, and bifaces and it may reflect the basic hunting–gathering orientation of the economy in combination with seasonal salmon-fishing.

During the Final Paleolithic – Early Neolithic Transition wedge-shaped microcores and burins disappeared almost everywhere in the region but the bifacial technique continued its evolution (bifacial cutting tools are the most important instrument in salmon-fishing gear). Novopertovskaya culture demonstrates an alternative technological decision – prismatic blade cores exploitation. This also allowed a maximum number of blanks and tools with long cutting edges.

Additional important tool types include wood-working tools which were found everywhere in the Middle and Lower Amur Regions, Maritime Region, and Sakhalin Island at the sites dated to 11,000–9,000 RCYBP. They may be connected with wide range of activities within the seasonal salmon-fishing (construction of light shelters for fishers, construction and repair of dams, traps and weirs along with the making of shelters for fish butchering and smoking). This shift in the took-kit is visible in the sites located along the rivers and other ideal places for fishing.

The early invention of pottery in the Far Eastern region (Middle Amur, Lower Amur, Japanese Islands) as early as 14,000–13,000 RCYBP also correlates with the salmon-fishing. First of all, it may be logically connected with preparation of food on the fire. Multiple by-products (oil, caviar, bone flour etc.) also required containers for storage, measuring, and transportation. According to the recent data the initial hearth of pottery-making independently appeared in the Middle Amur Region (Gromatukhinskaya culture) and spread its technological innovation first to the Lower Amur Region (about 13,000–12,000 RCYBP) (Fig. 4.5 – *1–2*) and later to the Maritime Region (11,000–10,000 RCYBP) (Zhuschikhovskaya 1997).

Another explanation of early pottery use is found in the need for bowls and cups used during ceremonies and rituals. In periods of salmon-fishing activity feasts may be connected with the beginning ("First Salmon Ceremony") and the end ("Thanksgiving Ceremony") of the annual salmon run, and require the consumption of special types of food and drink. Such ceremonies are described for North American Indians of the Northwest Coast and California, for aboriginals of Lower Amur Region, Sakhalin, and for the Ainu people in Northern Japan (Dietler and Hayden 2001; Gunther 1926, 1928; Medvedev 2005; Fobres et al. 1994).

Small amounts of salmon bones are known on Kamchatka Peninsula (Extreme Northeast of Asia) at the Ushki Lake Site. The lake itself is the place for salmon spawning and ideal position for salmon-fishing. Earliest cultural component of this site is dated by radiocarbon by 11,000–11,500 RCYBP and is represented by a series of subterranean dwellings. Small fragments of burned salmon bones (fish heads) were found in the ancient fire-places (Dikov 1993). This corresponds with the tradition recorded on Kamchatka by travelers and ethnographers in eighteenth and nineteenth centuries. Local aboriginals used to have two fireplaces in their dwellings – one for cooking and another one for ritual purposes including the "fire feeding ceremony." They would throw pieces of food (meat, fish, berries, nuts etc.) to the fire as a symbolical gratitude to the ghosts and ancestors.

According to archaeological and ethnographic records salmon-fishing specialization led to the creation of a social structure which can be described as "transegalitarian." This social phenomenon develops in highly productive territories with the possibility to accumulate resources and food in long-term storage and to redistribute it among members of the society in case of need (Dietler and Hayden 2001; Owens and Hayden 1997).

The image of salmon in the decorative arts and crafts traced over aboriginal cultures of Far Eastern and North American people was met in Final Paleolithic materials in the Far East (Amur Region, Maritime Region, and Sakhalin Island). This may be interpreted as the earliest evidence of special shamanistic practice connected with the attraction and blessing of Salmon.

We believe that archaeological materials (both – direct and indirect traces) in the Russian Far East and on the Japanese Islands support the idea of the initial origin of salmon-fishing in this part of the Pacific and its spread to the northern latitudes, including the North American coast from this center right after the LGM. This type of resource (easy to collect, rich, renewable, predictable, etc.) may play very important role in the intensity of migrations in Northern Pacific including the initial peopling of the New World from Asia.

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Chapter 5
Early Technological Organization Along the Eastern Pacific Rim of the New World: A Co-Continental View

Samuel C. Willis and Matthew R. Des Lauriers

Introduction

In this chapter, we address the current understanding of Late Pleistocene subsistence technology along the New World Pacific Coast. Artifact assemblages from these early coastal sites are here viewed as *remnant* components of more complete living technological systems. Many scholars investigating the Peopling of the New World have understandably focused their attentions on faunal remains, radiocarbon dates, and paleoenvironmental reconstructions. While clearly necessary, interpretation of early coastal human behavior, which limits itself to the study of these elements alone, leads to an ipso facto deterministic set of models to explain the initial peopling of New World Pacific coast. This determinism springs from the fact that a narrow examination of ecofactual data and the subsequent application of ecological explanatory models can potentially lead to circular reasoning, despite the demonstrated effectiveness of these models in many situations. A more explicit focus on those categories of data formed intentionally through (as opposed to being incidental byproducts of) human action will provide a perspective on the earliest archaeological record of the Americas that could be integrated with a range of different theoretical approaches.

Recently, many scholars (Roosevelt et al. 2002; Des Lauriers 2006; Erlandson et al. 2008) have begun to question not only the chronology but also the entire trajectory of early colonization of the New World landscape. Earlier views have seen the initial occupation of the Pacific coastlines of the New World as secondary to demographic expansion of populations already resident in interior terrestrial environments lying east of the cordilleras that rise like battlements along the Pacific Coast. For reasons linked to the history of research, the cultural focus of Americanist archaeologists, and possibly even politics, it has been posited that the earliest hunter-gatherers eschewed the lands bathed by the Pacific waters for millennia, and at some point during the late Pleistocene-early Holocene (LP-EH) transition, small

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bands of inlanders slowly headed west and began adapting to littoral settings. Numerous scholars have summarized the faulty rationale underlying these assumptions and have provided mounting evidence for an early Pacific coast occupation and maritime exploitation, including the likelihood of an early coastal pathway into the Americas (Fladmark 1978, 1979; Gruhn 1994; Dixon 2001; Erlandson 2001, 2002; Mandryk et al. 2001).

Here, we attempt to assess whether an early technological pattern can be identified in the archaeological record of New World Pacific sites. Multiple levels of investigation are incorporated into this assessment including typological studies, raw material studies, and relative diversity or homogeneity of the assemblages. These indicators are evaluated for LP assemblages along the New World Pacific coastline investigated to date. While we acknowledge the broad scope of these investigative levels, a more detailed synthesis of New World Pacific coast artifact assemblages involving more robust statistical testing of metric attributes and morphological patterns is in progress.

Our review of early Pacific coast assemblages is principally focused on those assemblages reliably dated to at least ca. 10,000 RCYBP, or ca. 11,500 cal BP. Those data presented in the literature as calendar years BP are transformed to radiocarbon years BP via CALIB software (Stuiver and Reimer 1993). The current population ($N = 12$) of LP-aged Pacific coastal and pericoastal sites includes a mean occupation at ca. 10,513 RCYBP (12,450 cal BP) with a range spanning ca. 10,907–10,119 RCYBP. The chronometrically supported population is suggested to represent consistent and habitual occupation of the coastline by widely distributed populations at ca. 12,000 years ago (Fig. 5.1). Note that the Los Vilos locality is not quantified due to questionable chronometric results.

The image that emerges from this examination indicates a diverse array of tool forms and manufacturing technologies used at the individual site level. This pattern is likely due to small groups sequentially adjusting their toolkits to numerous and varying environments along an expansive coastline. Yet, when viewed on a broad, co-continental scale, a synchronic consistency is apparent in the majority of the assemblages. We argue that a generalized pattern of technological organization was present along long stretches of the Pacific coastline during the initial colonization phase of the Americas. The composition of the assemblages and their proximity to the Pacific Coast suggest that the earliest peoples to settle the New World Pacific Coast were likely generalized coastal foragers implementing interchangeable, flexible technological patterns constrained by local environmental conditions.

Remnant Assemblages in Marine–Terrestrial Interface

What adaptive characteristics are reflected in early technological systems along the New World Pacific coast? According to Bamforth (1991) and Collins (1997), interpretations of subsistence that are based on a single assemblage cannot completely

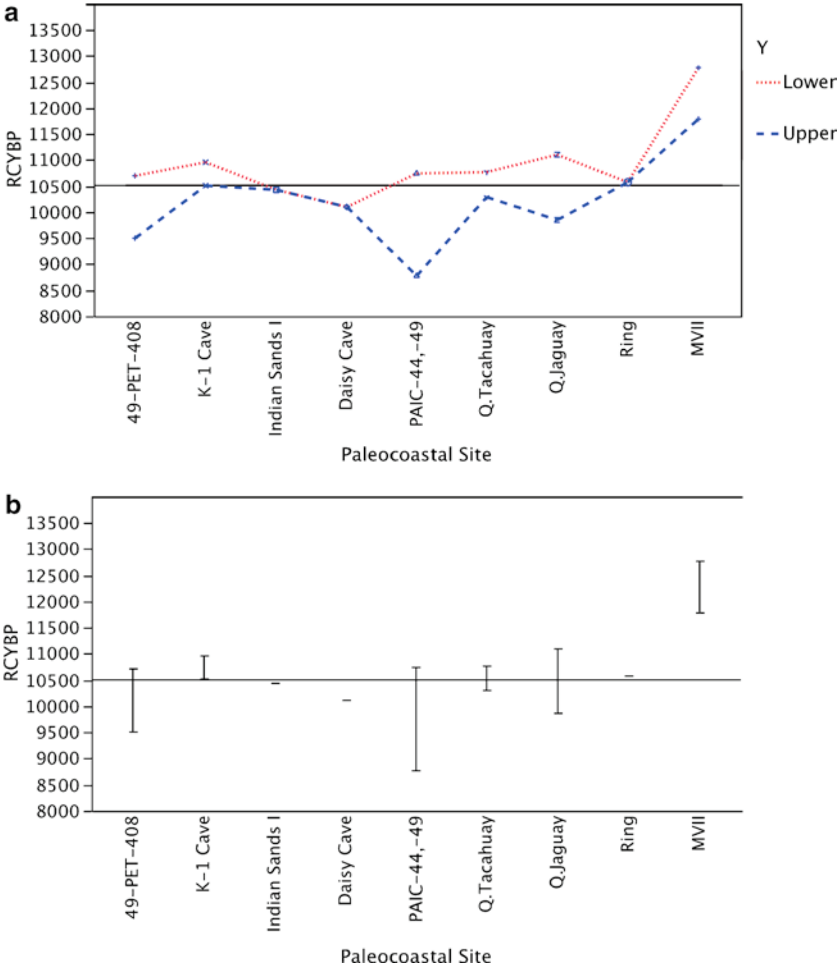

Fig. 5.1 The overlay plot (**a**) and range chart (**b**) display the chronometric record for select LP-aged sites from the New World Pacific coast

substantiate large-scale adaptive patterns because the site's assemblage is simply a reflection of the technological organization used by a group reacting to local conditions at the site level (e.g., specific season, available raw material). To provide an accurate understanding of basic adaptive patterns reflected in a technological system(s), multiple site assemblages should be compared diachronically and synchronically (Bamforth 1991; Collins 1997).

This concept is essential for any attempt to understand large-scale human events such as the initial entry into and colonization of a region as vast as the New World Pacific coast. Without proclaiming a complete adherence to an exclusively maritime colonization process, we point out that investigations of the early prehistory of the Pacific coast region have long suffered from theoretically *land-locked* biases (Carlson 1998). At the heart of the matter is the implication of many early views that initial colonizing peoples were not adapted to or regularly exploiting coastal environments. Carlson (1998) expertly traces out this process of thought from its beginnings in Old World European archaeology to its establishment in New World Pacific coast prehistory via Kroeber, and the currently dominant neo-Kroeberian configuration (Matson and Coupland 1999). Recent research along the Pacific Coast has not only challenged but also essentially demolished this paradigm.

Current evidence exists for littoral and neretic fishing and shellfish gathering at many LP-aged coastal sites. Given that the LP paleoenvironmental conditions along some sections of the coast were conducive to human habitation (Mandryk et al. 2001; Heaton et al. 1996), it is unlikely that groups moving down any coastal corridor – whether fully dedicated to marine resource harvesting or not – would have ignored the perennial resources of the ocean. We suggest that most of the earliest populations responsible for creating the coastal archaeological deposits currently under investigation were transhumant coastal foragers using a generalized and adaptable system capable of incorporating coastal, lacustrine, and terrestrial resource bases (Lynch 1971; Sandweiss et al. 1998; Fedje et al. 2004a, b; Davis 2007; Davis and Willis 2011). In some geographic contexts, such as the narrow and arid Baja California Peninsula, this pattern may have become more constrained, resulting in the development of more derived settlement and subsistence patterns at a relatively early date. Elsewhere, the persistence of settlement mobility would have militated against the development of resource-specialized toolkits or the establishment of highly localized social and human ecological patterns.

Possible Technological Systems

How can early artifact assemblages reveal whether the archaeological sites examined here were home to seasoned fishermen accustomed to the vastness of the Pacific vista, or big game hunters seeing only the edge of their world? What would the functional demands and limiting constraints be for a technological system operating within a LP period coastal environment? Bamforth (1991) and Tartaglia (1976) point out that one very obvious conditioner of technological systems will be the local environment.

An a priori assumption of early coastal subsistence technology studies in the Americas (especially North America) is that refined lithic toolkits, notably bifaces (see Cassidy et al. 2004), indicate a terrestrial orientation (Carlson 1998), whereas early coastal traditions would have required only simple, unsophisticated tools (Rick et al. 2001). Carlson (1998) opposes this view suggesting that lithic tools (e.g., pebble tools, bifaces) could easily be integrated into a maritime technology. Other researchers studying hunter-gatherers in coastal and pericoastal environmental contexts have acknowledged this fact as well (Bennyhoff 1950; Lyman et al. 1988; Kuang-Ti 2002; Des Lauriers 2006; Davis and Willis 2011). An additional consideration is that the majority of site assemblages in our sample display multifunctional qualities characteristic of a generalized (but not unrefined) toolkit and technological organization (Nelson 1991).

The majority of LP sites on the New World Pacific coast exhibit a relatively low diversity in terms of lithic artifact types or forms, whereas the bulk of the remnant assemblages are represented by the products of lithic reduction and the attendant *debitage* (Table 5.1). This situation is evident along the North American Pacific coast in particular, where lithic artifact diversity is seemingly low at the individual site level, especially if the lithic subassemblage is uncritically examined without follow-up research to determine empirically the function and use-life history of the basic element of the technological system. The seemingly low diversity of tool types at the majority of these early sites may allude to a rapid diffusion of a set of subsistence ideals, or be the result of population movement along the coast. Des Lauriers (2006) offers the latter as a possible reason for the similarities of early coastal and inland lithic toolkits in the Alta California–Baja California border region. But there may be different avenues by which to focus our views of assemblage *sameness* or assemblage *distinctiveness*. For instance, if we regard these early coastal remnant assemblages as components of larger technological systems, we may argue that assemblage diversity was in place along the LP period Pacific Coast, manifest in distinct technologies designed for specific subsistence functions. Bifacial, unifacial, and groundstone lithic technologies, as well as organic technologies consisting of bone and antler implements and fibrous cordage and netting gear, were employed by early Pacific Coast populations within a variety of microenvironmental contexts, which is suggested here to require the development of broad based organizational strategies (e.g., technological) to help insure human success within a landscape.

LP Period Sites: The Evidence So Far

On Your Knees Cave/Alaska/10,300–8,500 RCYBP

On Your Knees Cave (49-PET-408) is located on the Prince of Wales Island along the southeastern coast of Alaska. Well known for its late Quaternary faunal record (Heaton et al. 1996), the cave also includes a substantial prehistoric cultural deposit with EH and LP components (Dixon et al. 1997; Dixon 2001). Associated with the EH component are a single human burial, microcores and microblades, bifaces, macroflake cores, and additional lithic tools and debitage. Imported obsidian is present in the lithic assemblage and originates ca. 80 km northeast from 49-PET-408. Underlying the EH component is an ephemeral LP occupation that includes a small sample of lithic debitage and a single bone “awl or punch” dated to ca. 10,300 RCYBP (Table 5.1) (Dixon 2001:287).

Table 5.1 List of absence/presence of artifact types for select LP and EH assemblages along, and in proximity to, the New World Pacific coast

	49-PET-409	K-1 cave	Indian Sands I	Daisy cave	PAIC - 44–49	Las Vegas complex	Quebrada Tacahuay	Quebrada Jaguay	Ring site	Paiján complex	Amotape tradition	Los Vilos locality	Cueva Lago Sofia I	Cueva del Medio	Monte Verde II
Lithic															
Leaf-shaped			X		X					X					
Stemmed biface		X			X										
Fluted biface														X[a]	
Other biface															X[b]
Early biface/preform			X		X					X					X
Formal uniface			X		X		X[c]	X[c]		X	X		X	X	
Nonformal modified flake			X	X	X	X	X	X	X	X	X	X	X	X	X
Debitage	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Cobble tool						X				X		X[d]	X		X
Prepared macrocore										X[e]	X[f]	X[g]	X[g]		
Amorphous core			X[h]		X	X				X	X[i]	X			X
Bola stone															X
Groundstone						X				X					X
Osseous – shell															
Unipoint						X									
Bipoint															
Harpoon (toggle, etc.)									X[j]						
Fish hook					X	X									
Scraper					X	X									
Other	X[k]									X[k]					
Other organic (wood, plant, etc.)															
Fiber cordage															X
Container						X									
Watercraft	X[l]			X[l]											

Ochre/pigment		X							X
Other									X[m]
Cultural features									
Hearth	X[n]	X	X	X	X	X	X	X	X
Posthole		X		X[o]					X
Structure		X							X

[a] South American fishtail variety (Borrero 1999)

[b] Bi-pointed El Jobo-like lanceolate biface (Collins 1997, Dillehay 1999, 2000)

[c] Bimarginally retouched modified flake (Keefer et al. 1998; Sandweiss et al. 1998, De France et al. 2001)

[d] Unmodified manuport cobbles (Jackson 2003)

[e] Discoidal and single platform core varieties (Ossa and Moseley 1972; Chauchat and Pelegrin 2004)

[f] Single platform, cylindrical (Richardson 1978)

[g] Core/scraper plane. These are typically cylindrical single platform forms (Jackson 2003; Jackson and Prieto 2005)

[h] Core-on-flake or flake core (Willis 2005; Davis and Willis 2011)

[i] Multidirectional *horse-hoof* form (Richardson 1978)

[j] Bone harpoon fragments recovered in component dating between 10,575 and 8,755 RCYBP. It is likely that the specimens are associated with late Pleistocene occupation (Sandweiss et al. 1989)

[k] Antler tine or flaker (Dixon et al. 1997; Chauchat and Pelegrin 2004)

[l] Location on an island setting reveals use of watercraft (Erlandson et al. 1996; Dixon et al. 1997; Rick et al. 2001)

[m] Various wooden artifacts including a digging stick, stakes or wedges, and foreshaft fragments (Dillehay 1997, 1999, 2000)

[n] Fire-cracked rock possibly associated with a hearth

[o] Postholes are contained between strata dating between 10,800 and 10,500 RCYBP (Sandweiss et al. 1998:1832)

K-1 Cave/British Columbia/10,960–10,510 RCYBP

K-1 Cave (Fedje et al., Chapter 3) is located on Haida Gwaii, British Columbia. Two fragmentary stemmed bifaces were recovered stratigraphically situated within the skeletal remains of a single Black bear and were likely brought into the cave by the mortally wounded animal. Radiocarbon dates bracketing the stemmed biface fragments are between 10,525 and 10,660 RCYBP and between 10,510 and 10,960 RCYBP (Fedje et al. 2004a, b, Fedje et al., Chapter 3). K-1 Cave offers direct evidence that humans equipped with a stemmed biface technology hunted large mammals in a coastal setting at 10,500 RCYBP. While stemmed biface technology is documented for EH and LP sites in the interior PNW, this is the first example of its use on the coast (see Table 5.1).

Indian Sands/Oregon/10,430 ± 150 RCYBP

The Indian Sands (35CU67C) site is located on an uplifted marine terrace along the southern Oregon coast. A portion of the site includes a stratified record of LP and EH occupations, and a surficial lag of likely middle to late Holocene-aged artifacts (Davis et al. 2004; Willis 2005; Davis 2006; Davis and Willis 2011). The LP component (Component I) is associated with a single radiocarbon date of 10,430 ± 150 RCYBP on charcoal. An upper limiting bracket of stratigraphically ordered EH and middle Holocene TL assays ranges from 9,030 ± 900 to 6,440 ± 670 RCYBP (Davis 2006; Davis and Willis 2011).

Component I cultural material includes leaf-shaped bifaces, early-stage bifaces or preforms, a uniface, nonformal modified flakes, and flake cores or cores-on-flakes (c.f. Hovers 2007) (Willis 2005; Davis and Willis 2011). Lithic analysis reveals the use of multidirectional core-and-flake technology for the production of leaf-shaped bifaces, unifaces, and nonformal modified flakes (see Table 5.1). The majority of the lithic assemblage is manufactured from chert, whereas small chert nodules are available from exposed breccias on the site. Large macroflakes reduced from larger chert nodules (of unknown form) were subsequently used as single, broad-faced cores for the production of useable flakes. Additionally, use of imported obsidian from ca. 270 km inland is a direct evidence for early knowledge of toolstone sources and/or extragroup interaction. The Component I assemblage represents a generalized technological organization in an upland environment overlooking what was an extensive coastal plain at ca. 10,430 RCYBP (Davis et al. 2004; Willis 2004, 2005).

Daisy Cave/California/10,100 RCYBP

Daisy Cave (CA-SMI-261) is located on San Miguel Island, one of the Channel Islands of southern California. The site is a multicomponent shell midden with a basal date of *10,100* RCYBP (Erlandson 1994; Erlandson et al. 1996). The LP occupation is limited to a small sample of modified flakes and lithic debitage including abalone and mussel species (see Table 5.1). The upper EH-aged cultural component reveals a robust assemblage of bone bi-points, sea grass cordage, and lithic artifacts including bone bipoints. Abundant shell and fish remains were recovered in the EH component suggesting possible gorge, or hook-and-line fishing and fish net use (Rick et al. 2001).

Cerro Pedregoso and Richard's Ridge/Isla Cedros, Baja California, Mexico/10,745–8,775 RCYBP

These two sites have produced one of the most extensive samples of lithic technology from a terminal Pleistocene-early Holocene-aged coastal context in the Americas. A variety of biface forms were produced and used at these early sites, both for use as hafted knives and as projectile points. Hundreds of bifaces and biface fragments were found on the surface and excavated deposit of Cerro Pedrogroso, representing all stages of reduction, from initial bifacing of blocks, to "roughed-out" blanks, to bifacial preforms, to finished and broken points and knives. The diversity in the size of performs and finished bifaces is interesting, given the recovery of small, well-thinned bifaces in association with larger format, leaf-shaped and stemmed examples. The faunal data (which include 18 taxa of fish, several varieties of seabirds, sea mammals, sea turtles, and a few rabbit bones) suggest the largest of these fauna were hunted with stone-tipped weapons. There is a near absence of large terrestrial fauna in the archaeological assemblage (see Des Lauriers 2011) despite the presence of native Cedros Island Mule Deer (*Odocoileus hemionus cerrosensis*). Given the abundant evidence for the exploitation of marine fauna, the dearth of large terrestrial fauna is noteworthy.

The raw material selection inferred from an examination of the lithic artifacts from both Cerro Pedregoso (PAIC-44) and Richard's Ridge (PAIC-49) merits some discussion. The Cerro Pedregoso conglomerate deposit and the Punta Prieta quartz veins are the source for 90% of the tool stone recovered from PAIC-44. There is a complete absence of obsidian, which is not surprising, since it is unlikely that the long-distance trade networks that operated late in prehistory would have been established during the earliest phases of colonization. However, the absence of exotic toolstone suggests more limited regional mobility for the earliest Isla Cedros populations than that inferred for the people occupying Indian Sands, Oregon, for example. More surprising is the dearth of local island microcrystalline stone, so common in later deposits. Only eight lithic items (five flakes, one flake tool, and two hafted knives) – from a sample of over 3,000 – are from material that is clearly nonlocal in an immediate sense.

Centripetal cobble core technology is present in archaeological components that date at least as early as 10,100 RCYBP. In addition, the production of a large quantity of unifacial tools, largely in a format consistent with use as side and end scrapers, also is apparent from both surface and excavated contexts. Unifacially flaked tools made of clamshell were found in surprising numbers[1] at both PAIC-44 and PAIC-49 in surface and excavated contexts. These clamshell tools are a significant percentage of the formed artifacts from PAIC-44 (18% from unit 2, all levels), but have not been recovered or observed from sites dating later than 8,300 RCYBP. The abundance of so many inferred "scraping" tools provides an indication that the site was a base camp where both manufacturing and processing activities occurred, rather than a short-term camp occupied for a limited range of activities. A great deal of tool production occurred at PAIC-44, and many resources brought from at least 2 km away were being processed there. The residents ranged far afield from this location to a variety of distinct harvesting zones and returned to process the resources at the camp.

Quebrada Tacahuay/Peru/10,770–10,290 RCYBP

Quebrada Tacahuay is a LP shell midden exposed in the wall of an arroyo on the south coast of Peru. Dates for the early occupation range from 10,770 to 10,290 RCYBP on charcoal (De France et al. 2001). Faunal remains are rich in adult seabirds followed by marine fish, namely anchovy and herring, and shellfish (Keefer et al. 1998; De France et al. 2001). The presence of small schooling fish species is suggested as an indirect evidence of a sophisticated littoral or neretic netting technology. Terrestrial gastropod and mollusk remains were recovered in hearth feature fill. The lithic assemblage is comprised of one formal modified flake (bimarginally retouched), nine modified flakes (unimarginally retouched), and debitage ($N=12$). The assemblage is similar in composition and material as the Ring Site, located approximately 20 km to the north (Keefer et al. 1998; see below). Additionally, a single polished marine mammal bone tool was recovered (see Table 5.1). Quebrada Tacahuay is suggested to represent a specialized marine extraction and processing camp focused on seabirds and, to a lesser extent, small schooling finfish, shellfish, and marine mammals (De France et al. 2001).

Quebrada Jaguay (QJ-280)/Peru/11,105–9,850 RCYBP

Quebrada Jaguay is a LP-EH site situated on an alluvial terrace of the Quebrada Jaguay two kilometers from the modern Pacific Ocean coastline and was located approximately seven to eight kilometers from the coast during the time of the initial occupation (Sandweiss et al. 1998). Investigations at QJ-280 recovered a high

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[1] For example, 12 complete or fragmentary clamshell tools were found in layer D of unit 2 at PAIC-44, along with 17 identifiable pieces of clamshell debitage.

frequency of drum fish and marine mollusks. A small sample of rodent remains were recovered but are suggested as being noncultural in origin. The EH component includes cordage and , is considered to be a direct evidence for net fishing technology when coupled with the recovery of abundant drum fish remains. The LP component comprises lithic debitage and few tools – mainly modified flakes with bifacial retouch (see Table 5.1). This assemblage shares technological similarities with Quebrada Tacahuay. No evidence for bifaces was recovered. Lithic raw material includes extralocal petrified wood and obsidian. Trace analysis on the obsidian reveals Alca in the central Andes as the source, which is located ca. 130 km from the site (Sandweiss et al. 1998).

Site QJ-280 includes EH-aged posthole features associated with a structure floor and hearth. The structure is approximately five meters in width, circular, and semisubterranean, suggesting early pithouse construction. An additional series of circular postholes capped by LP-aged sediment dating between 10,800 and 10,500 cal BP (9,500–9,350 RCYBP) indicate a possible LP-aged structure. Other sites including EH-dated postholes in the region have been observed by Sandweiss et al. (1998). Although no additional LP-aged sites with these characteristics have been observed in the region, it is possible, given the likely LP-aged postholes at QJ-280, that this same EH semipermanent residential pattern may have its roots in the terminal Pleistocene. Quebrada Jaguay is suggested by Sandweiss et al. (1998) to reflect an EH and LP-aged transhumance pattern, similar to that as described for northern Chile by Lynch (1971).

Ring Site/Peru/10,575 RCYBP

The Ring Site is a deeply stratified shell midden located on an uplifted marine terrace less than one kilometer from the modern coastline of Peru. Occupation of the Ring Site ranges from 10,575 to 5,060 RCYBP (Sandweiss et al. 1989). The earliest component includes an ephemeral occupation with a small sample of lithic debitage, with no evidence of bifacial technology. Instead, bone tools including composite fish hooks and harpoon fragments are consistently present throughout the midden, suggesting that organic technology was important (see Table 5.1). A single bone harpoon head is bracketed by sediment with dates ranging from ca. 10,575 and 8,755 RCYBP. It is likely that the nonformal modified flakes and debitage were used to manufacture a more specialized, organic toolkit; an important South American trait has been suggested by some (Bryan 1973; Stothert 1985). The presence of composite fish hooks suggests that hook-and-line fishing was practiced by the occupants throughout the site's duration (Sandweiss et al. 1989). Subsistence appears to be based mainly on marine resources, and is similar to nearby sites Quebrada Tacahuay and Quebrada Jaguay. There is little evidence to support the harvesting of small schooling species. Terrestrial faunal remains recovered at the site are suggested to have originated from a postdepositional and noncultural context.

Los Vilos Locality: Quebrada de Quereo and El Membrillo-Quereo/Chile/13,500–11,000 RCYBP

Sites Quebrada de Quereo and Quebrada El Membrillo are located in arroyos cutting into marine terraces within the Los Vilos region of coastal Chile. Each site includes extinct megafauna purported to be associated with lithic tools; it has not been proven whether there is a direct association. At Quebrada El Membrillo Jackson (2003) reports *Mylodon* sp. dated to 13,500 ± 65 RCYBP; and paleolama remains are likely associated with unmodified manuport cobbles, cores, modified flakes, *planes* (likely core-tools), and over seventy pieces of lithic debitage (see Table 5.1) (Jackson 2003). Similarly, excavations by Nunez et al. (1994) at Quebrada de Quereo suggest lithic debitage is associated with paleolama and *Equus* sp., ranging in age from ca. 11,400 to 9,370 RCYBP. While association of artifacts and extinct megafauna is questionable for both sites, these results may represent the hunting of paleofauna in a coastal setting, if the interpretation is correct.

Monte Verde II/Chile/12,780 ± 240 and 11,790 ± 200 RCYBP

Monte Verde II (MV II) deserves recognition in this chapter, as it does in any discussion concerning early New World occupation, based on the fact that (1) it is a pericoastal site, (2) a portion of the lithic raw material assemblage recovered at the site, in the form of water-rounded cobbles, was transported to the site from the Pacific coast, and (3) multiple species of flora were found, including four types of seaweed imported from the Pacific coast, and *45 other plant species from inland forests and wetlands* (Dillehay et al. 2008:785). MV II places humans along the Pacific coast, as far as 41° south latitude, between 12,780 ± 240 and 11,990 ± 200 RCYBP (Dillehay and Pino 1997; Dillehay 1997, 1999), and reveals an extremely well-preserved technological system that was implemented in coastal and interior forested environments during the LP. Excellent organic preservation at MV II lends support to ideas proposed by Bryan (1973) and Richardson (1978) regarding an early emphasis on organic technologies, as the robust organic bone and wood tool assemblage at MV II is a testament to the limited role that the lithic assemblage played in the site occupants' technological system. Aside from a few projectile points and an early stage biface, the lithic industry consists mainly of modified flakes, cobble tools, groundstone, bola stones, and debitage (Collins 1997; Dillehay 1997, 1999). Organic implements including wooden stakes, hewn timber, fiber cordage, wooden shafts, a wooden digging stick, and other items reveal an extreme diversity in technology (see Table 5.1). Also present at MV II are the rarely preserved residential and specialized structures revealing the likelihood of semipermanent to permanent occupation of the site.

Other Notable Sites

Ultima Esperanza Sound/Magallanes, Chile/≥12,390 ± 180–9,500 RCYBP

Brief mention should be made of two cave and rockshelter sites located in the Ultima Esperanza Sound region of southern Patagonia; Cueva Lago Sofia 1 and Cueva del Medio respectively (Borrero 1999).

Cueva Lago Sofia 1, which includes the remains of ground sloth, horse, and guanaco in association with hearths and lithic material, was arguably dated to ca. 11,570 ± 60 RCYBP (Borrero 1999). The lithic assemblage includes formal unifaces, nonformal modified flakes, and a discoidal-like core (see Table 5.1). No bifaces have been recovered at the site. Subsequent redating from multiple samples of the Period I “Paleoindian” component suggests initial occupation of the cave between 10,710 ± 70 and 10,140 ± 120 RCYBP (Jackson and Prieto 2005).

Cueva del Medio (ca. 11,200 and 9,500 RCYBP) includes lithic material and cultural features associated with LP and modern faunal species. A controversial date of 12,390 ± 180 RCYBP was obtained from a hearth that also produced a date of 10,500 RCYBP. Borrero (1999) describes the lithic inventory as including fluted fishtail bifaces, sidescrapers, and other lithic specimens (see Table 5.1).

Paiján/Peru/10,800–8,500 RCYBP

The Paiján tradition is known mainly for its hallmark stemmed and needle-nosed Paiján projectile point (Ossa and Moseley 1972; Chauchat and Pelegrin 2004; Dillehay 1999; Dillehay et al. 2003). The tradition is associated with hundreds of sites in a restricted area along the northern coast of Peru spreading east to the coastal plain and reaching as far as the western Andean foothills. Chronology of the Paiján tradition ranges in age from ca. 10,800 to 8,500 RCYBP. The earliest Paiján period sites are typically associated with large lithic scatters and hearths, little organic tool preservation, evidence for multiple episodes of reoccupation (i.e., palimpsests), and transhumant use of the coast and interior coastal plain (Chauchat and Pelegrin 2004; Dillehay et al. 2003). The Paiján toolkit includes bifacial preforms, various scrapers made on flakes, denticulates, limaces, or slugs (see Chauchat and Pelegrin 2004:104, Fig. 56.1), occasional groundstone, cobble tools, amorphous flake-and-core forms, and formally prepared core forms including discoidal and single platform varieties (see Table 5.1) (Ossa and Moseley 1972; Chauchat and Pelegrin 2004). The hallmark Paiján artifact includes the narrow-to-expanding stemmed projectile point characterized by a triangular midsection constricting to a very narrow distal point (Ossa and Moseley 1972; Chauchat and Pelegrin 2004). Chauchat and Pelegrin (2004) suggest that the stemmed Paiján point is designed for use in marine habitats and is derived from an earlier fishtail point tradition farther east in the interior.

Las Vegas/Ecuador/10,800–6,600 RCYBP

While the Las Vegas culture, which is comprised of numerous sites on the Santa Elena Peninsula, is described in detail elsewhere (see Stothert 2011) brief mention is made because of its associated technological patterns. The recovered faunal and plant remains suggest the reliance on local resources from ocean, riverine, terrestrial, and mangrove swamp environments (Stothert 1985). Las Vegas technological organization included the use of bone, shell, and lithic material. Bone tools included three bone points that are suggested to be projectile points or fish gorges. A single bone spatula is suggested to be possibly a net rigging or clothes-making tool (Stothert 1985). Mollusk, univalve, and conch shells were transformed into small containers, scoops, whistles, and beads. Lithic tools were comprised mainly of modified flake and cobble tool forms. Chert flakes are minimally modified along their edges, with no evidence for formal unifacial or bifacial technology. Evidence of container technology is suggestive of an early sedentary residential system along the Ecuadorian coast (Stothert 1985:621).

Amotape/Peru/11,200–8,125 RCYBP

The Amotape tradition is based on approximately 10 pericoastal sites associated with tar seeps at the base of the Amotape Mountains on the Mancora Tablazo of the northern coast of Peru (Richardson 1978; Dillehay 2000). Amotape sites range in age from 11,200 to 8,125 RCYBP (Richardson 1978). The lithic assemblages are composed entirely of locally derived quartzite and chalcedony, and include notched and multi-pointed denticulates, modified flakes, and multidirectional and other prepared core forms with no evidence of bifacial technology (see Table 5.1). Richardson (1978) believes that the Amotape unifacial tradition is a portion of a larger organic-based technological system, including the use of organic projectiles that would have allowed early mobile humans to adapt more easily to multiple environments (Bryan 1973; Richardson 1978).

Discussion

Raw Material

The majority of early coastal sites described here contain lithic assemblages that are dominated by raw material derived from proximal source locations, often without apparent preference for high-quality stone. The physical configuration and fracture properties of raw material have a clear, immutable effect on the structure of a toolkit. As a reductive process, the manufacture of lithic tools cannot violate these preexisting constraints, regardless of the skill of the knapper. Lesser quality toolstone has traditionally been thought to be suited only to the replication of nonformal (i.e., expedient) toolkits, while high-quality material is seen as less constraining and an integral aspect of highly formalized tool designs (Andrefsky 1994a, b). For instance, Amotape lithic assemblages are largely comprised of nonformalized modified flakes manufactured nearly exclusively from local quartzites (Richardson 1978). Yet assemblages from the early Baja California Peninsular sites demonstrate that even difficult-to-work toolstone can produce refined, formalized tools.

In contrast to this localized pattern of self-sufficiency, evidence for importation of high-quality materials of nonlocal origin does exist at some early coastal sites. For example, the Indian Sands site in Oregon contains imported high-quality obsidians, and Quebrada Jaguay in Peru includes high-quality obsidian and petrified wood obtained from great distances. While the Indian Sands obsidian is typical of imported high-quality material (i.e., limited to the manufacture of formal tools), imported material at Quebrada Jaguay is used in the manufacture of nonformal modified flakes. This difference has possible implications for early technological organization along the New World Pacific coast. That is to say, raw material selection and toolkit composition may be attributed to a *neutral theory* (sensu Brantingham 2003) in which local raw material for the majority of the early coastal sites is procured on encounter-based forays, and the quantity and diversity of tool types and raw materials are the result of the amount of raw material an individual can physically transport. Morphological changes are suggested to occur within the toolkit as local materials, and the resulting tools manufactured from these newly acquired materials, are continually integrated into the existing toolkit (Brantingham 2003).

If a transhumant strategy (i.e., a mobile, likely seasonal use of diverse microenvironments within a larger landscape) existed along the LP Pacific coast, the archaeological record should contain evidence of residential mobility, involving movement from the coast to the interior coastal plain and uplands, and back again. This pattern may have facilitated movement of high-quality material to sites such as Indian Sands and Quebrada Jaguay. Not unsurprisingly, locations where travel and transport costs would have been prohibitive, such as island settings, display very little evidence of raw material importation during the initial colonization phase.

Technological Trends

Bifacial technology appears to play an important role in the small sample of LP technologies recovered from North American Pacific coastal sites. Indian Sands and PAIC-44 and PAIC-49 include foliate and stemmed bifaces that were used in conjunction with flake-core technology and the production of both formal and nonformal flake tools. While flake-on-core (c.f. Hovers 2007) technology is present at Indian Sands, only the Isla Cedros sites appear to contain a well-developed unifacial and centripetal core industry (Des Lauriers 2006), which may link the early Peninsular traditions to those farther south on the Latin American Pacific coast. The stemmed biface fragments recovered in K-1 Cave are a direct evidence of a LP-aged stemmed point technology associated with terrestrial mammal hunting in a pericoastal environmental context. Daisy Cave includes evidence of a unifacial flake and core technology that was employed in the production of nonformal modified flakes. So far, direct dating of these sites has demonstrated the simultaneous practice of a stemmed and foliate projectile point technology and a unifacial technology along long stretches of the Pacific coast during the terminal Pleistocene.

Also noteworthy is the recovery of fluted bifaces along the Pacific coast; however, the sample is minimal and includes no stratified or chronometrically dated sites (Moratto 1984; Erlandson 1994; Rick et al. 2005; Des Lauriers 2006). Although there is little we can learn from the discovery of isolated fluted points from surficial contexts, these data, at face value, suggest Paleoindians may have had only an ephemeral occupation along the New World Pacific coastline. While the recovery of fluted bifaces from the Oregon and California coast have in the past demanded little consideration of a possible earlier occupation (Erlandson 1994; Rick et al. 2005), a recent redating project of accepted Clovis occupations throughout North America has resulted in demonstrable evidence that Clovis fluted biface technology may not predate 11,050 RCYBP and probably continued to no later than 10,800 RCYBP (although Folsom and eastern North American fluted technologies continue to ca. 10,200 RCYBP or later) (Waters and Stafford 2007). As we have shown, multiple New World Pacific coast sites without fluted bifaces clearly predate, or are contemporaneous with, the Clovis technological tradition.

Our estimates place four technological strategies along the South American Pacific coast during the LP: organic projectile points/harpoon heads, bifacial stone tools, unifacial stone tools (i.e., unifacially and bifacially retouched flakes), and, fibrous netting/cordage. A reliance on unifacial lithic technologies and organic tools is apparent on the north coast of Peru and central coast of Chile. The continuing argument of a preprojectile unifacial *tradition* has yet to be resolved (Lanning 1970; Bryan 1973, Hurt 1977; Richardson 1978; Dillehay et al. 1992; Dillehay 2000; Scheinsohn 2003). However, bifaces were undoubtedly used by early South American populations based on Scheinsohn's (2003) observation that debitage analyses at some "unifacial" sites has positively identified the presence of bifacial thinning flakes. It is likely the unifacial tradition was simply part and parcel of a technological organization containing a high degree of organic implements, including an emphasis placed on wooden or bone and antler weaponry. This situation is recorded in numerous ethnographic contexts, including the Cocopa of Baja California, Mexico. The Cocopa relied almost exclusively on wooden projectile points hardened by fire for projectiles in hunting and fishing (Kelly 1977).

Lithic technologies traditionally associated with an inland subsistence adaptation are present along the Pacific coast of the Americas during the LP; it is unlikely that cultures using these technologies were oblivious to the economic potential of coastal waters. Early coastal sites such as PAIC-44 and PAIC-49, the Ring Site, Quebrada Jaguay, Quebrada Tacahuay, Daisy Cave, and some Paiján sites include lithic implements in direct association with marine resources. The composition of the lithic assemblages within this macro-marine–terrestrial interface is rather homogeneous, and inclusive to a generalized technological organization, suggesting use of these toolkits in both environmental contexts. Therefore, it is postulated that the overall pattern that emerges from the LP-aged New World Pacific coast archaeological record reflects the presence of highly mobile and transhumant coastal foragers implementing a generalized technological organization along the Pacific coast and adjacent interior coastal plains and uplands.

Conclusion

Here, we suggest that early populations of the New World Pacific coast were equally adept at terrestrial hunting-gathering and fishing-gathering in the littoral and neretic waters (i.e., as coastal foragers), and their toolkits were manufactured accordingly. Paleoenvironments undoubtedly differed in breadth both latitudinally along the coast and longitudinally from the coastlines to the coastal plains and mountains. A generalized technological organization is an appropriate description of the lithic assemblages of the majority of sites in our early coastal sample. Rather than viewing this feature as a simplistic adaptation to the environment, we see it as an evidence for a very sophisticated interaction with a marine–terrestrial interface, and the adaptation of technology to local situations and materials. Despite the fact that the small assemblage samples of the LP-aged coastal sites do not contain highly diverse sets of artifact types, the fact that an overall pattern of diversity is found in the number of separate technologies present in early New World coastal sites suggests that LP-aged groups were interacting extensively, or at least had the ability to extensively interact, with both terrestrial and coastal environments. Future development in the study of technology applied to specific environmental contexts is needed to better interpret the range of adaptive variation reflected in the early record of the Pacific coast of the Americas.

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Chapter 6
Technology, Mobility, and Adaptation Among Early Foragers of the Southern Northwest Coast: The View from Indian Sands, Southern Oregon Coast, USA

Loren G. Davis and Samuel C. Willis

Introduction

The archaeological record of North America's earliest Pacific Coast peoples provides critical information relevant to questions of the timing, mode, and manner of the peopling of the New World. This observation is relevant whether or not the first New World peoples migrated along a coastal or interior ("ice-free corridor") route. At the very least, our knowledge of late Pleistocene and early Holocene-aged human occupation in North America's coastal zones is important for its comparative value with other global records of coastal adaptations. Current knowledge about late Pleistocene-aged human occupation of the Northwest Coast of North America is limited to only a handful of sites bearing archaeological assemblages typically comprised of only a few artifacts.

Excavations at the Indian Sands site (35CU67c), located on Oregon's southern coast, recovered a relatively large early lithic assemblage in a buried, well-stratified depositional context spanning the late Pleistocene to middle Holocene periods (Davis et al. 2004). Previous discussion of our excavations at Indian Sands has been mainly descriptive, presenting primary facts about the site's geoarchaeological context (Davis et al. 2004; Davis 2006, 2008, 2009) and lithic technology (Willis 2004, 2005; Willis and Davis 2007). In this chapter, we provide a synthesis of all available information related to the earliest archaeological components and offer new perspectives on the poorly understood issues of technological organization and regional mobility patterns among the earliest hunter-gatherers of North America's Northwest Coast (Fig. 6.1).

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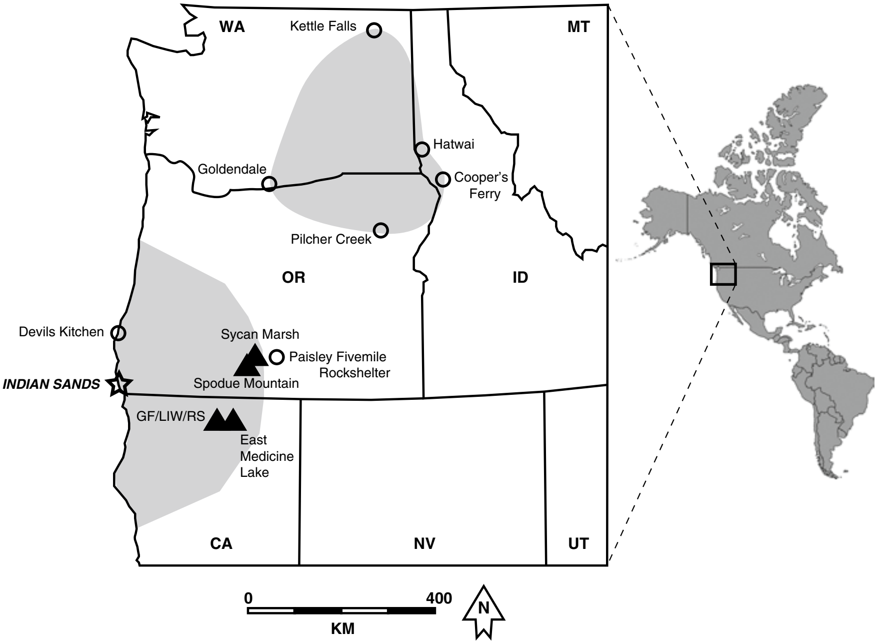

Fig. 6.1 Map showing the location of the Indian Sands site on the Northwest Coast of North America. Shaded polygon along coast marks hypothesized territorial extent of Component 1 hunter-gatherers. Triangles mark the location of obsidian sources traced to Component 1 debitage. Shaded polygon in the interior Pacific Northwest represents the hypothetical territory of Pioneer Period peoples of the Columbia River Plateau, following Ames (1988)

Stratigraphic Synthesis and Site Formation Model

The Indian Sands site lies on the southern Oregon coast approximately 8.5 km north of Brookings, Oregon. The site is situated on an uplifted marine terrace 100 m east of the Pacific Ocean and 30 m above mean sea level. The Indian Sands locality is underlain by the Jurassic Otter Point Formation (JOP), which contains cryptocrystalline silicate clasts, serpentine, blueschist, various volcanic rocks, and sandstone (Beaulieu and Hughes 1976; Monroe 1987) – all of which were technologically important lithologies used by prehistoric Northwest Coast foragers.

Archaeologically relevant stratigraphic units at the Indian Sands site are illustrated in Fig. 6.2 and include pedogenically altered eolian sediments of the 3Ab horizon, which are unconformably overlain by eolian dune sands of the 2C horizon. The age of the 3Ab horizon was initially established by Davis et al. (2004), based on its stratigraphic position above a truncated late Pleistocene-age (15,600 ± 1,800 cal BP) paleosol (4Bsb), and below the surficial 2C dune sands upon which lie a deflated lag of early Holocene-age marine shells ranging in age from 8,510–9,320 cal BP that may or may not include fossil specimens (Moss and Erlandson 1998;

Fig. 6.2 Overview photograph of excavations in progress at 35CU67c during 2003

Davis 2009; cf. Erlandson 2009). Recently, Byram (2009) has described historic accounts of prehistoric shell middens being mined and redeposited as roadbed aggregates along the Oregon coast. This process, he explains, may lead to the misidentification of shell scatters, like that at Indian Sands: "There may be instances where shell road lenses are easily mistaken for *in situ* midden deposits, particularly if roads are abandoned and revegetated. And shell road remnants themselves likely hold cultural materials other than shell" (Byram 2009:12). In light of these new considerations, we are now hesitant to use Moss and Erlandson's (1998) shell dates. Nevertheless, the chronostratigraphy presented by Davis et al. (2004) stands alone without these shell ages, as explained below. Fragments of charcoal from undisturbed sediments were found in direct stratigraphic association with lithic debitage and were adhering to fragments of fire-cracked rock in the lower part of the 3Ab horizon, ca. 10 cm above the 3Ab-4Bsb contact. These charcoal fragments returned an AMS age of 10,430 ± 150 RCYBP (12,799–11,819 cal BP @ 2 sigma) and are considered to reflect the timing of cultural activity related to cooking or the use of a warming hearth.

During excavations conducted in 2003, a series of four thermoluminescence (TL) samples were collected from the 3Ab horizon in excavation Unit F to test the site chronostratigraphy presented by Davis et al. (2004). These TL samples returned ages between 9,030 ± 900 cal BP and 6,440 ± cal BP (Table 6.1) (Davis 2006, 2008, 2009). In a depositional context in which sediments accumulate slowly and can be subjected to limited vertical mixing, the use of TL dating may reveal when a stratigraphic unit was completely buried and no longer subject to the processes of

Table 6.1 Stratigraphic distribution of cultural components and their associated artifact assemblages by excavation unit

Unit (cm below datum)	Horizon	Cultural component	Chronometric ages	Debitage	Tools	Lithics (*N*)	Fire-cracked rock
A,C,D,E,F,K,L (0)	2C[a]	3	Lagged deposit potentially spanning early Holocene through late Holocene; associated with questionable shell ages of 7,790 ± 70 year BP; 8,150 ± 120 year BP; 8,250 ± 80 year BP (Moss and Erlandson 1998; cf. Davis 2009)	1,217	13	1,230	34
Subtotal		3		1,217	13	1,230	34
A (0–50)	U3Ab[b]	2		269		269	
D (0–42)	U3Ab	2		211	4	215	26
E (0–32)	U3Ab	2		209	1	210	13
F (0–67)	U3Ab	2	[c]6,440 ± 670 cal BP @ 17 cmbd [c]6,950 ± 810 cal BP @ 27 cmbd [c]8,460 ± 960 cal BP @ 37 cmbd [c]9,030 ± 900 cal BP @ 52 cmbd	734	6	740	24
K (0–22)	U3Ab	2		306		306	11
L (0–32)	U3Ab	2		366	1	367	14
Subtotal		2		2,095	12	2,107	88
A (50–70)	L3Ab[d]	1	10,430 year BP (12,930–11,690 cal BP) @ 70 cmbd; (^{14}C date on wood charcoal)	61	2	63	7
D (42–62)	L3Ab	1		52	1	53	4
E (32–52)	L3Ab	1		98	3	101	8
F (67–87)	L3Ab	1		103	2	105	8
K (22–52)	L3Ab	1		275	3	278	15
L (32–52)	L3Ab	1		217	1	218	14
Subtotal		1		806	12	818	56
Total				4,118	37	4,155	176

[a] 2C = Surface; [b] U3Ab = Upper 3Ab deposit; [c] Thermoluminescence assays; [d] L3Ab = Lower 3Ab deposit

bioturbation. As sediments are gradually added to the site through time, this zone of bioturbation is incrementally elevated, and deeper portions of the deposit no longer receive light-exposed sediments. Once a deposit achieves this level of stability, its sediments begin to accumulate radiation in the absence of light. Thus, in the context of the site formation processes described above, a TL date from the 3Ab horizon indicates when that portion of the site was fully buried and no longer influenced by bioturbation. On such a basis, these TL age estimates provide minimum limiting ages, since the timing of their sedimentation must be older than their associated TL age. While this dating technique does not have the same potential level of accuracy that radiocarbon dating offers, TL analysis allows us to state confidently that the archaeological materials associated with a TL-dated sediment sample must be older than its TL age. Knowing the TL age of a stratigraphic layer in an archaeological site provides a means for critically evaluating the validity of other chronometric or relative dates. Thus, the TL and radiocarbon chronology from the 3Ab horizon indicates an internally consistent chronostratigraphic framework and supports the initial interpretation made by Davis et al. (2004) that early hunter-gatherers occupied Indian Sands during the terminal Pleistocene.

Cultural Components

In consideration of the site's temporal framework, archaeological materials associated with the 3Ab horizon can be divided into late Pleistocene and early Holocene cultural components. The 3Ab horizon thins and eventually disappears from profiles to the west of Unit F due to landward erosion of unconsolidated deposits. Through time, this process has deflated the upper portion of the 3Ab horizon, creating a lagged deposit of cultural material that covers the surface of the site. Because the 3Ab horizon lacks internal unconformities and accumulated gradually, based on the position of TL dates, we consider cultural materials recovered from the lower 20 cm of the 3Ab horizon to represent late Pleistocene-age site use and these cultural materials are parts of Component 1. Cultural materials recovered from 3Ab sediments above the bottom 20 cm probably date to the early Holocene and are grouped into Component 2. Cultural materials recovered from the surface of the site and from within the 2C sands are classified as Component 3. Cultural materials and marine shells scattered on the surface of the 2C sands to the west of our excavation units were not used in this study.

Figure 6.3 shows the stratigraphic distribution of cultural components at 35CU67c. Component 3 is a deflated layer of lithic tools, debitage, and burned shell. The TL ages associated with Component 3 are middle Holocene-aged to the east, in the area of excavation unit F. Deflation probably exposed and lagged out early Holocene-aged and later cultural materials on surfaces to the west, in the vicinity of excavation unit A. Considering that the 3Ab horizon has been completely deflated along the site's western edge, a lag of late Pleistocene through middle Holocene-aged cultural materials may be present at the 2C-4Bsb boundary.

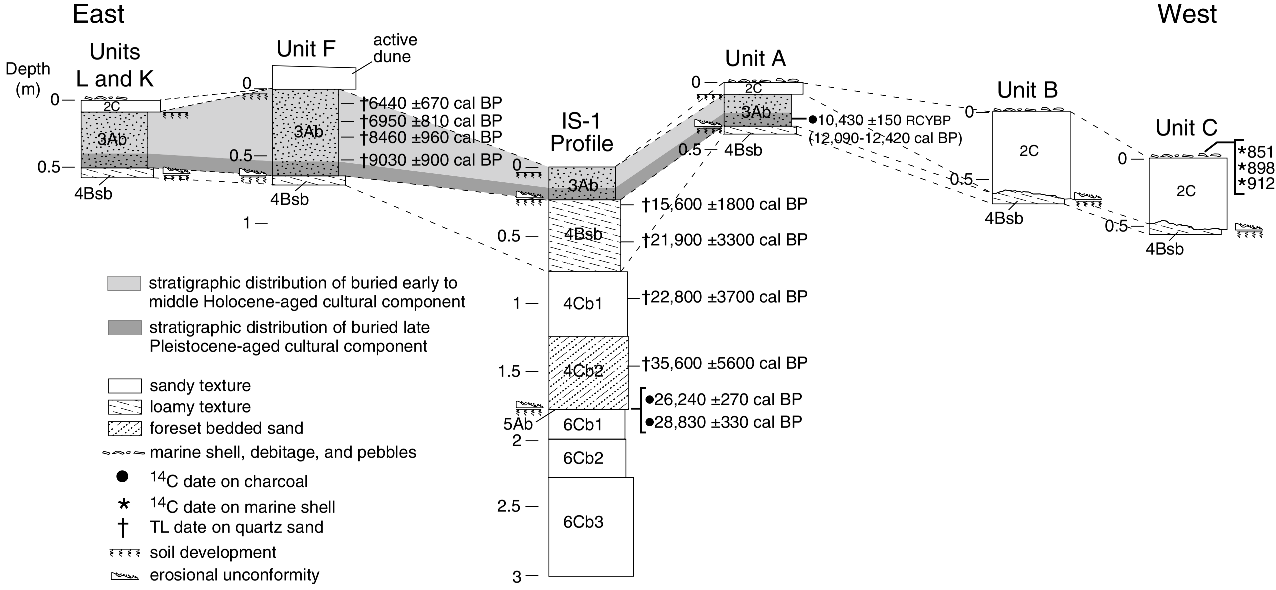

Fig. 6.3 Stratigraphic correlation along east-west axis through 35CU67c

Although we report our study of Component 3 lithic artifacts, we question the utility of this component as an analytical unit because it may contain archaeological materials spanning the early to late Holocene periods in areas east of excavation unit A, and also because it may include redeposited cultural materials historically mined from a shell midden and used as road bed aggregate (Byram 2009) in areas to the west of unit A. For these reasons, our following discussion largely focuses on the archaeologically intact Component 1 and 2 assemblages.

Component 3 includes a total of 1,217 pieces of lithic debitage, 13 tools, and 34 fragments of fire-cracked rock (Table 6.1). The tool assemblage includes a relatively high frequency of finished bifaces ($n=3$, or 23%) and nonformal modified flakes ($n=5$, or 39%). Two of the fragmentary finished bifaces retain partial bases and midsections. The forms of these two bifaces appear to be willow-leaf-shaped (i.e., foliate) with a slightly contracting basal margin, or are stemmed with weak and rounded shoulders. The remaining finished biface fragment is a proximal basal portion and is further indistinguishable in form. Two formal modified flakes were recovered in the 2C horizon and are considered to be end scrapers. The two end scrapers are circular in plan view, tabular in cross section, and exhibit patterned retouch along approximately 90% of the circumference of the flake margin. The retouched margin terminates at the platform area of the original flake (a feature most likely for hafting). The direction of edge retouch originates from the lateral surface of the flake. Core technology in the Component 3 assemblage includes two large multidirectional flake cores and is very similar to the core technology recovered from Component 1. The Component 3 toolkit displays a focus on the manufacture of finished bifaces and formal and nonformal modified flakes, which comprise 53% of the tool assemblage (Table 6.2). The Component 3 debitage assemblage is comprised of JOP cryptocrystalline silicates (CCS) ($n=1{,}188$, or 97.6%) and imported obsidian ($n=29$, or 2.4%). Debitage analysis reveals an emphasis on late-stage tool production and maintenance. Typologically, the majority of the flakes were broken flakes and flake fragments (*sensu* Sullivan and Rozen 1985). Platform remnant-bearing flakes retained multiple dorsal scars and platform facets, largely produced during bifacial thinning. Aside from the formal modified flakes, the Component 3 tool and debitage assemblage is very similar in composition and morphology to the two underlying cultural components (Willis 2004, 2005).

The Component 2 artifacts are contained within the upper portion of the 3Ab horizon (Fig. 6.3). Component 2 represents cultural occupation during the early and middle Holocene, the temporal context of which is provided by four TL assays that returned ages from 8,460 ± 960 cal BP to 6,440 ± 670 cal BP (Table 6.1). The artifact assemblage from Component 2 includes 2,095 pieces of lithic debitage, 12 tools, and 88 fragments of fire-cracked rock. Use of locally available JOP CCS was overwhelmingly favored ($n=1{,}192$, or 95.1%), with little obsidian debitage also present ($n=103$, or 4.9%). Late-stage tool production and maintenance is evident in the Component 2 debitage assemblage. The majority of the debitage population is contained in the broken flake and flake fragment category; there is a high frequency of bifacial thinning flakes, and the platform remnant-bearing flakes retain multiple

Table 6.2 Summary and frequency of formal tools recovered in all soil horizons at 35CU67c

Horizon/component	Lower 3Ab/C1								Upper 3Ab/C2								Surface 2C/C3										
Unit	A	D	E	F	K	L	(*N*)	(%)	A	D	E	F	K	L	(*N*)	(%)	A	B	C	D	E	F	G	K	L	(*N*)	(%)
Tool types																											
Early biface			1	1	1	1	4	33		2		2		1	5	42									1	1	8
Finished biface		1			1		2	17				3			3	25			3							3	23
Flake core[a]																											
Multidirectional	1			1			2	17											2							2	15
Modified flake																											
Formal										1					1	8			1		1					2	15
Nonformal	1		2	1			4	33		1	1	1			3	25	1		3			1				5	39
Sub-total	2	1	3	3	2	1	12	100		4	1	6		1	12	100	1		9		1	1			1	13	100

[a] Flake core as described by Hester and Nelson (1978) and Brantingham et al. (2001)

dorsal scars and platform facets. Lithic tool manufacture during Component 2 occupations focused on the production of early-stage bifaces ($n=5$), finished bifaces ($n=3$), and nonformal modified flakes ($n=3$) (Table 6.2). The attributes of the Component 2 tool assemblage are very similar to those of Component 1; however, unlike Components 1 and 3, no cores were found in the Component 2 assemblage. All finished bifaces in Component 2 appear to be basal fragments of hafted foliate points, two of which were manufactured from imported obsidian.

The Component 1 lithic assemblage is associated with the lower 20 cm portion of the 3Ab soil horizon (Fig. 6.3) and is considered to date to the late Pleistocene, based on an associated AMS date of 10,430 RCYBP on wood charcoal (Davis et al. 2004). This assemblage includes 12 formed lithic tools, 806 pieces of lithic debitage, and 56 specimens of fire-cracked rock (Table 6.1). The Component 1 debitage assemblage was composed of JOP CCS ($n=770$, or 95.5%) and imported obsidian ($n=36$, or 4.5%). A dominant pattern observed in the Component 1 debitage population includes that of late-stage tool production and maintenance. As with the debitage from the two overlying components, a high frequency of broken flakes and flake fragments, evidence for multiple dorsal scars and platform facets on platform remnant-bearing flakes, and a high frequency of bifacial thinning flakes were seen in this earliest assemblage. Additionally, size and weight aggregate analysis and a calculation of dorsal scar count and weight ratio (Carr and Bradbury 2001) reveal a focus on late-stage reduction and tool production rather than early-stage core production (Willis 2004, 2005). In the remainder of the paper, we focus our attention on the Component 1 lithic assemblage.

Analysis of the Early Lithic Tool Assemblage

The Component 1 lithic assemblage consists of 12 formed tools that are classified as early-stage bifaces ($n=5$, or 33%), finished bifaces or projectile points/knives ($n=2$, or 17%), flake cores ($n=2$, or 17%), and nonformal modified flakes ($n=3$, or 33%) (Fig. 6.4). Analysis of the formed tool assemblage was rather straightforward and included a description of tool morphology and measurement of linear and weight dimensions (Table 6.3). Bifaces were classified according to production stages described by Callahan (1979) and Connolly and Jenkins (1999). The early-stage bifaces share similarities with Callahan's (1979) stage II and III bifaces, which are characterized by the following: the presence of little to no cortex, straightening of the majority of the bifacial lateral margins, flake removals crossing the implement midline, relatively lenticular and flattened cross sections, and bifacial edge angles ranging from ca. 25° to 45° (Callahan 1979; Connolly and Jenkins 1999). Finished bifaces (i.e., projectile point/knives) from Component 1 include the following features: extensive flaking on both faces, straightening of lateral margins, extensive edge trimming, typically showing evidence for hafting, lenticular and flattened in cross section, and edge angles that approximate 25° to 45°. Of the four modified JOP CCS flakes from the Component 1 assemblage, all are nonformal in morphology.

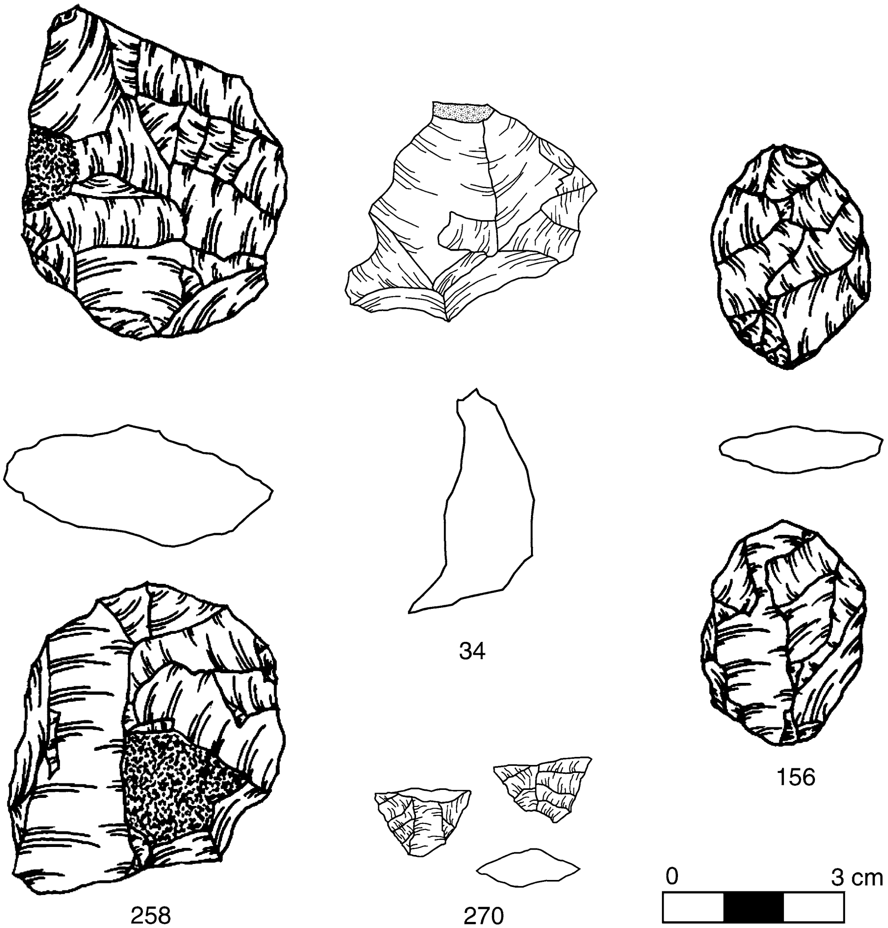

Fig. 6.4 Examples of artifacts recovered at Indian Sands associated with Component 1: early bifaces (a = K/258; b = E/156); core-on-flakes (c = A/34); and, a finished foliate biface basal fragment (d = K/270). The distinction of letter/number refers to the excavation unit and catalog number for each artifact and corresponds to data in Table 6.3

By definition, nonformal modified flakes are not manually retouched, lack extensive edge modification that alters the original flake characteristics, and show evidence of edge modification that is produced only as a result of use (Tomka 2001).

Tool Production and the Reduction Trajectory

Lithic analysis of the Component 1 assemblage reveals an emphasis on formal tool manufacture through the production of large, early-stage bifaces from large flakes (Table 6.2) (Fig. 6.4a, b). Finished projectile points are also seen here; however, the

Table 6.3 Measurements of formed tools from Component 1

Bifaces

Unit	Cat. No.	Material	MxL	MxWdt	MxThk	Wgt	Edge°[a]	BW[b]	BM°[c]	Stage
D	125	CCS	13.12	22.38	6.08	1.2	23	4.8	58	Finished
E	156	CCS	30.8	27.58	8.42	9	27	n/a	n/a	Early
F	202	CCS	46.46	32.48	10.18	15.4	48	n/a	n/a	Early
K	258	CCS	56.98	47.94	19	49.8	63	n/a	n/a	Early
K	270	obs	11.82	16.48	5.72	0.9	27	7.26	67	Finished
L	291	CCS	42.2	32.06	14.58	16.5	46	n/a	n/a	Early

Flake cores

Unit	Cat. No.	Material	MxL	MxWdt	MxThk	Wgt	SRT
A	34	CCS	46.8	32.68	13.6	15.4	Broken
K	259	CCS	57.26	34.54	21.82	27.6	Complete

Modified flakes

Unit	Cat. No.	Material	MxL	MxWdt	MxThk	Wgt	Edge°	RT Loc[d]	B/U[e]	F/N[f]
A	93	CCS	21.4	21.4	10.2	9.6	63	Proximal	Unimarginal	n
E	319	CCS	n/a	23.54	6.7	2.7	36	Lateral	Unimarginal	n
E	162	CCS	n/a	25.1	6.48	4.7	65	Lateral	Unimarginal	n
F	213	CCS	n/a	12.14	17.14	1.7	62	Distal	Unimarginal	n

[a]Edge° = edge angle; [b]BW = basal width; [c]BM° = basal margin angle; [d]RT Loc = retouch location; [e]B/U = bimarginal or unimarginal retouched margin; [f]F/N = formal or nonformal

fragmentary nature of each specimen suggests discard of broken items. Evidence for replacement of hafted bifaces from the onsite JOP CCS source is seen in a reconstruction of the early reduction trajectory employed at the site. We employ three lines of evidence to infer the presence of a full reduction trajectory (i.e., extraction of raw material to manufacture of completed formal tools) during the Component 1 occupation, including (1) the presence of large flake cores, (2) the observation that all early-stage bifaces and finished bifaces retain intact platforms, and (3) the mean linear dimension of all negative flake scars from lithic tools correspond to the linear size class of the entire Component 1 debitage population.

The reduction trajectory begins with production of large flakes from a parent JOP CCS nodule. Whether these CCS nodules were prepared cores or multidirectional amorphous cores is currently unknown. Once detached, these large complete flakes were implemented as cores (i.e., flake cores) (Fig. 6.4c, d). For the purpose of clarification, we make a distinction between a flake blank and a flake core. A flake blank is defined as "a usable piece of lithic material of adequate size and form for making a lithic artifact, such as unmodified flakes of a size larger than the proposed artifact, bearing little or no waste material, and suitable for assorted lithic artifact styles (Crabtree 1999:28)." A flake core is similarly a large macroflake but can produce debitage large enough to furnish useable flakes for further modification (Luebbers 1978; Brantingham et al. 2001). The two flake cores from Component 1 are relatively long and thick, with prominent single-faceted platforms (Table 6.3). Flaking patterns reveal that these flake cores were reduced and shaped along their lateral margins, ultimately resulting in the creation of an early-stage biface. These early-stage bifaces include a pseudocollateral flaking pattern and retain a prominent platform. Although the specific manner in which these early bifaces were used is not clear, extended reduction of the early-stage bifaces may have continued until a finished biface was produced. Alternatively, the early bifaces may have served as small portable cores, or as scraping and cutting implements reminiscent of Kelly's (1988) multipurpose core/tool favored by highly mobile foragers. Thus, the trajectory of biface production may support diverse functional outcomes based on different technological needs.

The finished bifaces appear as fragmentary basal segments, with each specimen retaining the platform created on its original flake (Fig. 6.4e). The retention of the platform on the proximal ends of both the early and finished bifaces appear to be a design strategy and a planned characteristic of the Component 1 reduction trajectory. Retention of the original platform may represent an engineering design used to produce a stronger haft element that could better resist failure from impact forces associated with its use as a projectile weapon. We hypothesize that projectile point fracture due to bipolar compression induced between the haft element and the target material might be reduced if the original flake platform, which had been kinetically preloaded during its initial production, is retained as a design element of the haft's basal area. Conceptually, the original flake platform had already bore the brunt of a strong percussive force; retouching this feature during point production would only weaken an inherently strong part of the objective piece.

The Lithic Landscape: Elucidating Early Mobility Patterns

Although preserved organic materials that might otherwise help us understand the resource catchment and larger environmental area exploited by the early occupants of the Indian Sands site are absent in the buried cultural components, we can approach an understanding of prehistoric land use by examining the provenance of lithic materials. In the case of the Component 1 assemblage at Indian Sands, lithic raw materials were derived from the immediately available JOP CCS source and from obsidian sources located nearly 300 km away. The majority of the Component 1 assemblage is composed of on-site JOP CCS ($n=781$, or 95.5%). Cryptocrystalline silicate-bearing sedimentary, metamorphic, and igneous bedrock units of the JOP formation are common throughout southwestern Oregon (Monroe 1987). The JOP CCS nodules available at Indian Sands and at in situ outcrops at the nearby Rainbow Rock source are naturally uncorticated, thus rendering the triple cortex typology analysis (Mauldin and Amick 1989) useless to infer early-stage reduction activities that are better revealed by size and weight aggregate analyses (Ahler 1989), a free-standing typology (Sullivan and Rozen 1985), a technological typology (Andrefsky 1998; Odell 2003), an attribute analysis including platform remnant-bearing flakes (Andrefsky 1998; Odell 2003), and a dorsal scar count and weight ratio (Carr and Bradbury 2001).

Because obsidian is exotic to the Oregon coast, its presence as debitage in the Component 1 assemblage reveals the operation of extensive trade routes, patterns of regional mobility, or both processes. Component 1 contains obsidian ($n=37$, or 4.5%) that originates from volcanic sources located in central Oregon and northern California. Two Oregon sources include Spodue Mountain ($n=25$, or 67.6% of the Component 1 obsidian) located 270 km ENE, and Silver Lake/Sycan Marsh ($n=4$, or 10.8%), which lies ca. 290 km ENE of Indian Sands. Obsidian was also linked to the Grasshopper Group source ($n=8$, or 21.6%), which is located 235 km ESE in the East Medicine Lake highlands of northern California.

The Component 1 obsidian debitage population is small in quantity and individual flake size, which are traits that are typical of lithic toolstone materials imported from great distances. The appearance of obsidian debitage in small sizes and quantities, and disposal of the hafting element of an obsidian foliate biface meets the expectations of a "decay-like" model (Féblot-Augustins 1993; Beck et al. 2002; Brantingham 2003), wherein the size of discarded artifacts and their associated debitage should show a strong negative correlation with the distance from their material source. Thus, as toolstone is transported farther and farther from its point of origin, it will be represented in smaller and smaller quantities and sizes within an assemblage. Féblot-Augustins (1993) hypothesizes that toolstones available within 0–5 km will contribute 60–80% of a typical assemblage, whereas imported toolstone with source distances of 200 km or more will dramatically drop in frequency, typically comprising less than 1% of the assemblage. Efforts to extend the utility of tools made from distal toolstone source materials will appear as extensive rejuvenation of functional margins, extensive reworking of broken items, and/or the discard of exhausted and broken tools including, in the case of Indian Sands, fragments of finished hafted bifaces (Gramly 1980; Beck and Jones 1990). Strategies employed to conserve toolstone materials are expressed through the extensive reworking and retouching of tools to maximally extend their use life. Toolstone conservation behaviors can also be identified in which higher ratios of formally modified tools to nonformally modified tools are present in lithic assemblages. This decay-like model is also thought to reflect the optimal use of materials and efficient expenditure of energy required to obtain high-quality toolstones through the design and use of formal lithic tools that are easily transported, resistant to breakage, and can be repaired as needed (Torrence 1989; Nelson 1991; Beck et al. 2002). The imported and locally available toolstone frequencies, their distances to sources, and formal tool composition reveal a distinctive pattern in the Component I assemblage at Indian Sands that conforms to a decay-like model.

Regional Comparisons of Lithic Assemblages

Analysis of the ratio between assemblage size and the diversity of formal tools and tool types in an assemblage are used to measure site function and technological organization. Following Kelly (2001), the assemblage size is the total number of artifacts (e.g., lithic tools and debitage; organic tools) and the assemblage diversity is simply calculated as the number of tool categories or tool types divided by the total amount of tools in the entire assemblage. A linear regression is then performed, with the assemblage size as the independent variable and the diversity of the assemblage as the dependent variable. According to some scholars (Camilli 1983; Shott 1989; Kelly 2001), a high regression slope indicates a greater degree of sedentism. Theoretically, a site that is occupied repeatedly over a long period of time for the purpose of conducting various activities will accumulate a lithic assemblage that reflects a diverse set of specialized technological applications. Conversely, a low regression slope signals either high residential mobility (i.e., short term occupation of a site) or an occupation involving a limited set of logistically organized, task-specific activities marked by an assemblage that is both generalized in its technological organization and lacking diversity (*sensu* Binford 1979). A regression with a negative slope typically indicates high residential mobility that leaves only an ephemeral trace of site occupation, with low assemblage diversity (Camilli 1983; Shott 1989). The strength of this analytical method is found in its ability to generate multiple comparisons of site assemblages from basic information commonly presented in journal articles and site reports. In order to ensure a good comparative sample, Shott (1989) recommends inclusion of key criteria: several assemblages must be compared; chronological and physical distance of the assemblages should be minimized; the degree of cultural complexity among sociocultural groups in question should be minimized; and compared assemblages must include at least one tool type that corresponds to a tool taxonomy shared (in at least one case) by all other assemblages.

Table 6.4 Comparison of lithic assemblage size (*N*) and diversity (*H*) among early Northwest Coast sites

Site	Chronology	*N*	*H*
Indian Sands U3Ab (Willis 2005)	MH/EH	2,107	0.33
Indian Sands L3Ab (Willis 2005)	LP	818	0.42
35CS9 (Hall et al. 2005; Davis et al. 2006)	MH/LH	867	0.24
35CS9 (Hall et al. 2005; Davis et al. 2006)	MH/EH	396	0.75
Tahkenitch 1 (Minor and Toepel 1983)	EH	80	0.71
Tahkenitch 2 (Minor and Toepel 1983)	MH	241	0.17
Yachats (Minor 1991)	MH	2,467	0.15
Duncans Point Cave (Schwaderer 1992)	EH	273	0.12
Namu (Carlson 1996; Rahemtulla 2006)	EH	44,020	0.07
Richardson Island 1 (Fedje et al. 2005a)	EH	151	0.55
Richardson Island 2 (Fedje et al. 2005a)	EH	500	0.28
Richardson Island 3 (Fedje et al. 2005a)	EH	2,014	0.26
Richardson Island 4 (Fedje et al. 2005a)	EH	499	0.21
Richardson Island 5 (Fedje et al. 2005a)	EH	552	0.24
Richardson Island 6 (Fedje et al. 2005a)	EH	585	0.25
Richardson Island 7 (Fedje et al. 2005a)	EH	956	0.15
Richardson Island 8 (Fedje et al. 2005a)	EH	954	0.10
Richardson Island 9 (Fedje et al. 2005a)	EH	157	0.21
Richardson Island 10 (Fedje et al. 2005a)	EH	491	0.11
Arrow Creek 1 (Fedje et al. 2005a)	EH	791	0.11
Lyell Bay South Lower (Fedje et al. 2005a)	EH	681	0.04
Lyell Bay South Upper (Fedje et al. 2005a)	EH	184	0.13
Lyell Bay East Lower (Fedje et al. 2005a)	EH	107	0.12
Lyell Bay East Upper (Fedje et al. 2005a)	EH	126	0.19
Kilgii Gwaay (Fedje et al. 2005b)	EH	4,029	0.12

df = 24, Y-intercept = 6.54, Slope = –1.04, $r^2 = 0.045$

In order to place our analysis of the early lithic technology from Indian Sands into a larger regional context, the assemblage size:diversity ratio was calculated for Components 1 and 2, which were then compared against ratios for 23 early to middle Holocene-aged archaeological components from other Northwest Coast sites (Table 6.4). Regression analysis of size and diversity among these early Northwest Coast archaeological components produced a low Y-intercept of 3.6 and a slope of –0.76 (Fig. 6.5) possibly suggesting the following: early foragers of the Northwest Coast practiced a limited range of activities at their sites, commonly recycled and reused tools, and were highly mobile (Camilli 1983; Kelly 2001). Furthermore, the nonsignificant linear regression value (r^2 0.039, correlation coefficient = –0.19) produced by this analysis indicates a strong inconsistency between the structure of early site assemblages at synchronic and diachronic scales (middle Holocene linear regression values include: r^2 0.146, correlation coefficient = –0.38, while early Holocene linear regression values include: r^2 0.05, correlation coefficient = –0.22). Yet, it is quite obvious that the negative relationship defined by the linear regression in Fig. 6.5 is affected by extreme outliers- namely, components

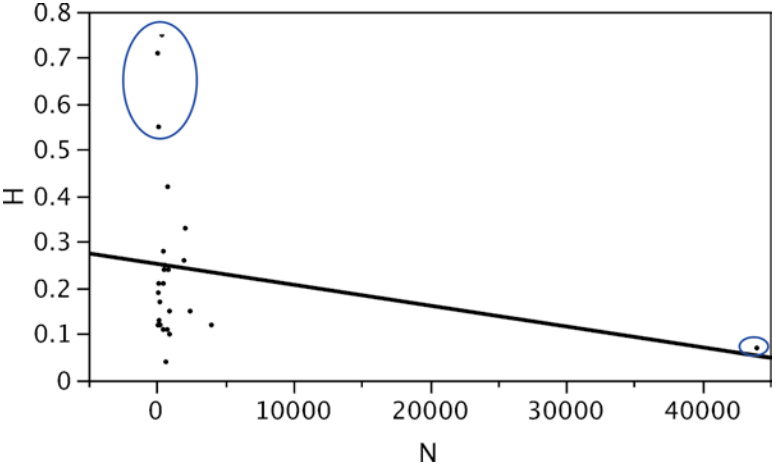

Fig. 6.5 Linear regression of assemblage size (*N*) against diversity (*H*) rates for selected early Northwest Coast archaeological sites listed in Table 6.4. *Circles* indicate extreme outliers

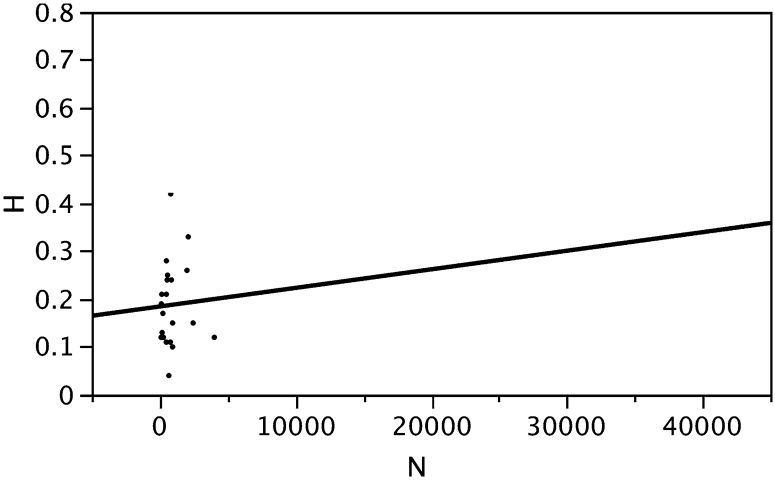

Fig. 6.6 Linear regression of assemblage size (*N*) against diversity (*H*) rates for selected early Northwest Coast archaeological sites listed in Table 6.4 with removal of outliers (circled in Fig. 6.5)

Namu, Richardson Island I, the early Holocene component from 35CS9, and Tahkenitch I. If these components are removed to achieve a more normal distribution (circled in Fig. 6.5), a positive, albeit slight, relationship may be observed (df = 20; Y-intercept = 6.6; slope = 0.18; $r^2 = 0.0017$) (Fig. 6.6). With two exceptions, both regression results (i.e., Figs. 6.5 and 6.6) are suggestive that early Northwest Coast lithic assemblages exhibit low diversity (i.e., nonspecialized) technological organization patterns, which would be highly adaptive in heterogeneous mosaic-like coastal environments.

Economic Orientation and Mobility

Our analysis of the lithic assemblage from Indian Sands reveals that its early human inhabitants manufactured and used a generalized lithic toolkit. Following Nelson (1991), we expect that a generalized toolkit will include elements of maintainability, transportability, and multifunctionality. Briefly, maintainability in toolkit design allows for both flexibility and versatililty in its application. Transportability refers to the degree to which a toolkit is portable. Multifunctionality is achieved by designing a small range of tools that can perform a wide variety of tasks. The observed emphasis on biface manufacture, coupled with a low diversity in lithic tool types in the Component 1 assemblage at Indian Sands, is reminiscent of Kelly's (1988) discussion of the inherently generalized nature of bifacial tools. That early hunter-gatherers at Indian Sands employed a generalized approach to technological organization informs our understanding of early land use on the southern Oregon coast. The concept of land use is subsumed under the rubric of spatial organization, which is defined by the territory size of a foraging group, their standardized movements within the territory, and the size of the foraging groups within the territory (Schalk 1978). Because Schalk used ethnographic data to understand variation in land use among Northwest Coast peoples, we can only address the broad modalities of early coastal land use patterns as inferred from the Indian Sands Component 1 lithic data. Clearly, this is a difficult proposition, since information about prehistoric group size, territory range, and patterns of mobility practiced within the territory is not directly available. Accepting these limitations, we offer some hypothetical perspectives on the possible range and mobility of early hunter-gatherer groups of the southern Northwest Coast.

Our inference of territory size and movements are largely drawn from considerations of lithic toolstone provenance, the nature of technological organization, and recorded average mobility rates of ethnographic foragers. Let us first consider the lithic raw material economy at Indian Sands. According to Kelly (1995) and Ames (2002), the maximum distance an average hunter-gatherer can travel on foot in a single day is approximately 20–30 km (cf. Binford 2001:Tables 7.10–7.13). Our studies of raw material provenance indicate that Silver Lake-Sycan Marsh obsidian was procured from a distance of ca. 290 km away, as the crow flies, and on average, obsidian toolstone moved about 260 km to arrive at Indian Sands. Considering a direct trip along one of the multiple east–west trending river valleys (e.g., the Rogue River valley, the Umpqua River valley, the Klamath River valley via the Trinity River in northern California), a trip to any one of the three obsidian source locations would minimally require 10–12 days. Of course, this trip would be much shorter if foragers employed canoes to facilitate upriver travel. This estimation does not consider the time needed to establish residential camps and procure food along the way.

O'Neill (2004) describes the use of central Oregon obsidians among early Holocene foragers of the Umpqua River valley, with diminishing amounts of obsidian occurring in sites located closer to the coast. Although O'Neill entertains the possibility that this pattern may be the combined result of trade networks and direct procurement, his consideration of direct procurement implies a pattern of land use within a territory range of at least 27,500 km^3 (O'Neill 2004:220). Ames (1988) estimates early settlement patterns of early Columbia River Plateau hunter-gatherers from the spatial distribution of similar technological and economic patterns that characterize the late Pleistocene to early Holocene period. These patterns include generalized lithic toolkits with stemmed and foliate points and flake core technologies. Ames argues that the distribution of these archaeological patterns may represent a foraging territory for the early Plateau period comprised of a few or many hunter-gatherer bands encompassing an area of ca. 190,000 km^2. In comparison, an area ranging 290 km away in all directions from Indian Sands would encompass all of the sources of obsidian found in the Component 1 assemblage. This 86,000 km^2 area might represent a smaller but contemporaneous foraging territory to that which Ames (1988) proposes for the Plateau region (Fig. 6.1). If the presence of obsidian from distant sources actually signals the presence of a large foraging territory during the late Pleistocene to early Holocene period, as hypothesized for the Plateau region, what are the causal factors behind such a situation? We can address this question by considering regional population density, carrying capacity, and paleoenvironmental conditions.

First, if population densities in the region surrounding Indian Sands were very low, large territories might have been required to maintain viable mating and social networks. On the basis of lithic raw material provenance and considerations of ethnographic hunter-gatherer population densities, MacDonald (1999:153) speculates that a Great Plains Folsom forging group might have used a maximal territory of ca. 109,000 km^2 to "encounter trading, mating and social opportunities" but more commonly moved within smaller areas. Comparatively, Amick (1996) anticipates a territory of ca. 120,000 km^2 for Folsom foraging groups.

Second, use of a large foraging territory may have been needed to deal with low environmental productivity or heterogeneous (i.e., low density, widely spaced) resources that limited hunter-gatherer carrying capacity in the surrounding landscape. The little information currently available regarding late Pleistocene environmental conditions along the southern Northwest Coast indicates that cold and dry glacial period conditions gave way to generally warmer and wetter conditions after 10,500 RCYBP (Worona 1993; Worona and Whitlock 1995; Pisias et al. 2001). Lower sea levels of the late Pleistocene exposed many additional square kilometers of additional land along Oregon's coast, representing a significant element of regional landscape ecology that was absent in middle to late Holocene times. Apart from direct evidence that early coastal peoples used marine species at certain locations, we have little information on how littoral and maritime resources were structured and distributed along the Northwest Coast during the late Pleistocene.

Third, in the absence of direct information on marine resource structure, we can hypothesize about the nature of the late Pleistocene resource base by considering how the effects of seasonality at moderate to high latitudes may have imposed a pattern upon resource availability. The parameters of Earth–Sun geometry in operation during the late Pleistocene greatly enhanced seasonality in the Northern Hemisphere (Kutzbach and Ruddiman 1993). At 11,000 cal BP, the Earth received far greater summertime solar radiation than today and far less solar radiation during the winter months. These different insolation patterns produced much warmer summers, and far colder winters, and probably enhanced patterns of seasonal resource abundance (cf. Fedje et al. 2004). Under these climate conditions, extreme seasonal resource shortfalls may have created significant economic stresses that could be alleviated by a coast-to-interior transhumant mobility pattern. In the absence of data that indicate the time of year Indian Sands was occupied, during the creation of Component 1, we cannot clearly know the timing of group movements within the landscape; however, use of an east–west transhumance through a series of discrete ecosystem types could have been adopted as a strategy to counter seasonal resource instabilities that are characteristic of the temperate modern-day Pacific Northwest and were undoubtedly more pronounced during the late Pleistocene period.

Archaeological research conducted in the past few decades has improved our understanding of the degree to which early peoples of North America were adapted to coastal environmental contexts. In addition to expanding our view of marine resource use, a pattern of late Pleistocene hunting in North American coastal regions is also emerging from other sites like K1 Cave and Gaadu Din Cave in British Columbia and Richard's Ridge on Cedros Island (Fedje et al. 2004; Des Lauriers 2006). These hunting patterns not only reflect what must be a more complete view of early coastal adaptations within a larger resource catchment, but they occur in the context of reduced northeastern Pacific upwelling (Davis 2011), which may have strengthened the need for a maintaining an adaptive orientation that enabled full use of coastal, pericoastal, and interior environmental resources. Thus, our view of early coastal adaptations seems more complicated than previously considered, and it should given the fact that late Pleistocene coastal foragers of North America probably lived in an environmental context where the abundance, distribution, and seasonal availability of resources were structured in significantly different ways than during the Holocene.

If the presence of obsidian artifacts at Indian Sands actually indicates that early coastal peoples ranged within a large territory, as we describe here, we also expect that they would need to be able to create and use a toolkit suitable for use in pericoastal, riverine, and upland environments. Considering the technological and material structure of the Component 1 lithic toolkit, it seems plausible to interpret early southern Northwest Coast peoples as highly mobile, generalized foragers. A generalized lithic toolkit emphasizing the production of bifaces offers a number of solutions to diverse ecological problems. That the presence of bifaces should automatically signal a lithic toolkit exclusive to terrestrial economies has been questioned (Carlson 1998; Cassidy et al. 2004). Lyman et al. (1988) and Bennyhoff (1950) provide evidence on how lithic bifaces can be integrated into harpoon weapon systems used for hunting large marine animals. In his study of foliate projectile points from early Pacific Northwest sites, Musil (1988) suggests that their design accommodated use of a socketed haft – a technology commonly used in harpoon systems (Bennyhoff 1950). Des Lauriers (2006) sees the presence of finished lithic bifaces in late Pleistocene-aged occupations on Baja California's Cedros Island as part of a toolkit clearly adapted to a coastal economy. Just as the presence of finished hafted bifaces at Indian Sands might signal a late Pleistocene terrestrial orientation to some, this toolkit could just have easily been used to hunt seals, sea lions, and other aquatic animals in a pericoastal environment. Thus, bifaces hold great potential for solving the broad range of resource acquisition problems early coastal foragers probably faced along the Northwest Coast of North America.

Conclusions

In this chapter, we seek to provide new perspectives on technological organization, economic orientation, and regional mobility patterns practiced by late Pleistocene-age hunter-gatherers of the Pacific Northwest through the study of archaeological components from the Indian Sands site. We conclude that the earliest human occupants at Indian Sands employed a generalized approach to their technological organization that was based mainly on locally available lithic raw materials. If early regional human population levels of the Pacific Northwest were as low as other contemporaneous areas of North America, then we may be justified in considering the presence and form of obsidian debitage and tool fragments to indicate the scale of macromovements in a regional territory (cf. MacDonald 1999), which appear to have extended as far east as the Northern Great Basin. Given the late Pleistocene paleoenvironmental context of the Pacific Northwest, we hypothesized that early hunter-gatherers employed some kind of transhumant land use system, which allowed them to move between pericoastal, riverine, mountain, and basin and range environments of southwestern Oregon and northwestern California. We hypothesize that the early occupants of Indian Sands applied a flake and core lithic toolkit well suited for the efficient production of large, early-stage bifaces, finished foliate bifaces, flake cores, and nonformal modified flakes in the use of a wide range of terrestrial and aquatic environmental contexts under a pattern of high residential mobility. In conclusion, we believe that the early occupants of Indian Sands practiced an adaptive pattern that cannot be understood as a diametrically structured orientation to Pacific Coast landscapes in which hunter-gatherers are either "coastal" or "interior," but not fully both.

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Chapter 7
Of Clams and Clovis: Isla Cedros, Baja California, Mexico

Matthew R. Des Lauriers

The Active Dialogue and Important Definitional Issues

What was once a reasonably direct archaeological debate regarding absolute chronology has become markedly more complex and now encompasses not only dating, but human ecology and agency, along with necessarily much broader frames of reference. Recent discoveries and new examinations of older finds have opened the door to a surge of reinterpretations, not all of which are very well anchored to reliable data. I refer of course to the dialogues surrounding the initial Peopling of the New World, although the general pattern of events described above could apply to the maturation of any investigative effort. I consider this an exciting time to be researching the earliest societies of the New World, although it is a time where the exuberance of being freed from narrow interpretive limits must be tempered by continued, if not heightened, rigor in the evaluation and recovery of data. Much of the nebulosity we encounter is the result of inconsistent definitions and varying application of critical terminology. I do not here call for rigid semantic standardization, but for a coherent conceptual framework that will allow the community of Paleo-Americanist researchers to communicate effectively across regional and theoretical boundaries.

Given the common focus of the contributors to this volume, defining what we mean by "the Coast" or "Coastal" may be an appropriate point of departure. As highlighted by Westley and Dix (2006:23), "… a secure definition of the coastal zone and what constitutes a coastal adaptation is essential … a secure archaeologically relevant definition of the coastal zone would provide a boundary that allows distinction between inland and coastal strategies of colonization." This point cannot be overemphasized, since the newly reinvigorated debate centers as much around the human ecological strategies practiced by the initial migrants to the New World as on the absolute timing of their arrival. In their recent paper, Westley and

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Dix (2006:23) advocate a perspective on the coast that recognizes the dynamism and variability inherent in that biome generally, while encouraging scholars to assess "perceptually relevant changes in climate, sea level, geomorphology, oceanography, and resources." They then propose the integration of relevant archaeological data, providing "insights as to whether coastal migration was likely given the circumstances, and if so, what environmental processes existed that past humans would have had to contend with." Bringing the scale of analysis down to a particular coastline will allow us to highlight critical factors that may have influenced the process of colonization. This also avoids the pitfall of simply prospecting for increasingly older radiocarbon dates in the futile effort to find the "first" or the "oldest" in any ultimate sense of the terms. If we can better understand the *process* of initial peopling, then finding the very first sites may be unnecessary to reach

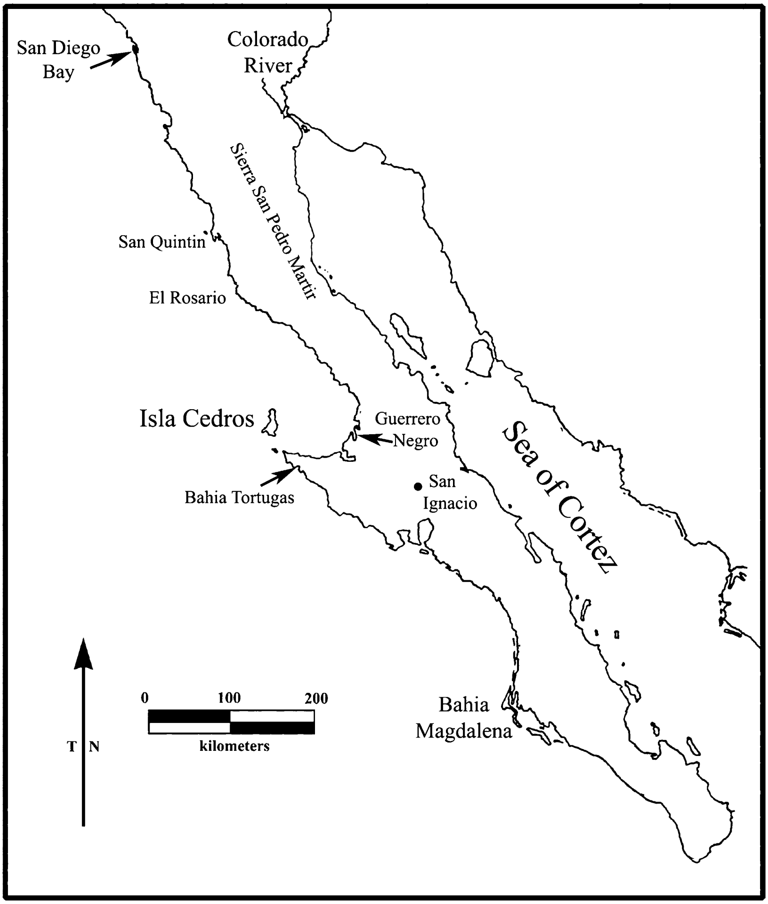

Fig. 7.1 Baja California with geographic areas discussed in the text

solid conclusions regarding the social and ecological factors underlying the Peopling of the New World in general, and geographically defined regions more specifically.

Following this general approach, it seems appropriate to pursue an evaluation of Mexico's Baja California Peninsula (Fig. 7.1), at least as far as available data will allow. The geography of the peninsula offers us a unique opportunity. Defining the "coastal zone" is almost a moot point. At no point in the Peninsula can one be more than 75 km from the coast, and in most areas, the distance is closer to 40 km. This is not a significant distance to most hunter-gatherer groups, and crossing the peninsula could be easily accomplished in a 2–3 day walk. Baja California's geography can essentially be understood as two "coasts" back-to-back.

Defining "Coastal"

For purposes of this discussion, a "coastal adaptation" can be defined as one that exploits a variety of littoral resources, depends upon the aquatic environment for both resources and some degree of transportation, and cannot be sustained *even seasonally* without access to the sea. There are examples of hunting and gathering groups who seasonally exploit marine resources, but are not dependent upon them year-round. I would exclude such flexible (but effective) strategies from the definition of a fully coastal adaptation. Such "part-time" resident groups are able to avail themselves of a wider range of opportunities than specialists, and such an adaptation could certainly have played a role in the initial Peopling of the New World, but we must distinguish such a transhumant pattern from that displayed by truly "coastal" people. This is not simple semantics, since much of the Terrestrial vs. Coastal debate depends upon the coastal migrants practicing a distinctly different lifeway from that of the fluted-point megafauna hunters.

To begin defining some of the basic features of the Peninsula, one immediately notes the steep bathymetry that is common to much of the littoral zone surrounding Baja California and the diverse richness of those waters (Steinbeck and Ricketts 1941; Gruhn and Bryan 2002; Fujita 2006; Des Lauriers 2006a). The steep bathymetry would have had at least two major effects: (1) early sites near the coastline would have been less likely to be destroyed as a result of submergence during eustatic sea-level rise; and (2) rocky shore ecological zones would have probably been able to keep pace with all but the most rapid pulses of sea-level rise, resulting in more stable resource bases along sections of coastline with appropriate bathymetry and substrate.

The historically documented richness of the littoral resources found in Peninsular waters cannot be assumed to extend back into poorly understood conditions of the Pleistocene, and depending upon the strength of the California Current, the northwest coastline of the Baja California Peninsula may have varied significantly from modern conditions. The influence of the oceanic currents on the ecology of the upper Sea of Cortez is uncertain, though increased flow of the Colorado River may have had an ameliorating effect on environmental stability, at least when compared to the heavily impacted modern situation.

Archaeological deposits on Isla Cedros, extending back at least 12,000 calendar years BP (PAIC-44 and PAIC-49, see below), contain shellfish assemblages, which include small quantities of cold water-loving red abalone (*Haliotis rufrescens*). Apart from a very limited area of intense upwelling on the Pacific Coast near El Rosario, Baja California, this is the furthest south that this species has been recovered in archaeological sites. Principal members (>30% by proportional weight) of the terminal Pleistocene-early Holocene mollusk species profile include California mussel (*Mytilus californianus*) and Pismo clam (*Tivela stultorum*), and the icthyofauna are dominated by temperate water species such as kelp bass (*Paralabrax clathratus*), sheephead (*Semicossyphus pulcher*), and ocean whitefish (*Caulolatilus princeps*).

If full Pleistocene oceanographic conditions were significantly different, by the transition to the Holocene (~10,000 RCYBP), relatively modern current and upwelling conditions were in force, at least for the immediate environs of Isla Cedros. This raises the possibility that productivity of the marine littoral in the Isla Cedros region was not significantly depressed during the time period between 12,000 and 9,000 calendar years before present. This is supported by a comparison of deep-sea cores taken off of San Francisco, Los Angeles, and Isla Cedros (Morin 1971), which suggests greater temperature shifts across the Pleistocene-Holocene boundary in the area between Point Conception and the U.S. Mexican border than zones around either San Francisco or Isla Cedros. The biogeographic continuity seen on Cedros Island during the terminal Pleistocene-early Holocene transition – is unlikely to have extended south along the Peninsula's Pacific coast beyond Bahia Magdalena, where sea surface temperatures, littoral composition, and species distributions change considerably (Pondella et al. 2005).

Water, or the Lack Thereof

One of the ecological factors that may have limited the potential of the Baja California Peninsula to draw early colonists is the relative dearth of potable surface water. Today, major, stable oases exist at some locations in the mountains of the central Sierras of the Peninsula, and water can be found at river mouths along the coast as far south as El Rosario. Water becomes more of a problem south of the Sierra San Pedro Martir, with the important and significant exception of Isla Cedros (Fig. 7.2). Isla Cedros is a large, high, rocky island near the midpoint of the Peninsula with abundant and reliable water. In contrast, the adjacent mainland is exceptionally dry, and today, receives its water through a combination of long pipelines running from the mountains and desalinization plants at places like Guerrero Negro and Bahia Tortugas. During the late Pleistocene to early Holocene period, this hydrologic situation would have been dramatically different, with dozens of pluvial lakes in interior basins and generally more mesic conditions present throughout the central Peninsula (Davis 2006). However, today, water availability

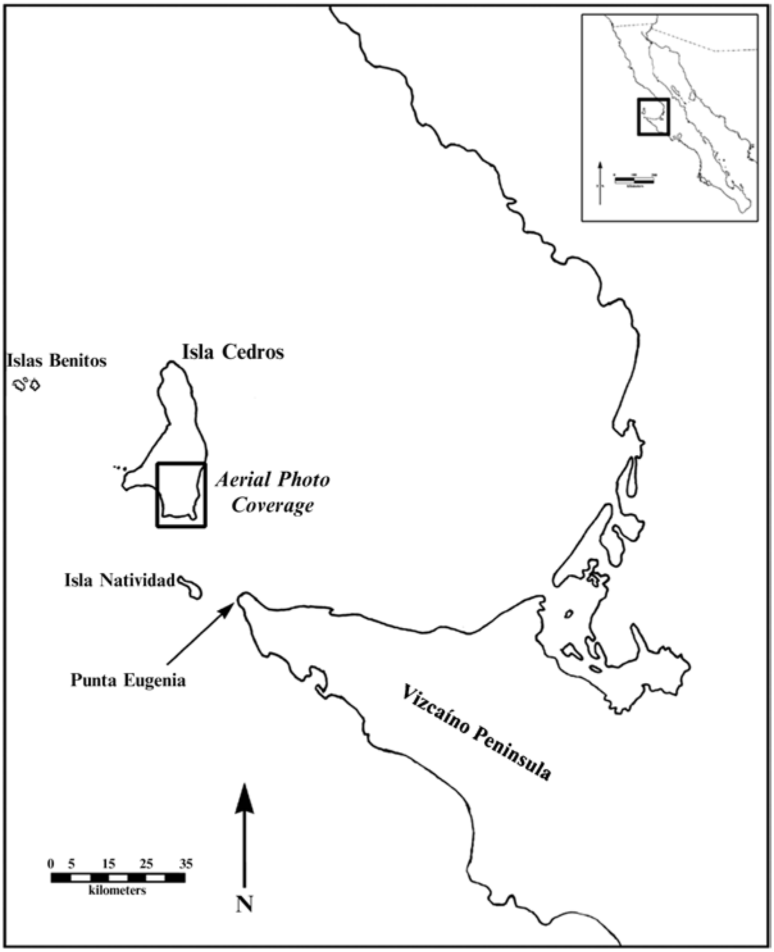

Fig. 7.2 The Isla Cedros-Bahia Vizcaíno region. The area covered in Fig. 7.2 is outlined

along the Peninsular coasts themselves would still have been more patchy and uneven. Early settlement is likely to have been drawn towards those areas with the most reliable water sources, such as the pluvial lakes and unusual, hydrologically "fortunate" locales like Isla Cedros. These latter areas (though not as isolated and oasis-like as they would later become) would have provided an incentive for advancing populations to move very quickly through the poorly watered areas, and for coastal locales to have made use of the most effective transport technology then available to them – watercraft. Combined with the intensive early occupation documented for some areas, such as Isla Cedros (Des Lauriers 2006b, 2008; Davis 2007; Erlandson et al. 2008), the restricted availability of water (though still more abundant than today) may have resulted in a certain degree of settlement circumscription, packing greater archaeological signatures into smaller areas, rather than evenly distributing it along the coastline and throughout interior basins. Some increased precipitation during most of the terminal Pleistocene – generally inferred for much of western North America (Haynes 1993) – would have charged now depleted aquifers, while rising sea level would have increased the pressure on near-shore aquifers, perhaps driving some water closer to the surface than exists at present.

The ecology of the central two thirds of the Peninsula would have been relatively arid compared to that encountered by southward moving migrants throughout the terminal Pleistocene and early Holocene, though there was consistently enough rainfall to support the pluvial lakes in interior basins (Davis 2003, 2006). Despite the paleoenvironmental variation of the late Pleistocene and early Holocene periods, the distinct floral community of the peninsula probably presented a steeper gradient of ecological variation across space than was seen in the marine littoral zone. The changing vegetation patterns would have presented an obstacle to any terrestrial hunter-gatherer group with a strong economic focus on plant resources. The obstacle would have only been overcome by knowledge and skill in processing the *Agave*, leguminous shrubs, and other xerophytic flora today common on the peninsula. Such resources are not abundant along the Pacific Coast north of the U.S.-Mexican border, though they can be found to the northeast in the Colorado Desert. Familiarity with this particular set of resources is important because of the intensive processing required to make many of them edible. For example, raw *Agave* (Fig. 7.3) is not only of little use as a food, but even the fibers are of limited

Fig. 7.3 *Agave shawii* on Isla Cedros, Baja California. Perhaps the single most economically important plant for Late Period indigenous populations on the island (Des Lauriers and García-Des Lauriers 2006). Archaeological remains of processing facilities (pits, ovens) required for its exploitation have yet to be identified for the earliest phases of occupation

utility without particular harvesting and processing techniques, which must be carefully balanced to ensure productive outcomes. However, direct evidence for the *economically significant* exploitation of *Agave* as a staple food source has yet to be recovered from early archaeological deposits on the Peninsula, though their presence and use have been confirmed by *Agave* charcoal and fibers recovered from terminal Pleistocene deposits at PAIC-49 on Isla Cedros.

Pleistocene megafaunal remains have repeatedly been recovered or observed at several locations along the Peninsula (i.e., San Quintin, El Rosario, San Ignacio) going back to the eighteenth century (del Barco 1988). At least four fluted projectile points have been documented in the Sierra de San Francisco in the vicinity of San Ignacio (Aschmann 1952; Gutierrez and Hyland 1994, 2002), and two have been recovered from Isla Cedros (Des Lauriers 2008). However, none of the available evidence has yet convincingly established the contemporaneity of the megafauna and human presence on the Peninsula. In fact, the presence of these Paleoindian points is more perplexing than illuminating, given what would have been the significantly lower density of megafauna in the arid, restricted, terrain of the Peninsula. Standard ecological thinking would predict that littoral resources should have been far more attractive in their ease of collection and general density – if the obstacle of limited availability of water could have been overcome.

Boat-building materials would have been limited along much of the coast, especially with rising sea levels drowning coastal marshes. Springs in the central mountains often have stands of tules and reeds, and pine forests may have existed at lower elevations of the central Sierras (Rhode 2002; Davis 2006), though transporting a sufficient quantity to the coast would have been awkward, but not impossible. Some locations would have collected large quantities of driftwood, particularly north and northwest facing beaches and the northern sides of points and capes along the Pacific coast. These locations also tend to have steep bathymetry and rocky shore littorals, even if longshore sediment transport generates some sand beaches at these locations.

The factors that might be expected to condition the patterns of Peninsular settlement by the First Americans can be summarized as follows: (1) only "coastal" and pericoastal zones are available in Baja California – walking down the central mountain ranges, it would be impossible to move into the Peninsula without feeling the climatic effects of the ocean, and seeing one, or sometimes two, coastlines from the central spine of the Peninsula is not uncommon – thus, making strong distinctions between coastal- and interior-oriented foragers is probably meaningless; (2) early settlements positioned along the Pacific slope of Baja California are more likely to have avoided submergence by eustatic sea-level rise due to the presence of relatively steep bathymetry; which would also have provided more stable ecological zones along some stretches of coastline; (3) terrestrial hunting might be more difficult and less productive than littoral foraging, considering the relatively lower terrestrial productivity and size of the Peninsula's interior area (compared to more northerly areas of western North America), and the relative richness of nearby littoral ecosystems; and (4) plant use probably increased later in time, after collectors learned to exploit the xerophytic floral communities found on the majority of peninsular terrains, which achieved their greatest extent following the onset of desert conditions in the early Holocene; and finally, (5) regardless of how closely modern conditions mirror those at the end of the Pleistocene, it is certain that water was less available on the peninsula than along the continental coastline to the north. This would have been the first time that coastal migrants would have encountered this difficulty. How quickly they found springs, seeps, and tanks, or how soon they learned to dig *batequis* (wells dug in the beach at arroyo mouths, above high tide, taking advantage of the differential density of salt and fresh water) would have determined how long this obstacle stood in their way to southward movement along the coast.

Isla Cedros, Baja California

Searching for a location where early occupation could have been focused, and where sufficient water and boat-building materials could have mitigated the lack of such along much of the Peninsular coastline, Isla Cedros presents itself as an excellent opportunity to further investigate the factors presented above. What is paradoxical about the data from this island is that it both reaffirms some of these ideas, while presenting us with information that cannot be so easily explained. Especially curious are the only two known examples of Paleoindian fluted point from a Pacific coast island (Des Lauriers 2008). The Arce-Meza fluted-point site (PAIC-70), like other fluted point localities on the Peninsula, is largely a surface deposit of lithic materials. In addition to the basal fragment of a bifacially fluted point, other large-format bifaces, unifacial scrapers, a variety of flake tools, and a substantial amount of debitage were also observed on the surface. Except for the fluted point, the lithic technology of PAIC-70 is markedly similar to that recovered from Richard's Ridge (PAIC-49) and Cerro Pedregoso (PAIC-44), two stratified shell middens on the island (Fig. 7.4) that contain basal strata dating in excess of 12,000 cal BP (Table 7.1; cf. Des Lauriers 2006b, 2010).

Table 7.1 Terminal Pleistocene ^{14}C dates from PAIC-44 and PAIC-49. Calibrated date ranges represent the full range of all intercepts at 2 sigma. Calibration conducted with Calib 5.0.2 and utilizing an empirically determined ΔR value of 50 ± 25 (Taylor et al. 2007). The reader is directed to Des Lauriers 2006b and 2010 for all currently available dates from PAIC-44 and -49

Laboratory No.	PAIC-site/ context	Layer	Material	13C/12C(‰)	14C age (RCYBP/ Cal BP)
UCIAMS-12844	-44c/unit 1	D	*Chione* shell, pair w/-12859	–0.6	10,520 ± 30/11,850–11,340 BP
UCIAMS-12859	-44c/unit 1	D	Charcoal, pair w/-12844	–21.2	10,095 ± 30/11,960–11,410 BP
UCIAMS-14388	-49/midden probe	20 cm depth	*Mytilus* shell	2.7	10,745 ± 25/12,240–11,930 BP

The technological system characteristic of these early contexts on Isla Cedros includes well-fashioned foliate and stemmed bifaces manufactured from quartz (Fig. 7.5), quartzite, low-silica content chert, and metavolcanic material. One of the most clearly diagnostic tool forms is not, however, a projectile point, but a carefully maintained unifacial tool with steep retouch and a high domed back (Figs. 7.6 and 7.7). These tools resemble similar forms found in a number of early contexts in western North America (Rogers 1966) and the Baja California Peninsula (Des Lauriers and Davis 2007). The fascinating aspect of this early industry as a whole is not the elaboration of any particular form, but the ability of these stoneworkers to manufacture highly refined, yet simple, forms from some of the most difficult

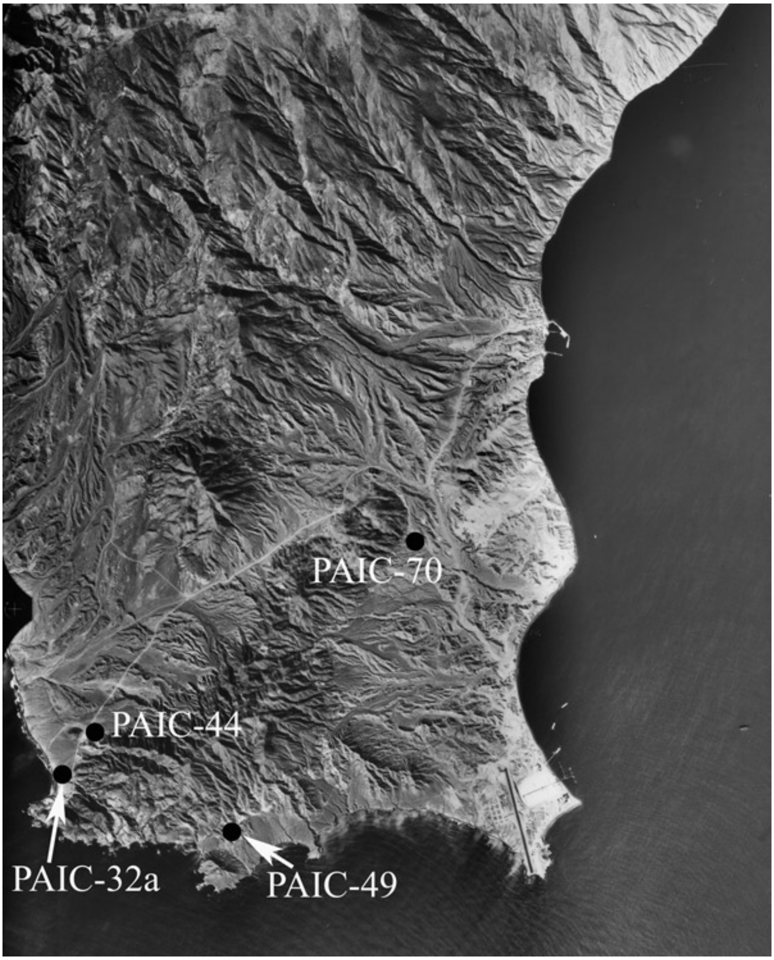

Fig. 7.4 Isla Cedros archaeological sites mentioned in the text. All contain components dating to the Terminal Pleistocene/Early Holocene transition or earlier except for PAIC-32a (Late Holocene)

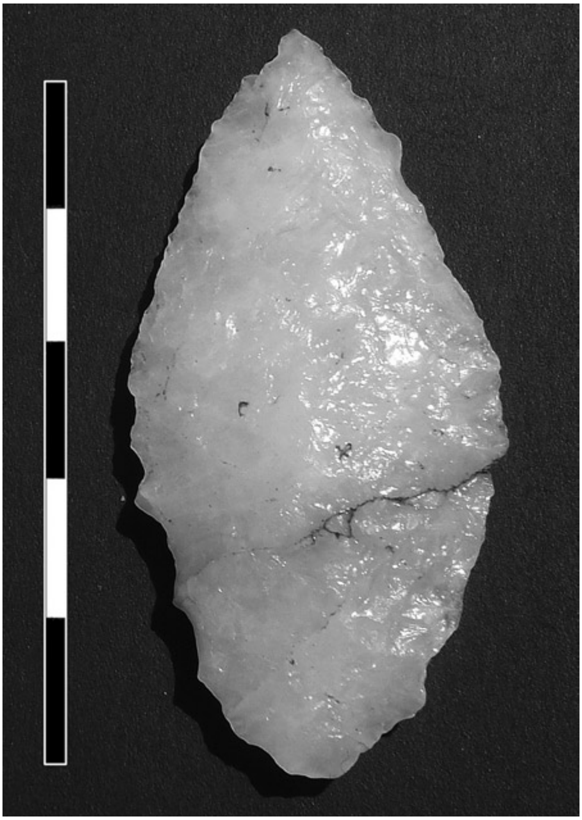

Fig. 7.5 A weak-shouldered stemmed point manufactured from local quartz, recovered from PAIC-44 in January of 2009 (see Des Lauriers 2006:265, Fig. 7.6c for a nearly identical specimen from the same site). Bifaces such as this example typify the assemblage from early contexts on Isla Cedros. While some variation in raw material choice and morphology exists, most of the variance seems to be a function of use-life progression for each artifact rather than any radical departure in technology or "style"

raw material types and configurations. This bespeaks a technological system that was not tethered to any particular source or quality of raw material. This would have been a flexible, generalized system that could not only be applied to varied suites of resources, but could also have been replicated anywhere, from any available source of stone. This technological strategy would have been very advantageous, particularly for colonizing populations who would not have yet located all the available sources of stone, even in areas where they had begun to establish more permanent settlement. Also, by practicing a technological system that can make use of a very wide range of raw materials, the selection of appropriate locales for settlement has one less constraint upon it, and considerations of food resources and especially *water* can assume even higher priority.

The two excavated early sites on the island, Cerro Pedregoso (PAIC-44) and Richard's Ridge (PAIC-49), in addition to displaying dense concentrations of debitage,

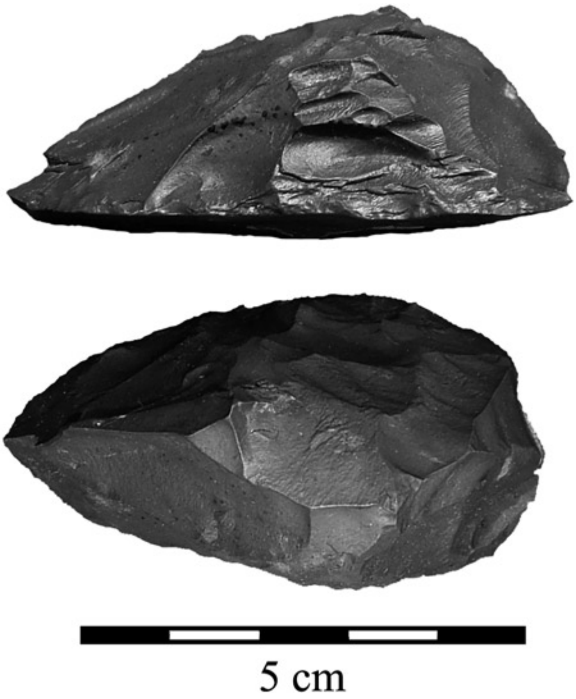

Fig. 7.6 A steep-edged, unifacially retouched tool, manufactured from dark gray fine-grained, metavolcanic stone and recovered at PAIC-44. This artifact and that shown in Fig. 7.5 are only two examples of the most diagnostic artifact type for the earliest phases of occupation on Isla Cedros. While some variability in form exists, the general concept, execution, and emphasis on clean, ventral to dorsal unifacial retouch are consistent

centripetal cobble-cores, large and small format bifaces, groundstone, single-piece shell fishhooks, and flaked clamshell, also contain evidence for the exploitation of a diverse range of fauna (Des Lauriers 2006b). The large and rather well-preserved assemblage of excavated shellfish remains includes rocky shore (i.e., *Mytilus californiensis, Haliotis cracherodii*, *H. rufrescens*, and *Lithopoma undosa*), sandy shore (i.e., *T. stultorum*, *Protothaca staminea,* and *Chione* sp.), and bay species (i.e., *Ostrea megadon*). The fish include a wide range of species that must have been acquired with an equally varied set of fishing equipment, as the list includes: small smelts (*Atherinosidae*), skates and rays (including *Myliobatidae*), flatfish (*Paralichthyidae*), sheephead (*Labridae*), kelp bass (*Serranidae*), and the often sizable white seabass (*Atractoscion nobilis*). The list of major fauna continues, with consistent presence of sea turtle (cf. *Caretta* sp.), Guadalupe Fur Seal (*Arctocephalus townsendii*), California sea lion (*Zalophus californianus*), and sea bird remains throughout the occupational sequence of the excavated early sites (Des Lauriers 2006b). Potentially even more indicative of a dominant emphasis on marine harvesting tasks during the occupation of these early Isla Cedros sites is the presence of notable quantities of sea grass (*Zostera* sp.) and other carbonized marine floral remains.

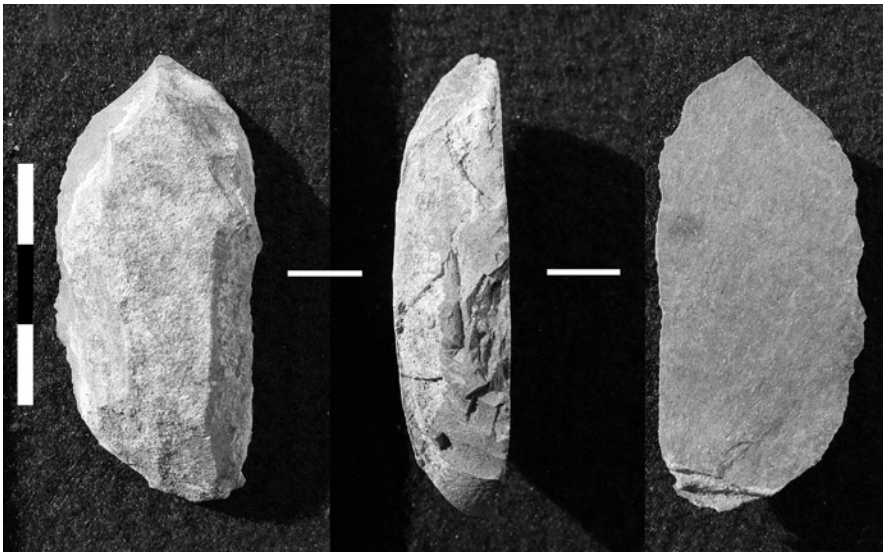

Fig. 7.7 A steep-edged, unifacially retouched tool from PAIC-49, and manufactured from gray basalt. Note the emphasis on the “sides” of this tool, in contrast to the attention paid to the outline and profile of the “ends” of the tool in Fig. 7.4

One of the more perplexing and unresolved issues regarding the subsistence economy of the initial colonizing populations on Isla Cedros involves the presence of pygmy mule deer (*Odocoileus hemionus cerrosensis*) and brush rabbit (*Sylvilagus bachmanii cedrosensis*) on the island (Mellink 1993). None of the Alta California islands are home to native artiodactyls or leporids, all those currently found there have been introduced within the last 500 years. Despite the availability of these additional subsistence resources on Isla Cedros, terminal Pleistocene colonizing populations appear to have largely ignored these taxa (Des Lauriers 2009). In fact, from a total of approximately 11 m^3 of cultural deposit, only a few dozen clearly identifiable rabbit bones have been recovered, which contrasts greatly with the discovery of more than 1,800 identified specimens of marine vertebrate bone. During excavations by the author at PAIC-44 in January of 2009, preliminary identification was made of a fragment of artiodactyl metapodial, along with a few small fragments of dense cortical bone, which may be attributable to these larger terrestrial herbivores. However, such material was not widely distributed and was recovered only from a single 1×2 m excavation unit, despite approximately 8 m^3 of deposit being excavated and screened through 1/8″ mesh.

Recent work with the trans-Holocene faunal assemblage from Diablo Canyon in central California (Jones et al. 2008) suggests that, where available, deer will be exploited with some regularity, even when abundant marine resources are available. Perhaps the early colonizing populations of Isla Cedros had, by the time of arrival in central Baja California, become so emphatically focused on marine resources that their habitual subsistence and settlement practices simply did not result in frequent encounters with Cedros Island deer. Today, these browsing herbivores favor the more heavily vegetated upper slopes and westward draining arroyos. Thus, a possible explanation for the vanishingly small quantity of deer bone may be that the landscape in the immediate environs of the two excavated early sites may not have provided much opportunity for fortuitous encounters between early Cedros Islanders and pygmy deer. However, this would also mean that the inhabitants of Cerro Pedregoso and Richard's Ridge must not have been making frequent foraging trips into the interior of the island, nor was deer apparently an attractive enough resource to encourage a subsistence shift at any time during the first 1,500 years of the Island's human history.

Given the *selective* focus on marine resource use indicated by the fauna and the surprising (when compared with many other coastal sites) density of bifaces, projectile points, and projectile point fragments recovered from the site, the dearth of terrestrial fauna is probably not indicative of an overriding dietary emphasis on plant resources, or a different technological focus, as is often inferred for later Millingstone assemblages in Alta California (Erlandson 1991; Jones 1996; Jones et al. 2002, 2008). The choice made by the early colonizing population of Isla Cedros to not heavily exploit the native pygmy deer is interesting and could be explained by any number of models anchored in behavioral ecology, including the search and transport costs enforced by the rugged topography of the island; however, such avoidance was not to remain the case for the whole history of the island.

Late Holocene sites contain ample evidence of deer exploitation, including substantial quantities recovered from the Punta Prieta site (PAIC-32a), which dates to between 2,300 and 700 rcybp and is located less than 800 m from Cerro Pedregoso (PAIC-44). The more recent native society of Isla Cedros apparently found the potential value of pursuing deer significant enough to budget labor expenditures on something other than the marine resources which abounded around their rugged island home. They never did extirpate the deer, despite over 12,000 years of evidence for their use by island people. This is an unusual pattern in human colonization of islands, since the descendants of these deer still browse on fog-laden bushes in the early morning hours and silhouette themselves on ridgelines at dusk on this remote Baja California island. The lower emphasis on deer hunting apparently began with the first arrivals on the island, and some measure of sustainability was maintained for over 10,000 years. Despite significant continuities in the ecology of Isla Cedros itself, and a presumed continuity of human populations, the drawn-out colonization phase pattern did not last forever. By the end of the early Holocene, between 8,000 and 7,000 years ago, the "Paleopeninsular" technological system, settlement pattern, and subsistence regime (Des Lauriers and Davis 2007), which had remained intact across the terminal Pleistocene-early Holocene period, were gone, replaced by new, and in some ways, less intensive patterns (cf. Des Lauriers 2009).

Recently, five other sites on the island have been located whose surface manifestation, lithic assemblages, and shellfish profiles strongly resemble those from the Richard's Ridge (PAIC-49) and Cerro Pedregoso (PAIC-44), though further work is required to confirm their contemporaneity. Clearly, what can be inferred from an examination of the Isla Cedros record is a strong focus on, and capable exploitation of, a diversity of marine and littoral resources at a very early date (Des Lauriers 2006b). While these sites probably do not represent the earliest arrival of humans on Isla Cedros, they almost certainly represent components left by the earliest stages of human colonization along the Pacific Coast of the Peninsula. At the same time, the strong emphasis on marine resources and relatively intensive early occupation of Isla Cedros bespeak a population that was not unfamiliar with coastal settings and aquatic resources. Indeed, if later demographic conditions are any indication, the strong settlement viability of what is today the Isla Cedros region for terminal Pleistocene human occupation may have also provided a “launching pad” of a sort for further population movement down the Pacific Coast. While Isla Cedros would have been marginally connected to the mainland at glacial maximum (Des Lauriers 2006b), its imposing topography, unique hydrology, and salient position as the tip of the Vizcaino “hook” probably made it an ecological “island” that was part of a settlement “archipelago,” which included the pluvial lake basins and other fairly stable, resource-rich locations stretching both north and south of this rugged mountain-in-the-sea.

In conclusion, evidence for the terminal Pleistocene occupation of the whole peninsula (Gruhn and Bryan 2002; Gutierrez and Hyland 2002; Davis 2003; Fujita 2006; Des Lauriers 2006b, 2008), the early, intense focus on marine resources, and the clearly documented early occupation of peninsular coastlines and ‘islands’ contemporary with (if not earlier than) the occupation of similar locales further north (Johnson et al. 2002; Erlandson et al. 2007, 2008) all circumstantially support models which see the peopling of the New World being accomplished at least partly by way of a dispersal of founding populations along the Pacific coast (Fladmark 1979; Gruhn 1988; Dixon 1999; Erlandson et al. 2002, 2007, 2008). However, some models that have characterized the ecological foci of coastal migrants as being just as specialized as the Clovis big-game hunters of the interior Llanos may be missing important dimensions to this process that new data are beginning to reveal. If the bearers of the Clovis tradition were, in fact, highly mobile, terrestrially focused foragers, then the archaeological traces of such groups on the Peninsula may represent short-term forays into uncharted territory that did not ultimately lead to extensive colonization by follow-on groups practicing similar strategies. They came, they saw, they left. Conditions may not have been suitable, or sustainable, for groups with narrower technological requirements and subsistence strategies. The actual initial *colonization* of the Peninsula, whether earlier, contemporary, or later than Clovis, would therefore have been accomplished more effectively by technologically flexible, broadly skilled opportunists. The technological systems employed by Paleopeninsular groups (Des Lauriers and Davis 2007) are a strong indicator of this strategic breadth and are fundamentally disparate from systems employed by the Paleoindian populations of interior North America both immediately before and during the Pleistocene-Holocene transition.

That early people of the Americas were innovative and resourceful is *not* in question. That they were *capable* of adjusting their technology and behavior to overcome virtually any ecological obstacle in their way is also a foregone conclusion.

What is particularly intriguing is that the new data seem to suggest that it was precisely this flexibility and adaptability that formed the core of early technological and social patterns, rather than rigid adherence to a narrowly focused lifeway. In fact, the variability that we encounter in the archaeological signature of terminal Pleistocene and early Holocene populations of the Baja California Peninsula must be recognized as the palimpsest of days, weeks, months, years, decades, and even centuries of human occupation at sites like Cerro Pedregoso on Isla Cedros, the Covacha Babisuri site on Espiritu Santo Island (Fujita 2006), and the Abrigo Escorpiones site south of Ensenada, Baja California (Gruhn and Bryan 2002). Human–environmental relationships cannot be simply characterized as stable or undergoing collapse. Rather, the cycles through which they can pass, in the constitution and maintenance of such systems, are dynamic and in a constant state of change and flux (*sensu* Redman 2005). High-resolution records like those at PAIC-49 on Isla Cedros, where the full 1.7 m of site deposits span little more than four centuries of time (centered on 12,000 cal BP), will provide even better opportunities to understand human behavior and ecological conditions during timeframes as variable and dynamic as the Pleistocene-Holocene transitional period. Given such fluctuating conditions, we should not imagine that early colonizing populations would have been perfectly comfortable with either the new environments or their existing means of interacting with the new flora, fauna, and landscape. As such, in these early sites, we are seeing the accumulation of material deposited by people who were learning, experimenting, and refining their relationship with the new natural and social worlds to which they had journeyed, so very far from where they started.

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Chapter 8
Changes in Molluscan Exploitation Patterns During the Late Pleistocene and Early Holocene in Eastern Cantabria (Northern Spain)

F. Igor Gutiérrez-Zugasti

Introduction

In the last 30 years, one of the liveliest debates in regional prehistory has revolved around the economic and social changes occurring in hunter-gatherer societies in the Late Pleistocene and Early Holocene. At the present time, a consensus appears to have been reached among the different authors regarding the existence of a specialisation process in the capture of red deer and ibex during the Solutrean and Magdalenian, and a later diversification in subsistence, with a greater exploitation of other resources, such as smaller mammals, birds, fish, molluscs and crustaceans, as occurred in other parts of Europe and Asia (Flannery 1969; Stiner 2001). Although some authors maintain that, despite the specialisation, diversification began to be evident in the Solutrean (Straus and Clark 1986:353), most researchers agree that the process commenced in the Late Magdalenian and became more generalised in the Azilian and especially during the Mesolithic (Gassiot 2000; González-Morales 1982; González-Sainz 1989; González-Sainz and González-Morales 1986; González-Sainz and González-Urquijo 2007), when it reached its peak, due to a decrease in population mobility and an increase in the occupation and probably the use of the coast (González-Morales 1995).

Within this diversification, molluscs played a role whose importance in the economic strategies of human groups is generally difficult to assess. It is usually claimed that the exploitation of molluscs slowly increased in importance within the hunter-gatherers' economic strategies, from a hypothetical minor use in the Upper Palaeolithic to reach its greatest significance in the Mesolithic. Thus, some authors (González-Morales et al. 1999; Ortea 1986; Straus and Clark 1986) have proposed the existence of an intensification process in the use of these resources over time, caused by the pressure of an increasing population. The reason for this is based

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mainly on two arguments: on the one hand, the larger number of sites located in coastal areas during the Mesolithic, and on the other, a reduction over time in the size of the most commonly gathered species, *Patella vulgata*. However, for other authors (Bailey and Craighead 2003), the reasons given to explain this intensification process are not sufficient to prove that the process existed. Although they accept the first argument, in the case of the second, they propose that the variation in the size of *P. vulgata* specimens is due to climate change, which caused this species to reduce in size. In support of this hypothesis, apart from the biometric analyses themselves, they carry out a study of the age distributions, whose results were interpreted in terms of no overexploitation, which implied attributing the reduction in size to environmental factors. However, it is possible to make a critique common to both hypotheses, and this is that basically they were both constructed from the evidence from a single site, La Riera (in Asturias, in the western sector of Cantabrian Spain) supported by numerous Mesolithic settlements (of the Asturian culture) existing in the same area, without taking into account data from settlements in other parts of the region. In this respect, it is true that until recent years, a gap has existed in the archaeomalacological record for some parts of the region, especially in the centre and the east (Communities of Cantabria and the Basque Country). However, data is now available from excavations carried out in the last couple of decades, some of which are presented in this chapter and which will help to review the hypotheses based on data from La Riera.

Another of the topics that has been discussed most frequently in the region is that of settlement patterns. Studies on this aspect have pointed out that the occupation of inland areas decreased significantly during the Mesolithic, in comparison with earlier periods, and that most settlements were located in coastal areas (González-Morales et al. 1999; Straus and Clark 1986). However, this does not mean that the interior was not occupied during the Mesolithic, as has been shown by the recent finds of new sites, such as Los Canes, Arangas, El Mirón, Cubío Redondo and Cofresnedo. Nonetheless, despite this, it seems quite clear that coastal exploitation increased during the Mesolithic although it is also necessary to take into account that marine transgression in the Holocene has submerged the most of the Palaeolithic coastal sites. As a result, it is not easy to know the coastal occupation ratio or the real intensity of molluscan exploitation during those periods, so it is difficult to compare them with later periods, such as the Mesolithic. Thus, our view of the economic evolution of hunter-gatherers in the Palaeolithic–Mesolithic transition is partially biased by the rise in sea level, and this fact should be taken into account (González-Morales 1995:64; González-Morales et al. 1999:63) when we come to interpret the data. On the other hand, the rise in sea level can be seen in the amounts of coastal resources found in each archaeological layer, as the exploitation of these resources and their economic viability is determined by the distance of the site from the shore. Therefore, it is possible to obtain information about site functionality from the accumulations of molluscs, at least as regards the exploitation of the coast.

In short, this chapter seeks to establish mollusc exploitation patterns over time in the eastern part of the region, in the valleys of the rivers Asón and Agüera, and determine whether the use of these resources intensified over time. Equally, settlement patterns in relation to the position of the coastline and the functionality of the sites will be analysed, based on the mollusc exploitation data.

The Study Area and Its Environment

The study area is located in the eastern part of the Autonomous Community of Cantabria (Spain) and includes the Asón and Agüera river valleys (Fig. 8.1). Today, this area is characterised by a combination of different biotopes, especially the estuaries of the two rivers, the coastal fringe, valleys, and mountains of varying heights. These mountains are found not only inland but also by the sea, forming a rather abrupt coastline. For example, the mouth of the River Agüera is flanked by the hills of Cerredo (643 m) and Candina (472 m). The River Asón is similar; surrounding its estuary are Monte Buciero (378 m), which is the location of some of the sites providing information for this research, Pico Candiano (500 m) and Pico del Hacha (173 m). As characteristically in Cantabrian Spain, the rivers are short and abrupt, flowing between mountain ranges of considerable altitudes. Inland, a succession of limestone hills, rise up to some 1,100 or 1,400 m. They were marked by the formation of glaciers in the Pleistocene and orientated perpendicularly to the ridges that the rivers flow between and mark the geographical boundary with the Castilian Meseta. The whole area, both coast and interior, is dominated by limestone lithology, giving rise to greatly karstified scenery, with numerous caves, potholes and swallets.

The climate is oceanic, of the Atlantic type, although a number of peculiarities in eastern Cantabria generate the existence of multiple microclimates in the area. The average annual temperature in the coastal area is about 14°C, and this decreases slightly as we move inland. Similar variations are found in the precipitation figures, depending on the part of the region. Annual precipitation on the coast is generally between 1,100 and 1,400 mm, and this increases inland.

The autochthonous vegetation consists primarily of deciduous forests. Between sea level and 700 m above sea level, the forests are formed by deciduous oak, holm oak, ash, lime, and other similar species. Between 700 m and the tree line, at approximately 1,800 m, the forests are dominated by beech, oak and birch.

Material and Methods

For the analysis of changes in mollusc exploitation, data are available from a number of sites that have been excavated and studied in different ways, providing enough information to make a reliable estimate. Thus, the sites of La Fragua, La Trecha, Arenillas and the Mesolithic level at La Chora (Gutiérrez-Zugasti 2006, 2009a, b) were the focus of an archaeomalacological study. The methodology used to identify and quantify the malacological material is based on that developed by Moreno (1994), with the modifications and extensions proposed in Gutiérrez-Zugasti (2009a). The nomenclature of the species has followed the CLEMAM list for the northern Atlantic (http://www.somali.asso.fr/clemam/index.clemam.html). The shell-gathering zones were established according to the habitat preferences of each species and their amounts in the deposits. In the case of *P. vulgata*, the

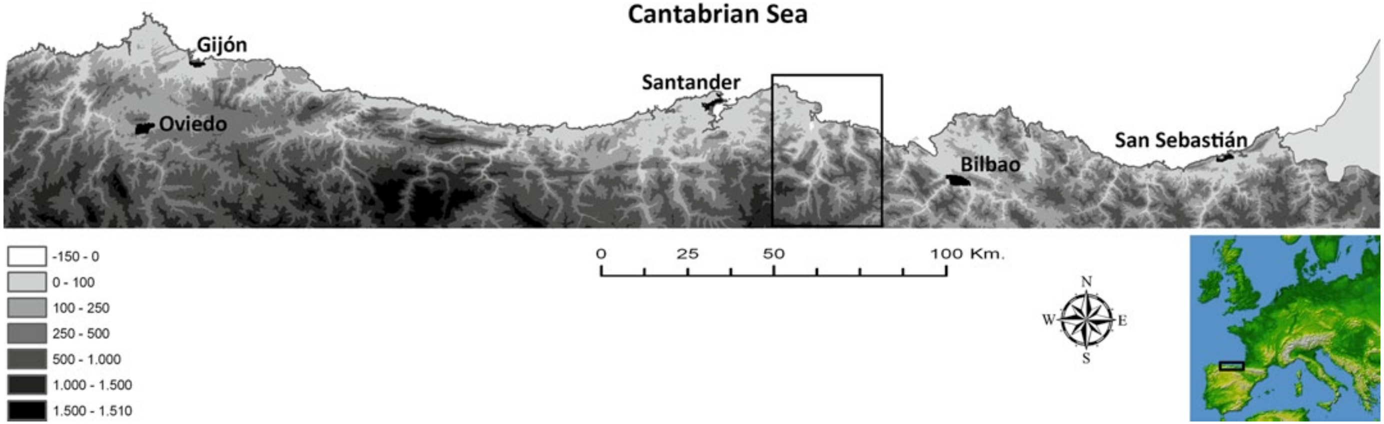

Fig. 8.1 Location of the study area

length/height ratio has been used to establish the zones, while the equations given by Bailey and Craighead (2003) were used to determine the exposure. The ages of this species were determined by using the method described by the same authors, based on counting the annual growth rings.

In addition, the literature has been studied to acquire the data from other sites, of which only El Perro (Moreno 1994), El Horno (Fano 2005; Vanhaeren et al. 2005), El Mirón (Straus and González-Morales 2005) and partially Cubío Redondo (Aparicio 2001; Ruiz-Cobo and Smith 2003) and Cofresnedo (Ruiz-Cobo and Smith 2003) have been studied with modern methods. For other sites, the information is limited to the simple mention of the presence or absence of different species, as occurs in the old levels at La Chora (Madariaga 1963; Yudego 1995), El Otero (Madariaga 1966; Yudego 1995), El Valle (Breuil and Obermaier 1912; Obermaier 1925; García-Gelabert and Talavera 2004) and El Tarrerón (Apellániz 1971).

The information regarding the chronology of the sites can be seen in Table 8.1. All calibrations in this paper were made using Calpal at 1σ, CalCurve: CalPal2007_HULU (Weninger and Jöris 2008; Weninger et al. 2008), except the older dates from La Trecha (taken from shells), which were not calibrated because of the current uncertainties about the reservoir effect on the Cantabrian coast.

In order to calculate the distance of the settlements from the coastline, first it was necessary to reconstruct the curve of the rise in sea level in North Spain. This has been achieved by using global data, taken at a planetary level (Fairbridge 1961; Uriarte 2003) and regional data in relation with the French coast (Ters 1973). This information has been complemented with data from Cantabrian Spain itself (Cearreta and Murray 1996, 2000; Leorri and Cearreta 2004; Mary 1992; Salas 1995). Once the position of the coastline in each period had been determined (Table 8.1, last column), the distance from the sites was calculated by Alejandro García Moreno using ArcGis 9.2. The information on bathymetry came from BACO application, developed by the Coastal and Oceanographic Engineering Group of the University of Cantabria (Spain) and the Ministry of Environment (Spanish Government).

Molluscan Exploitation During the Late Magdalenian (15,600–13,400 cal BP)

The main evidence for the study of the Late Magdalenian in the area is provided by the sites of La Fragua and El Perro, both of which are now located on the shoreline (Fig. 8.2). However, the radiocarbon dates from both sites correspond to a moment in the Late Magdalenian when the coast would have been situated a considerable distance away from the sites (over 7–8 km away). Nonetheless, malacological material is present in both deposits, although the exploitation of this kind of resource was not systematic at this time (Table 8.2). The only molluscs gathered in any quantity were *P. vulgata* in the case of La Fragua, and *Patella* sp. and *Littorina*

Table 8.1 Chronology of the sites included in the study and corresponding sea level

Site	Level	Lab Ref.	Date RCYBP	Date cal BP	Material	Method	Source	Sea level
La Trecha	Cementado	URU-0050	5,430 ± 70	6,200 ± 90	Carbonate	C14	González-Morales et al. (2002)	1
La Trecha	Cementado	URU-0051	5,600 ± 310	6,410 ± 360	Charcoal	C14	González-Morales et al. (2002)	1
Arenillas	0	GrN-19596	5,580 ± 80	6,380 ± 70	Charcoal	C14	Bohígas and Muñoz (2002)	1
El Tarrerón	III	I-4030	5,780 ± 120	6,590 ± 130	Charcoal	C14	Apellániz (1971)	1
Cubío Redondo	3–6	Beta-106049	5,780 ± 50	6,580 ± 60	Charcoal	C14 AMS	Ruiz-Cobo and Smith (2003)	1
La Trecha	Cementado	URU-0039	6,240 ± 100		Shell	C14	González-Morales et al. (2002)	−5
La Chora	Conchero	GrN-20961	6,360 ± 80	7,300 ± 90	Charcoal	C14	Yudego (1995)	−5
Cubío Redondo	3–6	Beta-106050	6,630 ± 50	7,520 ± 50	Bone	C14 AMS	Ruiz-Cobo and Smith (2003)	−10
La Fragua	1sup	GrN-20963	6,650 ± 120	7,540 ± 90	Charcoal	C14	González-Morales (2000)	−10
Cofresnedo	V0	GrA-20146	6,845 ± 45	7,680 ± 50	Bone	C14 AMS	Ruiz-Cobo and Smith (2003)	−10
La Fragua	1med	GrN-20964	6,860 ± 60	7,710 ± 60	Charcoal	C14	González-Morales (2000)	−10
La Trecha	1	URU-0038	7,500 ± 70		Shell	C14	González-Morales et al. (2002)	−15
La Fragua	1inf	GrN-20665	7,530 ± 70	8,320 ± 80	Charcoal	C14	González-Morales (2000)	−15
El Perro	1	GrN-18116	9,260 ± 110	10,450 ± 140	Charcoal	C14	González-Morales and Díaz (1992)	−45
La Fragua	3	GrN-20966	9,600 ± 140	10,930 ± 200	Charcoal	C14	González-Morales (2000)	−55
El Valle	E1	GX-24639	10,120 ± 280	11,820 ± 480	Charcoal	C14	García-Gelabert and Talavera (2004)	−60
El Perro	2a/b	GrN-18115	10,160 ± 110	11,790 ± 250	Charcoal	C14	González-Morales and Díaz (1992)	−60
El Valle	III	GX-23798	11,040 ± 150	12,960 ± 140	Charcoal	C14	García-Gelabert and Talavera (2004)	−65
El Valle	III	GX-23799	11,050 ± 150	12,970 ± 140	Charcoal	C14	García-Gelabert and Talavera (2004)	−65
El Valle	II	GX-24638	11,130 ± 170	13,040 ± 170	Charcoal	C14	García-Gelabert and Talavera (2004)	−65
El Horno	0	GX-26410	11,630 ± 170	13,520 ± 180	Bone	C14	Fano (2005)	−70
El Perro	3	GrN-20962	12,140 ± 180	14,260 ± 340	Charcoal	C14	González-Morales and Díaz (1992)	−75
El Horno	2	GX-27456	12,250 ± 190	14,410 ± 360	Bone	C14	Fano (2005)	−75
El Horno	1	GX-27457	12,530 ± 190	14,840 ± 380	Bone	C14	Fano (2005)	−80
La Fragua	4	GrN-29440	12,960 ± 50	15,530 ± 60	Bone	C14	González-Morales (2000)	−80

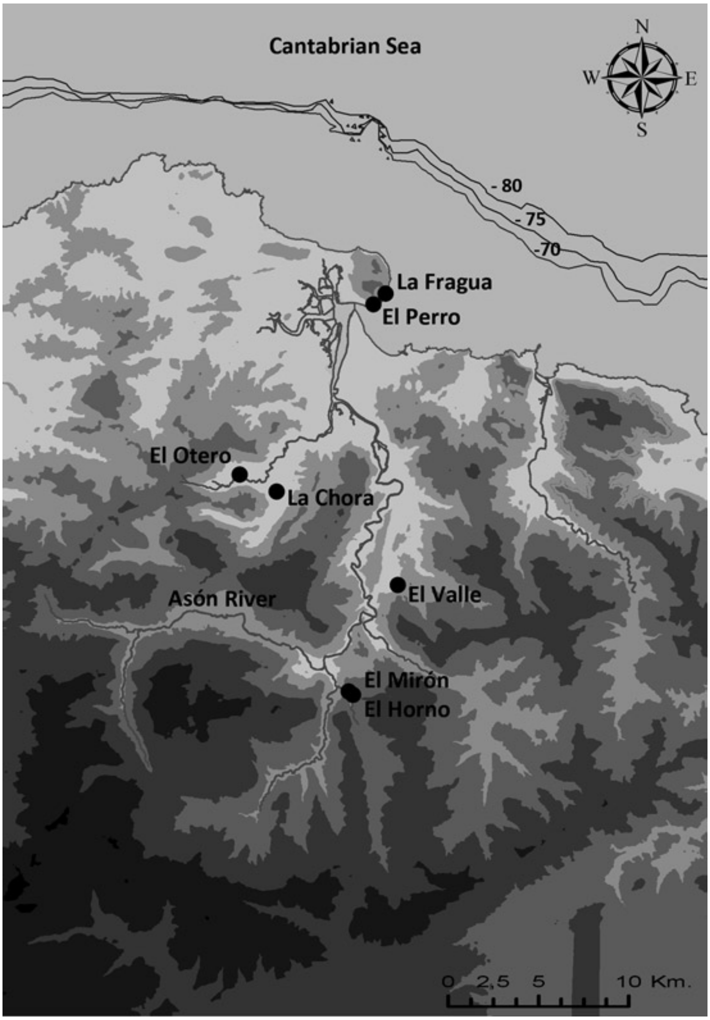

Fig. 8.2 Location of Late Magdalenian sites and sea level rise during the period (15,600–13,400 cal BP)

littorea at El Perro. The rest of the assemblages consists of a few bivalves of *Mytlilidae*, *Ostreidae* and *Cardiidae*, and gastropods potentially for use as ornamentation, such as *Littorina obtusata*, *Littorina saxatilis*, *Turritellidae* and *Nucella lapillus*. This pattern is usual in deposits of this period, with a significant presence of species preferring a cool climate. The abundance of *L. littorea* and the presence of *Mytilus* and *Ostrea* could be an indication of the exploitation of estuaries or very sheltered shores, which at that time would be more accessible from the sites than the more distant open shore. Nevertheless, the appearance of species like *Osilinus lineatus* may reflect an exploitation of more exposed coastal areas, such as beaches

Table 8.2 Abundance of the main exploited species at Late Magdalenian sites

	La Fragua 4		El Perro 2c		El Horno 3	El Horno 2	El Horno 1	El Mirón 106-107	El Otero 3	El Otero 2	El Valle
	MNI	%MNI	MNI	%MNI	MNI	MNI	MNI	MNI	MNI	MNI	MNI
Marine bivalves											
Mytilus galloprovincialis											
Mytilus sp.	1	0.2	45	4.5		1	1		P	P	
Ostrea edulis			3	0.3					P	A	
Ruditapes decussatus									P		
Scrobicularia plana										P	
Marine gastropods											
Littorina littorea	1	0.2	261	26.3					P	P	P
Osilinus lineatus			28	2.8						P	
Patella vulgata	269	62.7							P	P	A
Patella intermedia	1	0.2							P	P	
Patella rustica										P	
Patella ulyssiponensis										P	
Patella sp.	59	13.8	591	59.5							
Land snails											
Cepaea nemoralis	24	5.6									P
Total	429	100	994	100	2	11	14	3			

Quantitative data: MNI and %MNI when possible
Qualitative data: *A* abundant; *P* present; *S* scarce

Table 8.3 Zonation and exposure data of *Patella vulgata* from La Fragua, La Trecha and Arenillas

	Zonation (L/H)		Exposure	
Site and level	High shore (%)	Low shore (%)	Exposed coast (%)	Sheltered coast (%)
La Fragua – 4	52.3	47.7	47	53
La Fragua – 1	27.3	72.7	86	14
La Trecha – 1	14.9	85.1	82	18
Arenillas – 0	15.2	84.8	86.6	13.4

and cliffs, albeit in a very limited way. On the other hand, *P. vulgata* specimens at La Fragua were gathered in exposed and sheltered zones in equal proportion, and in both high and low zones (Table 8.3). Therefore, the finds of marine molluscs at these sites are probably a result of sporadic occupations as part of the coast-inland mobility of the human groups, and these sites were not used for the exploitation of marine resources because of their distance from the coast. In relation with that, it is likely that other settlements were used to exploit molluscs, located nearer to the coast at that time and now submerged under the sea.

Towards the interior of the River Asón drainage basin, two sites are of great interest, although the results obtained from them should be considered with certain precaution. These are the caves of La Chora and El Otero (Madariaga 1963, 1966), located in the Aras Valley (19–20 km from the coastline during the Late Magdalenian). Their stratigraphy suggests the human occupation took place at the end of the Magdalenian, as well as at other times. The difficulty in ascribing the malacological material to each strata with any degree of certainty was made clear in the revisions carried out by various researchers (González-Sainz 1989; Yudego 1995). This does not allow proposing a totally reliable model of exploitation. However, the available data seems to indicate the exploitation of estuaries, with a notable presence of *P. vulgata*, *L. littorea* and *Ostrea edulis*, among other species. This needs to be corroborated by more reliable data obtained by new excavations.

Finally, even further inland in the Asón valley, other sites can be chronologically situated in the Late Magdalenian. One of them is El Valle Cave (20–21 km from the coastline), with evidence of molluscan exploitation in that period. The most precise information on this aspect comes from old excavations (Breuil and Obermaier 1912; Obermaier 1925) and amounts to only a mention of the presence of abundant land snails together with a few marine molluscs, among which they cite *P. vulgata*, *L. littorea* and *Trivia arctica*. It is important to emphasise the significance of the exploitation of terrestrial molluscs, which is first seen at this time and which acquires greater importance in later periods. On the other hand, El Horno Cave (27 km) presents at least two levels belonging to this period where marine molluscs of an ornamental nature and not for subsistence were found, such as *Turritella* sp., *Trivia* sp., *N. lapillus*, *L. obtusata* and *Nassarius incrassatus* (Fano 2005; Vanhaeren et al. 2005). In the same way, only a few ornamental shells were found at El Mirón (27 km) (Straus and González-Morales 2005).

Molluscan Exploitation During the Azilian (13,400–10,800 cal BP)

To study the Azilian, it is possible to draw on information from the same sites listed above, and once again, the only totally reliable results come from El Perro and La Fragua, located 7 and 5.5 km from the coastline, respectively (Fig. 8.3). It should be pointed out that the date from La Fragua is situated on the Azilian-Mesolithic boundary in Cantabrian Spain. However, this level has been included as Azilian, as both the date and the composition of the level (with predominance of *L. littorea*) are reasonable matches for this period.

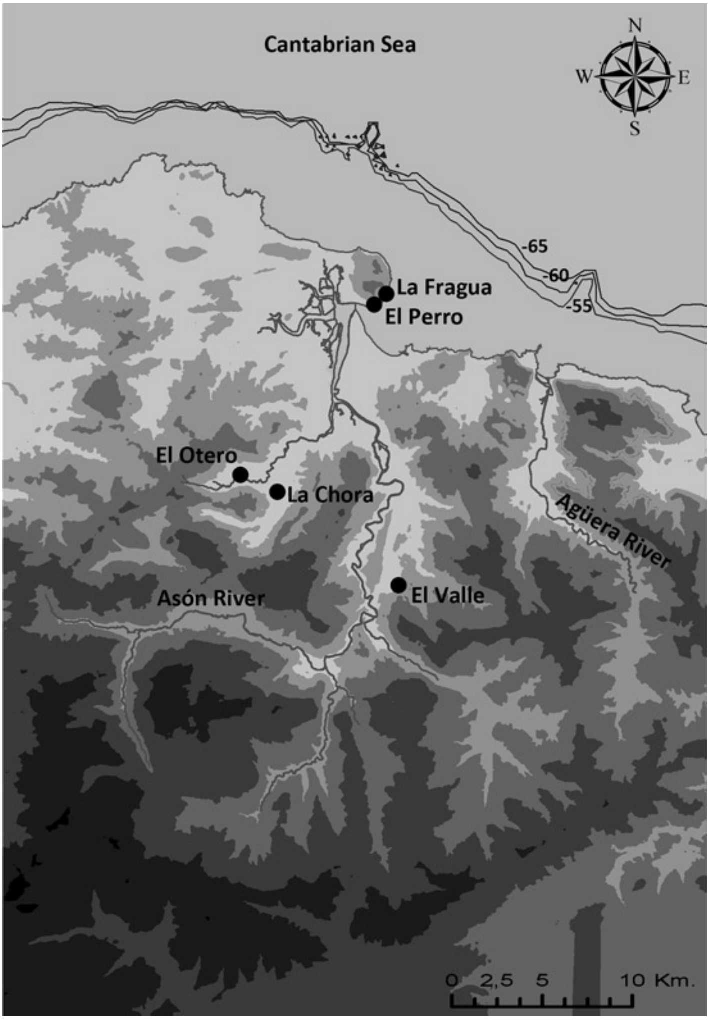

Fig. 8.3 Location of Azilian sites and sea level rise during the period (13,400–10,800 cal BP)

Table 8.4 Abundance of the main exploited species at Azilian sites

	La Fragua 3		El Perro 2a/b		El Otero 1	El Valle
	MNI	%MNI	MNI	%MNI	MNI	MNI
Marine bivalves						
Mytilus galloprovincialis	29	0.3	573	3.9		
Mytilus sp.					P	P
Ostrea edulis	1	0.1	73	0.5	A	
Ruditapes decussatus	1	0.1			S	
Scrobicularia plana					S	
Marine gastropods						
Littorina littorea	21	0.2	7,683	52.8		
Osilinus lineatus	1	0.1	114	0.8	P	
Patella vulgata	43	0.4			P	P
Patella intermedia	22	0.2			P	
Patella rustica					P	
Patella ulyssiponensis	4	0.1				
Patella sp.	56	0.5	5,186	35.7		
Land snails						
Cepaea nemoralis	10,387	93.9				A
Total	11,057	100	14,541	100		

Quantitative data: MNI and %MNI when possible
Qualitative data: *A* abundant; *P* present; *S* scarce

The most significant point is the huge difference in the exploitation carried out at the two sites (Table 8.4). On the one hand, the molluscan exploitation at El Perro continues in the same line as that followed in the previous period, although the exploitation of marine molluscs now becomes more intense, and *L. littorea* and *Patella* sp. together represent about 88% of the MNI of the level. On the other, at La Fragua, the exploitation was focused almost exclusively on the land snail *Cepaea nemoralis*, which makes up nearly 94% of the MNI of the shell midden, which has very few marine molluscs. In both cases, the pattern of marine molluscan exploitation is quite similar, and almost the same species were gathered, at least in the case of the main species. This pattern concurs with the rather cool climatic conditions that were still prevalent at the end of Younger Dryas and the start of the Pre-Boreal, and is shown by the abundance of *L. littorea* and *N. lapillus*. In the same way, the area where the molluscs were gathered is quite similar to the previous period, i.e. exploitation of estuaries or sheltered shores (*O. edulis*, *Mytilus galloprovincialis*, *L. littorea*) together with the exploitation of beaches and more exposed zones. Regarding the exploitation of the intertidal zones, the rocky high and middle shores were still being used, at the same time as a slight increase in the exploitation of the muddy low tidal zone can be detected (Gutiérrez-Zugasti 2009a). At La Fragua, however, land snails were probably gathered in the vicinity of the cave. The difference in the use of these two sites, located so near to each other, is probably related to their different accessibility and functionality. El Perro is a wide rock-shelter, which could hold a large group, with good access from the valley and probably from the estuary, whereas the characteristics and location of La Fragua were not so favourable at that time for the prolonged exploitation of both estuary and exposed coastal resources. Consequently, the site was used for a more sporadic exploitation of land snails, an occasional mammal, and a few marine molluscs.

At the sites located inland, like La Chora and El Otero (17–19 km from the coastline), it seems that the exploitation of molluscs followed a similar pattern to that at El Perro, with presence of the same species, although *O. edulis* acquired more importance. This is understandable taking into account the situation of these sites, from where the estuary could be exploited with greater ease and less effort than the open coast. By contrast, further inland (17–20 km from the coastline), at El Valle, the exploitation pattern resembles that at La Fragua, as it seems that *C. nemoralis* land snails were gathered in abundance, together with a few marine molluscs, such as *Mytilus edulis* and *P. vulgata*. However, at El Horno, although the site was probably occupied during the Azilian, as was confirmed by the dates obtained in Level 0, there is no reliable information regarding the chronological assignation of the molluscs found, given the mixed nature of the level, which contains material both of Magdalenian appearance and from other periods in recent prehistory (Fano 2005).

Molluscan Exploitation During the Mesolithic (10,800–6,800 cal BP)

The most complete archaeological records available are dated to the Mesolithic, as the sites of this period have been less affected by the changes in sea level that took place in the Early Holocene. Hence, as well as El Perro, La Fragua and La Chora in the lower Asón valley, there are sites in the middle part of the valley, like Cubío Redondo and Cofresnedo. The lower Agüera valley has the site of La Trecha. Consequently, the different sites cover much of the chronological sequence for the Mesolithic in Cantabrian Spain (Fig. 8.4).

All these sites can be divided into two types, according to the type of shell accumulation they contain. Thus, whereas at El Perro (4–6 km from the coastline), La Fragua (1–2 km), La Chora (5–10 km) and La Trecha (0–2 km), the exploitation of coastal resources was important; the other sites, located further inland, such as Cubío Redondo (18 km) and Cofresnedo (16–17 km), contain relatively fewer marine molluscs. At El Mirón (22 km) there are Mesolithic layers but without evidence of molluscs. Therefore, at this time, a double pattern can be distinguished, depending on the situation of the settlements, either coastal or inland. The data presented here supports the traditional idea that during the Mesolithic in Cantabrian Spain, the interior was occupied less intensively than in earlier periods, as is shown by the fewer sites of this type that have been discovered and by the lesser importance of their occupations (González-Morales et al. 1999; Ruiz-Cobo et al. 2007; Straus and Clark 1986). In consequence, the human groups preferred to occupy and exploit the coastal fringe rather than inland areas, which agrees with the restriction in the mobility of human groups associated with the strategy of diversifying resources.

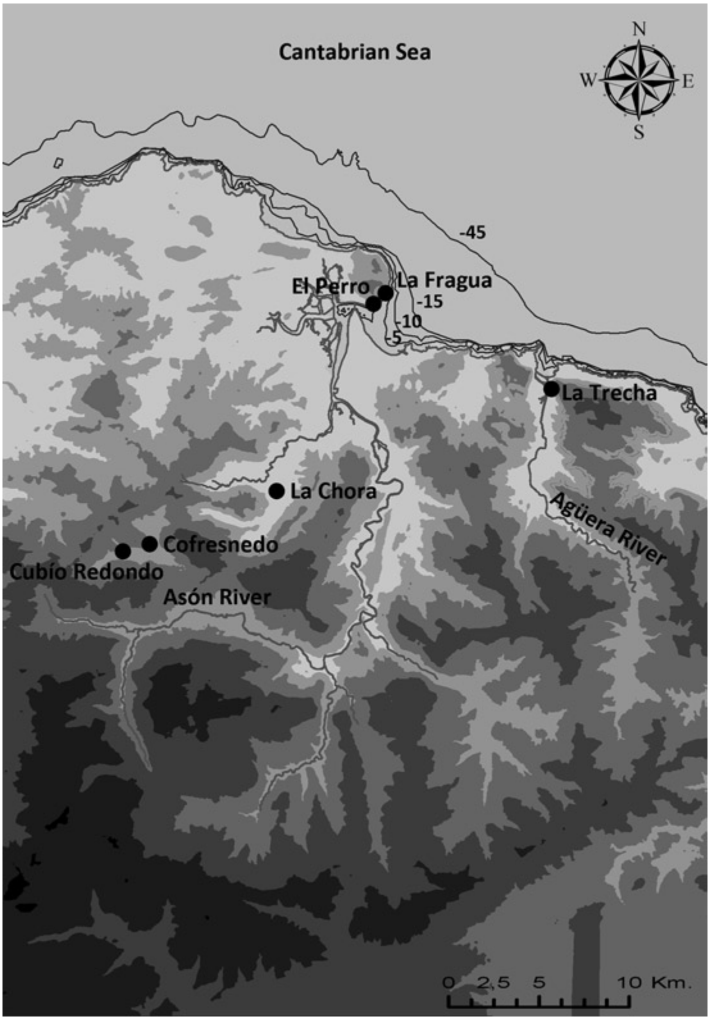

Fig. 8.4 Location of Mesolithic sites and sea level rise during the period (10,800–6,800 cal BP)

At this time, the groups occupying the coastal settlements gathered four main species: *M. galloprovincialis*, *Patella* sp., *O. lineatus* and *O. edulis* (Table 8.5). At first, as can be seen at El Perro, mussels are the species gathered most frequently. However, at La Fragua and La Trecha, *Patella* species were predominant in the preferences of the gatherers during the Mesolithic. The importance of *Patella* in the shell middens is clear, except at La Chora, where the main species are *O. edulis* and *M. galloprovincialis,* as a consequence of the prime location of the site for the exploitation of the estuary. The presence of large quantities of limpets like *Patella intermedia* and *Patella ulyssiponensis*, whose habitats are situated in the rocky shores of the middle and lower intertidal zones respectively, shows that more

Table 8.5 Abundance of the main exploited species at Mesolithic sites

	El Perro 1		La Fragua 1		La Chora		La Trecha 1		Cofresnedo V0	Cubío Redondo 3–6
	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	MNI
Marine bivalves										
Mytilus galloprovincialis	7,274	47.0	1,028	8.4	28	13.3	186	10.9	1	
Mytilus sp.									1	
Ostrea edulis	770	5.0	58	0.5	27	12.8	87	5.1		
Ruditapes decussatus			37	0.3	2	0.9	14	0.8		
Scrobicularia plana	1	0.0			72	34.1	7	0.4	1	
Marine gastropods										
Littorina littorea	55	0.4	1	0.1						
Osilinus lineatus	1,907	12.3	542	4.4			245	14.4		
Patella vulgata			875	7.1			176	10.3		
Patella intermedia			5,473	44.5	17	8.1	388	22.8		
Patella rustica										
Patella ulyssiponensis			1,302	10.6	1	0.5	85	5.0		
Patella sp.	4,931	31.8	2,505	20.4	4	1.9	307	18.0		
Land snails										
Cepaea nemoralis			214	1.7	30	14.2	24	1.4	P	A
Total	15,484	100	12,290	100	211	100	1705	100		

Quantitative data: MNI and %MNI when possible
Qualitative data: *A* abundant; *P* present; *S* scarce

exposed areas are being exploited than in earlier periods, with the added effort that this involves. In the same way, the biometric analysis of *P. vulgata* shows that this species was being collected on the exposed and lower shore (Table 8.2). At the same time, the presence of species from sandy or muddy substrates suggests gathering in estuarine areas.

Regarding the sites in the middle and upper valleys, they all contain few marine molluscs, due to their distance from the coast, which limits movements towards the coast and its exploitation. The few marine species that appear in the deposits may have been brought when the group travelled inland from the coast, or less probably, during sporadic visits to the coast from the sites. However, at Cubío Redondo (Aparicio 2001), the land snail *C. nemoralis* was consumed in large quantities, in a similar way to the consumption of the same species noted in Level 3 (Azilian) at La Fragua, and in the Late Magdalenian and Azilian levels at El Valle. It is necessary to point out that this type of strategy is found at numerous sites, especially inland ones, in the eastern sector of Cantabria (Ruiz-Cobo et al. 1999, 2007), although the absence of detailed studies for most sites does not allow a reliable chronological or cultural attribution, or any other assessment of the sites. In any case, the sites that have been researched (Aparicio 2001; Gutiérrez-Zugasti 2006, 2009; Ruiz-Cobo and Smith 2003) provide enough information to propose that this type of strategy was adopted sporadically.

Molluscan Exploitation During the Mesolithic–Neolithic Transition (6,800–6,300 cal BP)

Little information is currently available about the Neolithisation processes in Cantabrian Spain. However, if the available data is considered, some changes can be seen, mainly in subsistence and technology, after 6,800 cal BP (Arias and Fano 2003). Until approximately 6,300 cal BP, these changes are characterised mainly by the presence of pottery and some evidence of agriculture and pastoralism. This does not imply the existence of a break with the economic activities of earlier periods, as at most sites evidence has been found of both hunting and gathering, and the new productive activities of the Neolithic. After 6,300 cal BP, the main novelty is the introduction of megalithic architecture in the region.

In connection with the use of coastal resources, the exploitation of molluscs during the transition from the Mesolithic to the Neolithic, in the Asón and Agüera valleys, maintains a very similar pattern than that seen in the Mesolithic (Fig. 8.5). Thus, coastal sites such as Arenillas (0–1 km) and La Trecha (0–1 km) contain large amounts of molluscs, with a predominance of species of the *Patella* genus and *O. lineatus*, and to a lesser extent, *M. galloprovincialis* and *O. edulis* (Table 8.6). Among inland sites, these same species are found, as at El Tarrerón (17 km), although in smaller quantities, whereas at Cubío Redondo (14 km) land snails continue to be exploited, as in the Mesolithic. In the same way, the zones where the

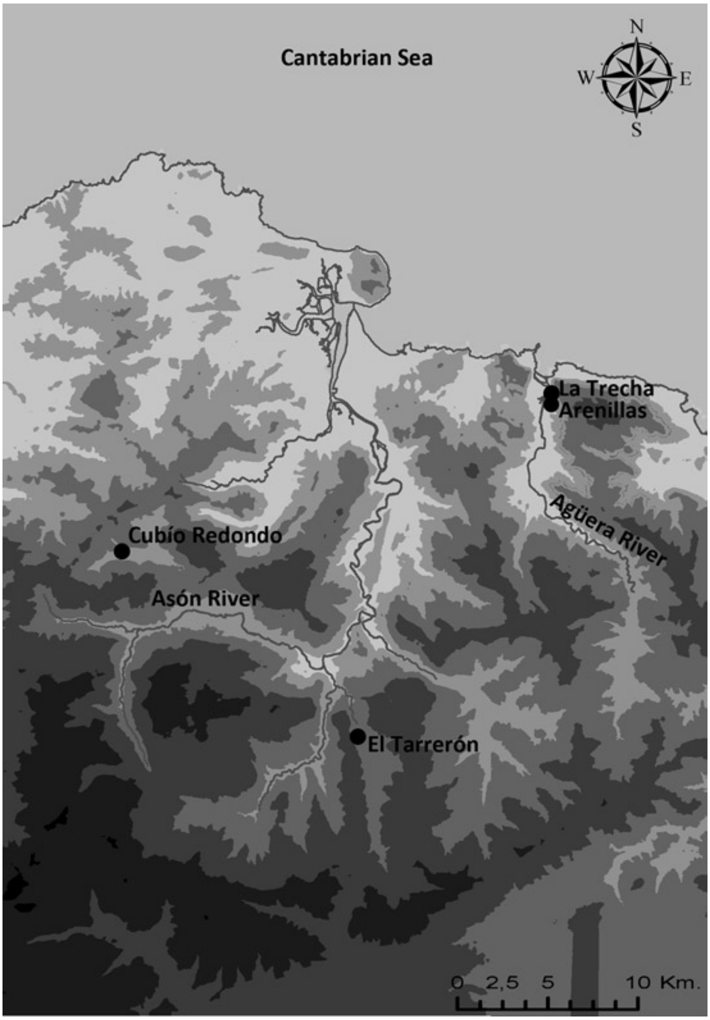

Fig. 8.5 Location of sites and sea level during the Mesolithic–Neolithic transition (6,800–6,300 cal BP)

molluscs were gathered are the same ones used in the Mesolithic, with a predominance of the exploitation of exposed, low shore, rocky zones (Table 8.2). Although the archaeological record and the available data are not abundant, a similar use to the one documented in the previous period can be observed, with an exploitation of the same species and a similar settlement pattern. In addition, none of these sites show evidence of agriculture or pastoralism, and the only new technological feature is the appearance of some pottery sherds at Arenillas.

Table 8.6 Abundance of the main exploited species at the Mesolithic–Neolithic transition sites

	Arenillas		El Tarrerón III
	MNI	%MNI	MNI
Marine bivalves			
Mytilus galloprovincialis	1,627	15.3	
Mytilus sp.			P
Ostrea edulis	755	7.1	P
Ruditapes decussatus	77	0.7	
Scrobicularia plana	43	0.4	
Marine gastropods			
Littorina littorea			
Osilinus lineatus	712	6.7	P
Patella vulgata	1,384	13.0	P
Patella intermedia	2,802	26.3	
Patella rustica			
Patella ulyssiponensis	611	5.7	
Patella sp.	1,042	9.8	
Land snails			
Cepaea nemoralis	302	2.8	
Total	10,457	100	

Quantitative data: MNI and %MNI when possible Qualitative data: *A* abundant; *P* present; *S* scarce

Discussion

Throughout the whole period, the qualitative composition of the shell middens has remained practically stable, that is to say, that the same species have been exploited at nearly all times. Hence, in general *Patella* has been the most frequently gathered genus, and is usually the most abundant in the deposits. However, at certain times, larger amounts of other species have accumulated, as occurs during the Azilian at La Fragua (*C. nemoralis*) and El Perro (*L. littorea*), and during the Mesolithic at La Chora (*M. galloprovincialis* and *O. edulis*) and El Perro (*M. galloprovincialis*). These changes could be the consequence of different reasons. First, the existence of settlements further from the coastline, or the poor accessibility of the site in the case of the Azilian level at La Fragua, would have favoured the gathering of land snails, whereas the greater ease of access to an estuary would have resulted in the exploitation of species like *L. littorea*, *M. galloprovincialis* or *O. edulis* during the Azilian and Mesolithic at the sites of El Perro and La Chora. All the species mentioned, together with *O. lineatus*, are the basis of gathering strategies, during the transition from the Pleistocene to the Holocene, for human groups in eastern Cantabria. Even so, in the light of the available evidence, *Patella* sp. can be considered as the most important malacological resource throughout the period of study.

It is worth emphasising that in this period, a notable change occurred in mollusc populations due to the improvement in climatic conditions. In the early twentieth century, Count of the Vega del Sella (1916) observed the existence of differences in the composition of Palaeolithic and Mesolithic shell middens in Cantabrian Spain, and attributed them to a warmer climate during the Holocene. The clearest example of this change is the predominance of the cool-climate adapted species *L. littorea* in the Palaeolithic and even Azilian middens, and the greater abundance of the species of milder environments *O. lineatus* during the Mesolithic. Vega del Sella and later researchers have approached this issue as if a total biological replacement took place and both species could be considered fossil-guides. However, in recent years, both species have been found together at a number of sites (Gutiérrez-Zugasti 2006, 2009a; Moreno 1994), which suggest that although the substitution may have been rapid, it was more gradual than previously thought, and this reduces their value as chronological indicators. Even so, a clear trend exists towards a decrease in the numbers of *L. littorea* parallel to a rise in the amounts of *O. lineatus*, during the course of the Holocene. In the same way, other warmth-adapted species have increased their presence in the middens with the arrival of milder conditions, causing slight changes in the qualitative composition of the shell middens. This is the case of *P. intermedia*, which becomes the most commonly gathered species of the *Patella* genus during the Mesolithic, in place of *P. vulgata*, which usually prefers cooler climates and predominates in the Late Magdalenian and Azilian. Despite this, at certain sites, *P. vulgata* continues to appear in considerable quantities in the Mesolithic.

Regarding the areas where the molluscs were gathered, if the natural habitats of the different species are taken into account, it is possible to see a slight increase in the exploitation of the lower, more exposed and rocky intertidal zones. This is reflected in the abundant gathering of species like *P. intermedia* and *P. ulyssiponensis*, especially during the Mesolithic and the Early Neolithic. However, the more sheltered high and middle zones continue to be exploited too. In the same way, in time, an increase takes place in the presence of species which live on sandy or muddy substrates (*Ruditapes decussatus*, *Solen marginatus*, *Scrobicularia plana*), which shows an increase in the exploitation of estuarine areas during the Mesolithic and Early Neolithic, probably due to the formation of Holocene estuaries at this time. However, their presence continues to be marginal in comparison with species from rocky shores, which are undoubtedly the basis of molluscan exploitation throughout the whole period.

Therefore, both the larger accumulations of molluscs and the exploitation of lower and more exposed zones seem to indicate an intensification in the exploitation of these resources. Unfortunately, the biometric data are not sufficient to be able to draw any definitive conclusions about this issue. However, according to the data from La Fragua, La Trecha and Arenillas, a decrease in size can be seen between the Late Magdalenian and the Mesolithic, corroborated by the analysis of the age distributions (Table 8.7). Thus, these data support Straus and Clark's interpretation that the decrease in size was due to greater anthropic pressure on the resources and not to climate change. Taking into account the biometric data and age distributions in Bailey and Craighead for La Riera, it can be seen not only that the sample sizes are

Table 8.7 Size and age evolution of *Patella vulgata*

			Size				Age			
			Patella vulgata		*Patella intermedia*		*P. vulgata*		*P. intermedia*	
Site	Level	Period	*n*	Length	*n*	Length	*n*	Length	*n*	Length
Arenillas	0	Meso–Neo	808	27.4	1398	23.5	106	3.9	106	3.5
La Trecha	1	Mesolithic	87	27.4	180	23.1	102	3.7	107	3.3
La Fragua	1	Mesolithic	523	27.8	2,678	25.5	118	3.6	113	3.3
La Riera	29	Mesolithic	5	42.4	34	25.1			34	4.0
La Riera	28	Azilian	107	31.8	5	28.2	36	4.4	5	4.4
La Riera	27	Azilian	183	37.7	23	30.9	40	5.2	23	4.6
La Riera	26	Late Magdalenian	126	33.2			29	4.5		
La Fragua	4	Late Magdalenian	197	33.4			112	4.3		

rather small, which is a problem for interpretation, but also that in the case of *P. vulgata*, the sizes of the individuals during part of the Late Magdalenian and the Azilian are slightly smaller than in nearly all the earlier periods, whereas in the case of *P. intermedia*, a steady reduction is seen between the Late Magdalenian and the Mesolithic, both in size and in age. Therefore, the actual data support the existence of an intensification process in the exploitation of molluscs over time, and that this process occurred in the eastern part of the region as well as in the west.

Finally, some differences have been noted in settlement patterns and the functionality of sites, in relation with the changes that took place in the position of the coastline as a result of the rising sea level. Thus, sites such as La Fragua, El Perro, La Chora, El Otero, El Valle and El Horno were situated at a certain distance from the coast in the Late Magdalenian, and were not appropriate for the exploitation of marine resources. This explains the small number of molluscs in their deposits in this period, when the sites were used for economic strategies more suited to inland areas. However, during the Azilian, some of these sites, e.g. El Perro, La Chora or El Otero, because of their increasing proximity to the shoreline, were in a relatively good position to exploit the estuary, whereas others like La Fragua, despite being very near to El Perro, cannot have been chosen for this function because it has poorer access and is less inhabitable, except on rare occasions (for gathering land snails). During the Mesolithic, when the territory took on a form very similar to its present one, El Perro, La Fragua and La Chora, in the lower Asón valley and La Trecha in the lower Agüera valley, were used for a quite intense exploitation of coastal resources. At the same time, other sites located inland, in the Asón valley and distant from the coast, e.g. Cubío Redondo and Cofresnedo, have few remains of marine molluscs. These can be considered a result of occasional or seasonal coast-interior mobility and not a systematic exploitation of littoral resources. This same pattern can be seen in the transition between the Mesolithic and the Neolithic, with a wide exploitation of malacological resources at coastal sites, like La Trecha and Arenillas, and a much less important one at inland settlements, like El Tarrerón and Cubío Redondo, although at the latter site, a significant use was made of land snails, as in the Mesolithic.

Conclusions

Although the main species of the gathering strategies appear in the malacological assemblages throughout the period, some changes have occurred in the qualitative composition of these assemblages, due to the increase in the importance of warmth-adapted species (*P. intermedia*, *O. lineatus*) at the expense of those preferring cooler conditions (*P. vulgata*, *L. littorea*), as a result of the rising temperatures, mainly in the Mesolithic and Early Neolithic. In the same way, the synchronic inter-site differences in mollusc exploitation patterns are due to their different characteristics as regarding accessibility and/or functionality. In this respect, several changes have taken place in the location (coast-inland) and functionality (inland or coastal exploitation/open coast or estuary exploitation) of the studied sites, in close relationship to the sea level rise. Thus, settlements that were used in the Late

Magdalenian to exploit inland areas, as they were then located far from the coast, are used during the Mesolithic to exploit coastal resources, since the rise in sea level had brought them into an advantageous position to exploit this biotope.

In the light of the available information, a relative increase in the occupation of coastal areas and in the exploitation of molluscs can be noted throughout the chronological sequence being studied. This is shown by the distribution of sites and the steady increase in the general amounts of molluscs recovered from the deposits. Thus, at least during the Azilian, molluscan exploitation, of both marine and land species, was carried out with an intensity similar to that of the Mesolithic, as can be seen at sites like El Perro and La Fragua. Equally, an increase has also been identified in the exploitation of sandy and muddy zones of estuaries, and especially of lower intertidal areas of open, rocky shores, and this can be regarded as indicating intensification. Finally, the biometric and age distributions data for *P. vulgata* suggest a decrease in both cases, between the Late Magdalenian and the Mesolithic, reflecting an intense exploitation of these resources. Therefore, the data indicate the existence of an intensification process in the exploitation of molluscs which began at least in the Azilian.

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Chapter 9
Paleolithic Landscapes and Seascapes of the West Coast of Portugal

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Introduction

The antiquity of coastal adaptations has gained renewed attention in the last several years as archaeologists have recognized that coasts have long been important foci of human settlement (Bailey 2004; Bailey and Milner 2003; Erlandson and Fitzpatrick 2006; Fa 2008; Price 1995; Sauer 1962; Westley and Dix 2006). As Bailey and Milner (2003) pointed out,

> … coastlines have been a primary focus for human settlement, population growth and dispersal from the earliest periods of prehistory, dynamic zones of cultural interaction and social change, and that they should not be viewed as marginal zones or barriers but as gateways to human movement, contact and cultural innovation (p.2).

Coastal zones are ecotones where marine, estuarine, and terrestrial habitats converge to produce some of the ecologically richest places on the planet. The shore offers many easily gathered food options including molluscs, crustaceans, echinoderms, stranded marine mammals, and even fish and birds. Estuaries contain abundant communities of edible shellfish and plants. The moderating influence of the ocean provides a more equable climate for many plants and animals, including humans. During the Pleistocene, coasts offered refugia for plants and animals when harsher climatic conditions prevailed. Pleistocene coasts were as dynamic and productive as they are today and certainly attracted foragers throughout the Paleolithic.

In recent research, the timing of coastal settlement and resource exploitation has become intimately linked to the emergence of modern human behavior, especially regarding social interaction, diet, and physiology. So far, the earliest evidence is associated with early modern humans in South Africa, perhaps as early as 160,000 years ago (Henshilwood et al. 2001; Marean et al. 2007; Parkington et al. 2004). This is manifested in both subsistence residues and the production of shell beads

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for personal adornment (Henshilwood et al. 2004; d'Errico et al. 2005). Coastal resources may have also played a critical role in the development and expansion of the human brain by providing long-chain polyunsaturated fatty acids, specifically docosahexaenoic acid (DHA) (Broadhurst et al. 1998, 2002; Crawford et al. 1999; Cunnane et al. 1993; Cunnane 2000; Eaton et al. 1998; Parkington 2001). DHA is not produced in the human body and occurs naturally in aquatic plants and animals. If coastal resources supplied this "brain-specific" nutrient at the time of major relative brain size increase, evidence for coastal settlement and subsistence should date to roughly 500,000 years ago with the appearance of archaic *Homo sapiens* or *H. heidelbergensis* (Parkington 2001; Ruff et al. 1997).

In Europe, the importance of coasts to early humans has been difficult to ascertain given the rarity of coastal Pleistocene sites. Despite this problem, the available evidence shows that early humans occupied coastal zones. The Lower Paleolithic site of Boxgrove is located in a coastal setting, but marine resource utilization by *H. heidelbergensis* is not evident (Roberts and Parfitt 1999). In her taphonomic appraisal of Terra Amata, Villa (1983) reported the recovery of burned *Mytilus* shells that would appear to confirm their collection and consumption by humans. At Grotte du Lazaret, shells from several species of marine gastropods, bivalves, echinoderms, brachiopods, and bryozoans provide evidence for transport and use of marine resources (de Lumley et al. 2004). A few coastal caves in Italy, Gibraltar, and Portugal offer unequivocal evidence that Neanderthals consumed seafood (Antunes 2000a, b; Stiner 1994; Stringer et al. 2008). Was this an occasional occurrence, or was coastal settlement a regular part of Neanderthal ecology? We know that Neanderthals successfully adapted to rapid fluctuations in climate, at millennial and centennial scales, throughout Marine Isotope Stages (MIS) 4 and 3. The recent research on stable isotopes and trace elements and biophysical studies of metabolic requirements suggest that Neanderthal ecological niches in much of western and central Europe were similar to large carnivores: low population density, highly mobile, focused on medium and large herbivores. This strategy remained successful until anatomically modern humans arrived around 40,000 years ago. In the Mediterranean region, a flexible adaptive strategy to exploit coastal ecosystems may have enabled a longer survival (Finlayson 2008; Hockett and Haws 2005, 2009). Sites such as Figueira Brava, Gorham's and Vanguard caves show that Neanderthals in Iberia apparently enjoyed a greater diversity of large and small terrestrial game, marine mammals, fish, shellfish, birds, and edible plants than populations in western and central Europe (Antunes 2000a, b; Stringer et al. 2008). By 55,000 years ago, Neanderthals may have overexploited shellfish communities in coastal Latium (Stiner 1994; Stiner et al. 2000).

Upper Paleolithic modern humans arrived in Europe with a coastal appreciation demonstrated by the Aurignacian use of marine shells as personal adornments (Kuhn et al. 2001). Coastal dietary adaptations are well documented by the stable isotope analyses of the Gravettian burial "Il Principe" from Grimaldi Cave in Italy (Pettitt et al. 2003). This individual apparently derived up to 25% of his diet from the sea. Manne and Bicho (this volume) present further evidence of Gravettian marine exploitation at Vale Boi in southern Portugal. Solutrean people in Cantabrian

Spain heavily exploited marine shellfish as the limpet size diminution data from La Riera show (Ortea 1986). Morales-Muñiz and Roselló-Izquierdo (2008) document a broad range of marine resource use at Cueva de Nerja in southern Spain. Evidence for coastal adaptations increases substantially by the end of the Pleistocene and early Holocene as eustatic sea-level rise and isostatic change brought the shoreline closer to modern positions (Bicho and Haws 2008). Thus, in Europe there is evidence for at least 55,000 years of coastal resource use by humans.

In this chapter, we define the coastal zone of the Portuguese margin and present a model for Paleolithic coastal settlement in Portugal in relation to variation in ocean productivity and environmental change. We then discuss the archaeological and geological evidence for Pleistocene coastal deposits in Portugal. In some sections of the Portuguese coast, steep bathymetry and tectonic uplift have protected Pleistocene coastal landscapes and Paleolithic cave and open-air sites. Sites that would have been close to the sea during MIS 3 highstands and MIS 2 lowstands contain evidence of marine resources. Figueira Brava was near a raised MIS 3 shoreline and has evidence for marine mammals, shellfish, and birds (Antunes 2000a). Vale Boi, in Algarve, contains evidence for marine exploitation during MIS 2 from the Gravettian to the Magdalenian deposits (Stiner 2003). The site is only 2 km inland today and was likely the same distance inland during the Pleistocene (Bicho 2004). Recently discovered open-air archaeological deposits at Praia Rei Cortiço and Mira Nascente in Estremadura demonstrate that Neanderthals regularly occupied coastal wetlands during MIS 5 and 3. Here, we present details on these locales and their implications for understanding Neanderthal behavior and the antiquity of coastal adaptations in Europe.

Defining Coastal Zones

Westley and Dix (2006) highlight some key issues for conceptualizing the coastal zone. Three important variables include distance to the tidal zone, extent of maritime influence on climate and environment, and human perception. The strictest definition of a coastal zone would conservatively limit discussion to an area of a few meters to hundreds of meters inland from the shore. Arguably, large estuaries may extend many kilometers inland, and thus distance to shore may increase and include substantially larger areas. The influence of oceanic conditions on terrestrial climate and vegetation may extend hundreds of kilometers inland. This is certainly the case for Iberia as the characteristic Mediterranean climate of warm, dry summers and cool, wet winters is generated by the position of the Azores High and the strength of the North Atlantic Oscillation.

Human perception of coastal zones is equally problematic as many "coastal" peoples have territorial ranges that may extend hundreds of kilometers inland. Of course, any coastal vs. inland distinction is an analytical concept created by archaeologists and probably does not reflect past peoples' perception of space. Archaeologists often rely on the distribution of shell middens and other marine items as an indicator of coastal adaptations. This can seriously limit an appreciation of the past, since shell middens reflect a specific type of coastal resource use and their importance may be overrepresented by preservation/visibility biases. Furthermore, shell middens are usually found within a few kilometers of the tidal zone; thus, demarcating the areal extent of coastal adaptations based on the distribution of shell middens in time and space reflects an extremely conservative perspective (Bailey and Milner 2003).

The archaeological record for the Upper Paleolithic provides a basis for considering a more inclusive definition for a coastal zone. From at least the Upper Paleolithic in Portugal, people transported coastal items to sites up to 40 km inland (Haws 2003; Bicho 1994; Moreno-Garcia and Pimenta 2002; Zilhão 2000). The Gravettian site of Lagar Velho, with cetacean remains, would have been 15–20 km inland (Moreno-Garcia and Pimenta 2002). Lapa do Picareiro would have been almost 40 km inland when marine fish and shellfish were brought to the site during the Magdalenian (Bicho et al. 2006). Lapa do Suão, which is near the coast today and contains marine fish and shellfish, would have been 25 km inland during its Magdalenian occupation (Roche 1982). Preliminary chert sourcing of Upper Paleolithic artifacts from sites in the Rio Maior valley also suggests coastal-inland movement of people during the Upper Paleolithic (Shokler 2002).

Paleolithic people likely identified themselves as coastal during the Late Pleistocene through their use of the seascape (*sensu* Bailey 2004). This human seascape in Portugal incorporated the use of marine shells as personal ornamentation or objects of beauty, the consumption of seafood, and settlement in close proximity to the shore.

Links Between Coastal Productivity and Intensity of Human Settlement

In a global survey, Perlman (1980) observed that coastal adaptations strongly correlated with coastal biomass production. The spatial and temporal variability of coastal productivity has important implications for human groups with a coastal focus (Price 1995). Variations in productivity would have required flexible adaptations to ensure survival. In a recent overview, Erlandson and Fitzpatrick (2006) reiterated these points and explicitly stated the need to "understand the regional productivity of marine ecosystems for humans, along with detailed archaeological research to test the linkages between marine productivity and the development of coastal and maritime adaptations" (p.10). Coastal environments are complex, and resource availability is not simply a function of climate. As Westley and Dix (2006) point out, sea level, oceanographic conditions, and geomorphology each play a role in determining the structure of coastal environments. Pleistocene climatic instability caused rapid and large amplitude fluctuations in sea level that in turn led to continuous changes in coastal environments.

During the Pleistocene, enhanced ocean circulation increased the productivity of marine ecosystems and negatively impacted terrestrial resource availability along the Iberian Margin (Pailler and Bard 2002; Thomson et al. 2000; Turner and Hannon 1988; Turon et al. 2003). Pulses of intensive coastal upwelling off the west coast of Portugal created rich, diverse marine ecosystems that would have offered tremendous opportunities for human societies (Abrantes 2000; Bicho and Haws 2008; Haws 2003). Sea-level changes and geomorphic responses constantly altered the morphology of the coast. These changes would have been especially pronounced during MIS 3 when rapid, millennial-scale fluctuations in sea level of 25–30 m amplitude occurred (Rohling et al. 2008a; Siddall et al. 2003, 2008). During lowstands, an extensive area of the continental shelf was exposed. Steepened water table gradients would have increased groundwater flow and created coastal springs and wetlands (Faure et al. 2002). Some suggest deltas were more common features than estuaries (Schubel and Hirschberg 1978; Westley and Dix 2006). During highstands, marine productivity was lower, but increased tidal ranges created estuaries and extensive mudflats. The transitional phases of climatic instability characterized by Heinrich and Dansgaard-Oeschger events would have meant constant changes in climate, coastal productivity and sea level. Even within Heinrich events, Naughton et al. (2009) have detected shifts from wet/cold to dry/cool climates due to shifts in the Atlantic jet. These changes were likely witnessed on human timescales (e.g., Larsson 2003).

Identifying and Characterizing the Pleistocene Landscape and Seascape of the Portuguese Coast

Upwelling

Rich coastal environments occur along continental margins where the upwelling of cold, deep water brings nutrients near the surface. Abundant fish, shellfish, marine mammal and shorebird communities characterize upwelling zones and humans often focus settlement along these areas to take advantage of the resources (Perlman 1980; Bailey and Parkington 1988). Hunter-gatherers of the recent past exploited coastal resources near strong upwelling zones, and this can be traced back to the Pleistocene (Perlman 1980; Erlandson 2001; Parkington 2001). Off Portugal, a moderate summer upwelling of the Canary Current flowing north along the northwest African coast creates a rich, diverse marine ecosystem (Fiuza 1983). During the Pleistocene, the Polar Front moved south during cold events, and this enhanced ocean circulation and intensified Trade Winds in the North Atlantic. Ocean productivity peaked during MIS 6, 4, and 2, as upwelling intensity increased by an order of magnitude greater than the present (Abrantes 1991, 2000). Upwelling intensity remained higher than the present during the climatic instability of MIS 3 but roughly the same as today for MIS 5. For most of the Late Pleistocene, coastal environments were highly productive, and the rich, diverse marine ecosystems would have attracted human foragers.

Paleovegetation

In general, upwelling intensity positively correlates with terrestrial aridity, thus further increasing the attractiveness of Pleistocene shores (Shi et al. 2000). Agreement can be found between the phases of intensified winds and increased upwelling and decreased temperatures and precipitation evident in the pollen records for cold periods (Combourieu Nebout et al. 2002). Pleistocene coastal vegetation in Portugal is primarily known from pollen analyses of sediments from deep-sea cores off the Iberian Margin. These cores contain pollen records from MIS 10 through the terminal Pleistocene. Broad regional-scale models of paleovegetation are possible but local-scale, fine-grained reconstructions are limited by the lack of corresponding terrestrial pollen records (Roucoux et al. 2001, 2005, 2006; Sánchez-Goñi et al. 2000; 2002). The data from MD01-2443 off SW Portugal span the period between MIS 10-6 (Roucoux et al. 2006). Peaks in pine and juniper are followed by rises in deciduous oaks. Evergreen oaks, olive, hazel, and alder are visible during high arboreal phases. During the interstadials and glacials, Ericaceae spikes as arboreal pollen decreases. The MIS 5 record from core MD95-2042 indicates warm, humid conditions with a mix of Eurosiberian and Mediterranean species (Sánchez-Goñi et al. 1999). There is a continuous presence of pine and Ericaceae and relatively high percentages of deciduous oak throughout the period. Mediterranean-type evergreen oak and olive communities peak in 5e, 5c, and 5a. Steppic vegetation (*Artemisia* & Ericaceae) indicates drier and cooler temperatures during the stadials. From MIS 5a, there is a marked decline in deciduous oak forest and increase in steppic vegetation with the onset of MIS 4 (Sanchez Goñi et al. 2005). The cores MD95-2042 and Su81-18 show high percentages of arboreal vegetation in early MIS 4 followed by a gradual and sustained decrease (Sanchez Goñi et al. 2008). The MIS 3 arboreal pollen frequency ranges between 5 and 25% with peaks and valleys roughly corresponding to Heinrich and Dansgaard-Oeschger (D-O) events (Roucoux et al. 2001; Sánchez-Goñi et al. 2002; 2008). During the cold events, steppic herbs and shrubs dominated, while trees occurred in low percentages (Sánchez-Goñi et al. 2002). Peaks in Mediterranean forest correspond to D-O warm phases throughout the MIS 5-2 sequence from core MD95-2042 and Su81-18 off Portugal (Fig. 9.1).

Off northern Portugal, cores MD99-2331 and MD03-2697 record similar climatic and vegetation fluctuations, but the species composition reflects more temperate, deciduous arboreal communities with lesser Mediterranean-type inputs (Sanchez Goñi et al. 2008). Overall, arboreal pollen percentages for MIS 4, 3, and 2 are lower in these cores.

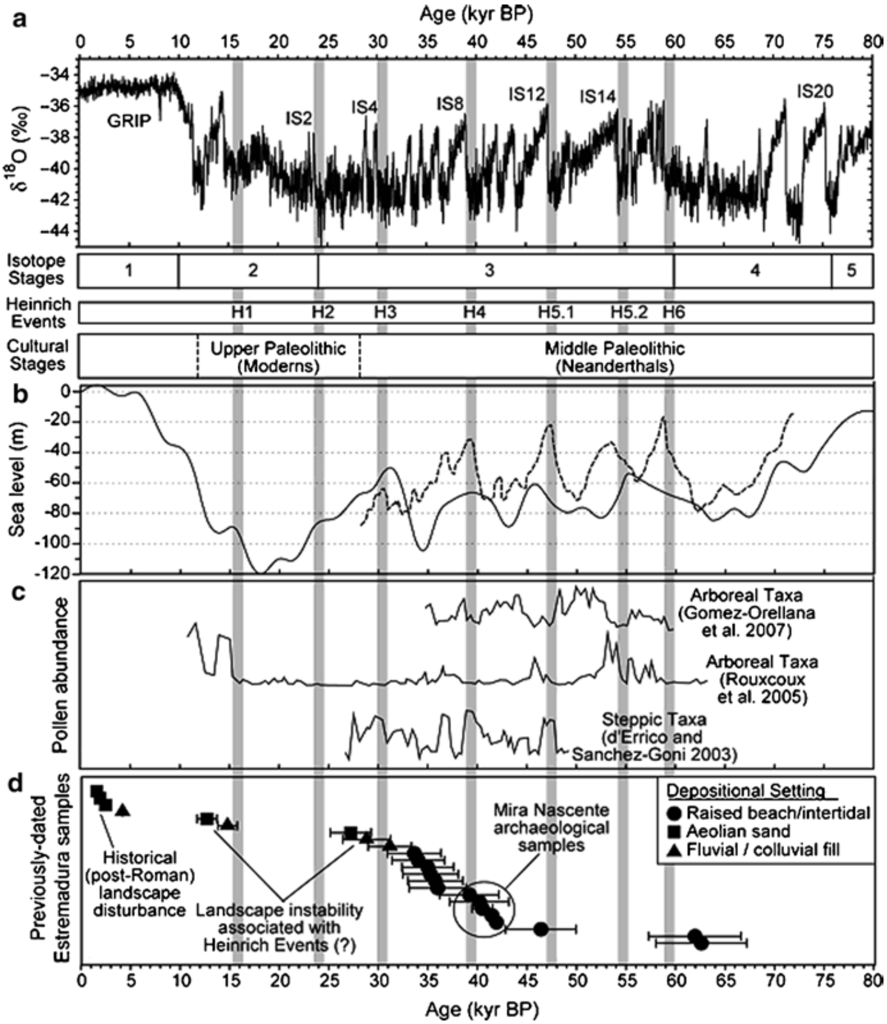

Fig. 9.1 Late Quaternary paleoenvironmental records. (**a**) Greenland ice core (GRIP) oxygen-isotope record plotted on the SFCP timescale of Shackleton et al. (2004). Greenland Interstadials (GI) numbered according to Bond et al. (1997); Heinrich Events according to Hemming (2004). (**b**) Eustatic sea-level reconstructions. Note poor agreement and large range of possible highstand levels during MIS 3. *Dashed line*: Shackleton et al. (2000). *Solid line*: Lea et al. (2002). Note possible relationship between Heinrich Events and sea-level rise during MIS 3. (**c**) Pollen abundance trends during MIS 2-3 from ocean sediment cores off Portuguese margin. Note rise in arboreal taxa between Heinrich Events, and rise in steppic taxa during Heinrich Events. (**d**) Dated samples from previous work by the project team in northern Estremadura. Note clustering of ages for three main raised beach complexes centered at 35,000, 41,000, and 62,000 BP and possible relationship between eolian/fluvial activity and Heinrich Events

The only reported terrestrial pollen records come from a series of organic deposits in the coastal cliffs at São Pedro de Muel and south of the Lagoa de Óbidos (Diniz 2003). Firtion and Carvalho (1952) reported pollen from mud beds in the cliffs at São Pedro de Muel. These contain evidence for a *Pinus pinaster* woodland and Ericaceae heathland that includes *Rhododendron.* Among the Compositae (Asteraceae) and Anacardiaceae, *Carduus* and *Rhus* were identified, respectively. Both are endemic to the Mediterranean and occur on rocky limestone substrates associated with *maquis* vegetation. *Betula* appears in the lower level, but not in the upper ones. *Corylus* shows a decreasing abundance from the bottom to the top. Our recent attempts to recover pollen from the mud layers failed to confirm these species. Instead, mud layer 1 contained Poaceae, mud layer 2 had *Picea*, *Tilia*, and *Acer*, and mud layer 3 had Poaceae, *Plantago*, and *Pinus*. OSL ages of 39,450 ± 2,980 cal BP and 46,660 ± 3,570 cal BP on sands bracketing Mud 4 suggest a correlation with D-O events. The deposits have a similar age as Mira Nascente, approximately 10 km south (Table 9.1, discussed below), and the species identified in this layer are also found at Mira Nascente. The deposits south of the Lagoa de Óbidos are radiocarbon-dated between 35 and 45,000 RCYBP but likely date to the Last Interglacial. The pollen data remain unpublished, but available summaries point to the presence of deciduous oak forests during the interstadials (Mateus and Queiroz 1993). Diniz (2003) suggested that a humid heath comprised Maritime pine, juniper, Ericaceae, and *Calluna* blanketed the coastal zone. The association of hazel, birch evergreen oak, and olive pollen indicates nearby refugia for oak-scrub Mediterranean taxa. Terrestrial gastropod frequencies from the cave, Lapa dos Furos, suggest warm, humid oak woodland in the limestone massif at 34,580 +1,010/ −1,160 RCYBP (Callapez 1999).

Paleowater

As Sauer (1962:47) noted,

> "(d)esert shores are not impoverished as is the adjacent land. If there were desert coasts, and it is most likely that there were such, potable water could still be found. Ground water, however slow and slight its movement by gravity, seeps out in places at the shore, at least at low tide."

In Portuguese Estremadura, sand mobilization and desert pavement formation along the coast indicate general aridification of the region (Daveau 1980, 1993; Zilhão 1987, 1990, 2000). Speleothem growth in Buraca Gloriosa ceased during cold periods, suggesting decreased flow or lack of groundwater in the limestone massif (Fig. 9.2). Faure et al. (2002) present a model for increased freshwater availability on exposed continental shelves during glacial sea-level lowstands. According to their model, sea-level regression steepened the coastal water table gradient and increased the hydrostatic head on inland aquifers. The released pressure from emerged land led to increased groundwater flow to the coasts. The model, based on

Table 9.1 Radiometric dates for Mira Nascente and São Pedro de Muel

Site	Level	Sample	Method	Lab reference[a]	^{14}C age[a]	Calendar age[b]
São Pedro de Muel	SP2	Quartz grain	OSL	UIC-2069		35,530 ± 2785
	SP3a	Soil organic matter	^{14}C	Beta-234378	21,640 ± 100	25,814 ± 492
	SP3b	Quartz grain	OSL	UIC-2066		35,260 ± 2590
	SP3d	Quartz grain	OSL	UIC-2068		39,450 ± 2980
	SP3e	Soil organic matter	^{14}C	Beta-208226	27,070 ±230	31,801 ±174
	SP3f	Quartz grain	OSL	UIC-2067		46,660 ±3570
Mira Nascente	MN2	Quartz grain	OSL	UIC-1875		36,035 ± 2750
		Quartz grain	OSL	UIC-1863		33,905 ± 2690
	MN3a	Charcoal	AMS ^{14}C	Beta-234375	37,540 ±600	42,175 ±461
	MN3a	Soil organic matter	AMS ^{14}C	Beta-208223	17,180 ± 80	(20,628 ± 292)
	MN3b	Organic matter	AMS ^{14}C	Beta-208224[c]	21,810 ± 160	(26,110 ± 499)
	MN3b	Quartz grain	OSL	UIC-1864		40,450 ± 2980
	MN3c	Charcoal	AMS ^{14}C	Beta-234376	36,720 ± 270	41,717 ± 311
	MN3c	Charcoal	AMS ^{14}C	Beta-208225	36,030 ± 710	40,744 ± 1,025
	MN3c	Quartz grain	OSL	UIC-1923		34,300 ± 2630
	MN4	Quartz grain	OSL	UIC-1868		>110,050 ± 8460
	MN5	Quartz grain	OSL	UIC-2065		150,920 ± 12,575
Praia Rei Cortiço	PC2a	Charcoal	AMS ^{14}C	Beta-234638	3,970 ± 40	4,448 ± 56
	PC2b	Quartz grain	OSL	UIC-2399		15,060 ± 980
	PC4	Quartz grain	OSL	UIC-2398		101,010 ± 7870
	PC5b	Charcoal	AMS ^{14}C	UGAMS-03254	46,850 ± 250	(50,356 ± 1854)
	PC5c	Charcoal	AMS ^{14}C	Beta-234369	34,270 ± 230	(39,694 ± 840)
		Charcoal	AMS ^{14}C	UGAMS-03912	49,560 ± 310	(53,781 ± 2055)
		Charcoal	AMS ^{14}C	UGAMS-03913	>51,200	Outside range
		Tree root	Conventional ^{14}C	UGAMS-03255	>49,600	Outside range

OSL ages are given for either green or blue excitation after infrared excitation, and for infrared excitation alone

[a] Beta: Beta Analytic, Inc., Miami FL. UGAMS: Center for Applied Isotope Studies, University of Georgia, Athens GA

[b] Calibration curve: CalPal2007_HULU (Weninger and Jöris 2008)

[c] Beta Analytic commented that the sample was too small for ^{13}C/^{12}C ratio measurement. However, a ratio including both natural and laboratory effects was measured during the ^{14}C detection to derive a Conventional Radiocarbon Age, suitable for applicable calendar calibration. The date should be treated as a minimum age

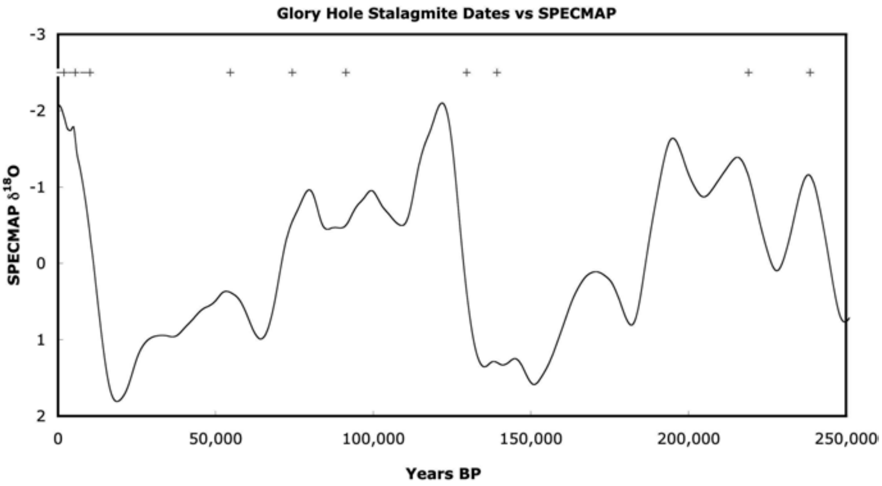

Fig. 9.2 U-Th dates from a speleothem from Buraca Gloriosa in Portuguese Estremadura plotted against SPECMAP. Dates generally correlate growth with warm periods with the exception of MIS 5e

observation of terrestrial lake basins, further suggests an increased desiccation of inland terrestrial zones as groundwater flow increased near the shore. Perennial or seasonal submarine springs characterize coastal karstic aquifers, and these would have been exposed and flowing during sea-level lowstands (Fleury et al. 2007). Thus, freshwater supplies in the karst region of Estremadura may have been restricted in the interior and readily available near the shore. Evidence for Late Pleistocene recharge of coastal aquifers is widespread in Europe (Edmunds et al. 2001). In northern Europe, ice sheets and permafrost precluded aquifer recharge during cold events, but ^{14}C and noble gas measures demonstrate recharge dating to the Last Interglacial and during mild interstadials. In southern Europe, recharge of coastal aquifers was continuous through the Pleistocene. Condessa de Melo et al. (2001) found evidence for Late Pleistocene recharge of the Aveiro Cretaceous coastal aquifer in Portugal.

Given these facts, it is likely that the western coast of Portugal was an extremely attractive place for human settlement and subsistence during much of the Late Pleistocene. Marine and estuarine resources would have been abundant, while the terrestrial resources near the coast may have been relatively poor during colder and drier periods. Freshwater would have been more plentiful near the coast due to lowered sea level and shoreward shift of water tables. For central Portugal, the most productive periods for marine resources would have been MIS 4, the Heinrich events, and cold D-O stadials of MIS 3 and MIS 2. During the Late Pleistocene cold events, coastal resources would have been critical to survival. Fish and marine mammals would have been important sources of protein and fat. Shellfish would have provided valuable carbohydrates in the absence of abundant plant carbohydrates. People may have focused settlement locations nearer the shore year round even during the warmer phases of MIS 3 as ocean productivity would have been relatively high. The intensified upwelling off Portugal would have created an extraordinarily rich marine setting with abundant fish and shellfish, marine mammals, and shorebirds. In all likelihood, Paleolithic people focused their settlement along the coast to take advantage of this easily obtained food supply.

Sea Level, Neotectonism, and Paleolithic Coastal Settlement

One of the main challenges for recognizing Paleolithic coastal adaptations has been recovering archaeological evidence of coastal settlement and resource use. Coasts worldwide have experienced rapid submergence since the LGM, inundating and/or destroying most archaeological evidence in the littoral zone. For the northern Portuguese coast, Dias et al. (2000) place the LGM sea level at −130–140 m which would mean that up to 20 km of continental shelf was exposed during Pleistocene lowstands. All previous lowstands, including those of MIS 3 should have been submerged or destroyed. However, remnants of Pleistocene coastal landforms are known from many zones along the coast of Portugal, despite the fact that most of the Pleistocene littoral zone has been lost or drowned due to sea level fluctuations (Fig. 9.3). Many of these have long been thought to result from interglacial highstands that reached heights above the present sea level. Recent application of radiometric dating techniques demonstrates that many of these are much younger and implies significant neotectonic uplift of Pleistocene coastal deposits.

Northern Portugal

In the north of Portugal, between the Rio Minho and Esposende, Meireles and Texier (2000) have summarized and reinvestigated the occurrence of 10 marine terraces thought to date between the Late Pliocene and Late Pleistocene (see also Teixeira 1944). Lower and Middle Paleolithic artifacts, predominately quartzite, have been found on these terraces (Meireles 1992). Viveen et al. (2009) observe 8 fluvial terraces of the Rio Minho that may correspond to the marine terraces. The river terraces may date to the last 800 ka, but no radiometric dates have been produced on either the marine or river terrace group.

Between Espinho and Aveiro, Granja and colleagues have reported Late Pleistocene coastal/shore deposits but no associated archaeology (Araújo 2002, 2005; Araújo et al. 2003; Carvalho et al. 2006; Granja 1999; Granja and Carvalho 1995; Granja et al. 1999; de Groot and Granja 1998; Thomas et al. 2008). At the Esmoriz and Maceda beaches, Granja and Carvalho (1995) describe two lagoonal beds of grayish silty sands and a paleoforest that comprise the Maceda Beach Formation. The upper lagoonal bed dated to the last deglaciation and the older one dated to the end of MIS 3. The paleoforest contains trunks of *Pinus sylvestris* dated between

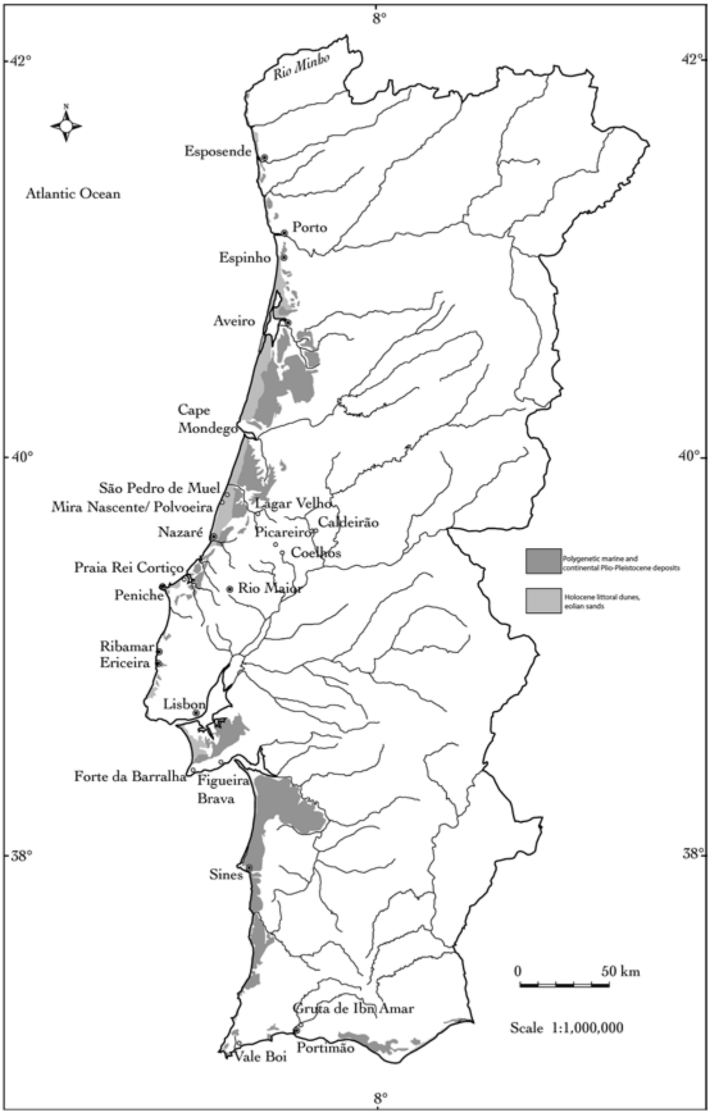

Fig. 9.3 Map of Quaternary coastal deposits in Portugal. The map also includes sites mentioned in the text

20,700 ± 30 RCYBP (24,704 ± 217 cal BP) and 29,000 ± 690 RCYBP (33,334 ± 665 cal BP). De Groot and Granja (1998) attribute the preservation of these Pleistocene and overlying Holocene deposits to neotectonic activity along the NNW-SSE strike-slip fault that controls the regional geologic framework. While the shore deposits have not yielded archaeological materials, the adjacent Quaternary dunefield contains wind-polished Paleolithic artifacts (Carvalho 1964, cited in Granja and Carvalho 1992).

Near Cape Mondego, Soares et al. (2007) report Pleistocene raised beaches from the Farol Deposit. These deposits contain marine shells (*Nucella lapillus, Patella vulgata, Littorina littorea*) indicative of cooler ocean temperatures during their formation. The authors estimate the age as Early/Middle Pleistocene, but no archaeology has been reported from this locality.

Northern Estremadura

Coastal Pleistocene deposits in Portuguese Estremadura have yielded tantalizing evidence in the past several decades. At Pedrógão, north of Leiria, Aubry et al. (2005) excavated a Middle Paleolithic site exposed below the modern beach. While the location may suggest a near-shore situation, no sedimentary details have been published, and the authors did not offer a definitive explanation of the site context.

The recent Paleolithic Landscapes and Seascapes of Portuguese Estremadura project recorded tectonically uplifted Pleistocene coastal sediments exposed in eroding coastal bluffs between São Pedro de Muel and Peniche (Benedetti et al. 2009). The region is marked by steep bathymetry offshore, intensely faulted Cenozoic sandstones and conglomerates along the coast, and Mesozoic limestone bedrock with abundant caves and rockshelters within 10 km of the shore (Fig. 9.4). Tectonic stresses including several active salt diapirs have produced a diverse assemblage of rocky headlands, protected bays, fault-strike valleys, and uplifted bedrock platforms along the coast. North of Nazaré, the study area is covered by eolian dunes that extend 10–15 km inland. To the south, isolated dunes occupy gaps in the coastal bluffs. A valley underlain by a salt diapir runs parallel to the shoreline, serving as a sediment trap for coastal-draining rivers.

Until 2005, the Paleolithic archaeology of this region was almost completely unknown due to a lack of previous field investigations. The 2005–2008 survey focused on three areas encompassing the hydrographic basin of the Rio Alcoa, Rio Tornada and the coastal margins north and south of Nazaré. The team surveyed the coastal cliffs north of Nazaré where Pleistocene deposits are visible and mapped the location of about 50 lithic scatters of which about 12 are definite Middle or Upper Paleolithic sites on exposed or deflated Pleistocene surfaces along the coast (Fig. 9.5).

Pleistocene deposits between São Pedro de Muel and Vale Paredes (Mira Nascente) sit on an uplifted wave-cut platform that is etched across dipping Jurassic limestone beds exposed at elevations of 10–20 m in the coastal bluffs. The extent of the uplifted platform coincides with the margins of an active salt diapir mapped by Rasmussen et al. (1998) that intersects the coastline. Other raised beach sections are found on similar wave-cut platforms along the flanks of the Caldas da Rainha diapir, south of the Óbidos lagoon. Stratigraphic sections atop these platforms contain a diversity of Pleistocene near-coastal deposits including foreshore, beachface, berm overwash, tidal flat, fluvial, and eolian facies (Benedetti et al. 2009).

The stratigraphic sections reveal significant sea-level variations and show that tidal flats conducive to the formation of abundant shellfish beds existed in

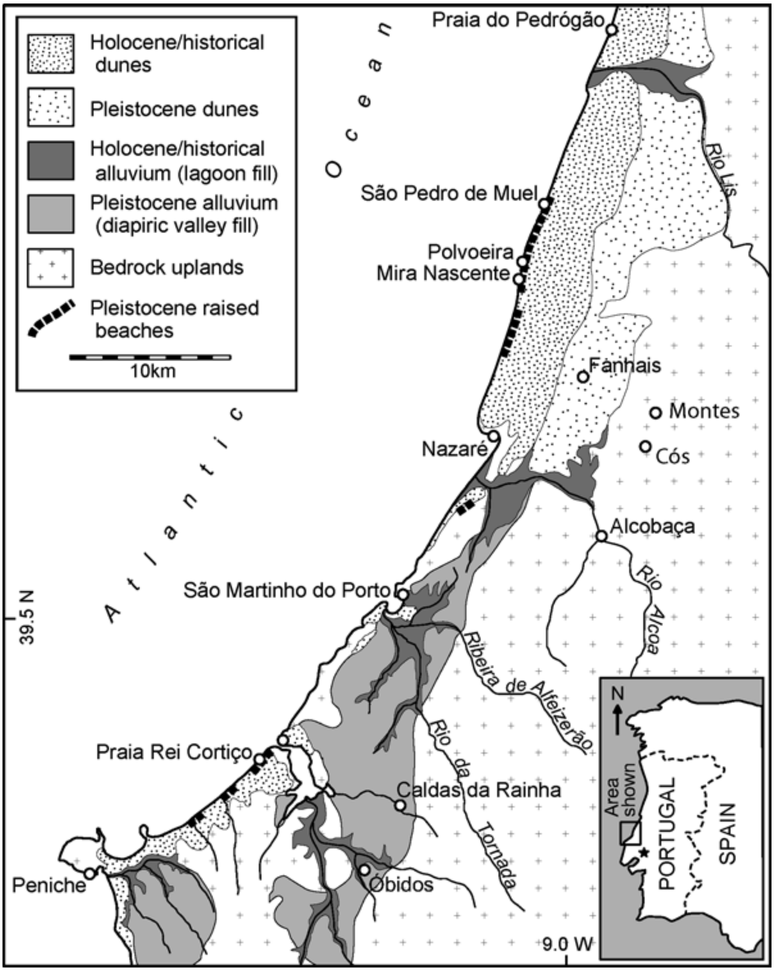

Fig. 9.4 Map of 2005–2009 survey area in Portuguese Estremadura

back-barrier and estuarine environments during the Middle Paleolithic. However, microfossil indicators of marine origin are generally not present in uplifted coastal deposits along the Iberian Atlantic margin, as has been noted in previous studies (Alonso and Pagés 2007; Ferreira 1991, 1995; Meireles and Texier 2000; Zazo et al. 1999). As a result, depositional environments in the study area have mainly been determined on the basis of sedimentary structures: hummocky cross-stratification characterizes shoreface deposits, low-angle cross beds with moderate sorting characterize beach deposits, and chevron bedded sands or wave-rippled muds characterize tidal flat deposits. Additional evidence supporting a marine origin for these deposits includes pollen assemblages that are dominated by coastal taxa(discussed below), particle size similarities with modern intertidal deposits, and very low values of magnetic susceptibility (Benedetti et al. 2009).

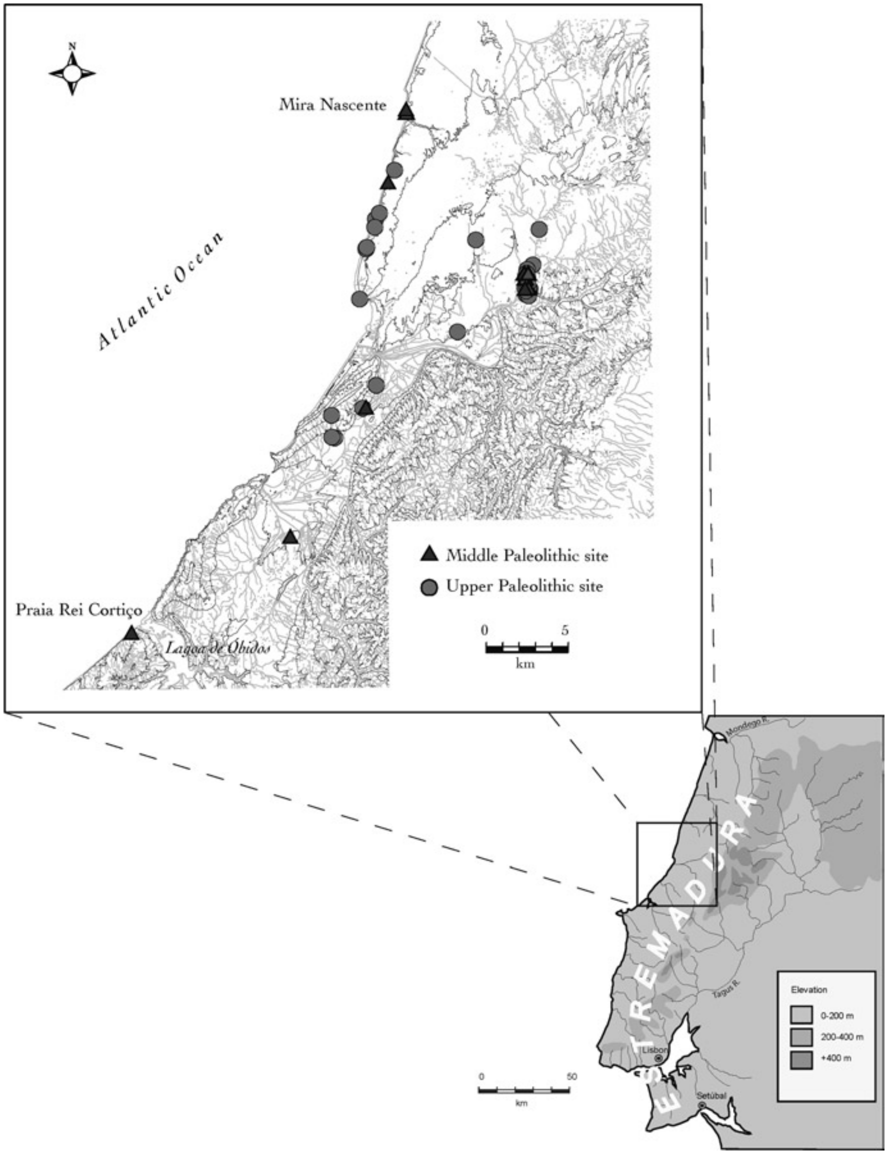

Fig. 9.5 Paleolithic sites found during the 2005–2008 survey. *Dark lines* indicate 10 m contours, *gray lines* indicate streams

Uplift rates for the Estremadura coast, including tectonic and isostatic components, can be constrained by comparing the modern elevation of raised beaches with estimated eustatic sea level during the period when they were deposited. Sea-level reconstructions for MIS 3 vary widely, but most agree on 3 or 4 high-stands between 60-30 ka reaching levels of −20 to −80 m relative to modern. Given the age of the deposits, uplift rates of about 1–2 mm year^{-1} have prevailed along this coastline. Raised beaches dating to 35 ka and 42 ka are separated by the H4 event; another at 62 ka immediately precedes H6. These ages lend support to a model of ice sheet purging and sea-level rise in phase with the timing of Heinrich Events (Hemming 2004).

Evidence from inland sections suggests climate-driven landscape instability beginning with H3 and continuing through the glacial maximum. Geomorphic activity in this period includes dune transgression, fluvial aggradation, and colluvial deposition. Luminescence ages imply that the sand mobilization began before 27 ka (Benedetti et al. 2009). Thick fills in coastal-draining river floodplains and a diapiric valley paralleling the coast suggest very high rates of upland erosion around the same time. Following deposition, the valley fills were reworked by eolian activity and later trenched during the sea level lowstand of the glacial maximum (MIS 2). These findings highlight the magnitude of geomorphic response to climatic instability during MIS 3, which was probably responsible for as much landscape change as the extreme aridity during the LGM. They also provide paleoenvironmental context for the newly discovered Paleolithic archaeological sites in the region.

Mira Nascente

One of the most significant sites found during the survey, Mira Nascente, was tested in 2005 and 2006 (Figs. 9.6 and 9.7). The site is located in a raised coastal deposit about 10 km north of Nazaré. The entire MN 2-3-4 sequence outcrops continuously in eroding coastal bluffs between Polvoeira and Vale Paredes. Testing at Mira

Fig. 9.6 Excavations at Mira Nascente

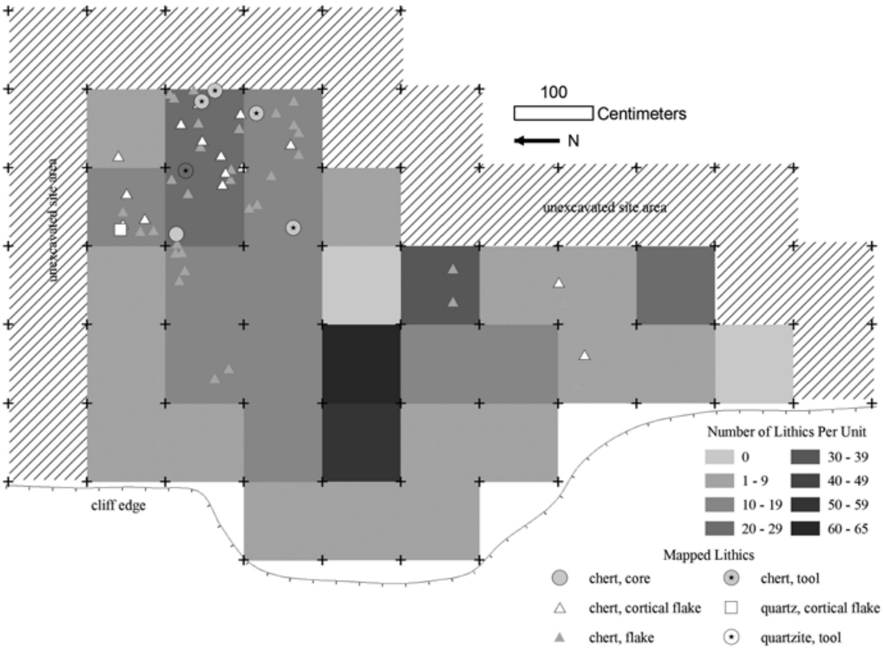

Fig. 9.7 Excavation plan of Mira Nascente

Nascente yielded a collection of flint tools, cores, and chipping debris in a discrete stratigraphic level of foredune or tidal flat sands in close lateral association with organic-rich lagoon and channel fill deposits dated 40–42 ka. The artifact-bearing stratum at Mira Nascente is a medium-to-fine white sand layer that is capped by a weak paleosol (unit MN3; Figs. 9.8 and 9.9). The sedimentology of the artifact-bearing white sand (MN3) strongly suggests a tidal flat. At Polvoeira, this unit is capped by ripple-laminated mud with root traces extending into the underlying sand (PV3a-b). The abundance of pebbles increases toward the base of the unit, in a fining-upward sequence that is consistent with tidal flow. The white sand lies beneath a beachface deposit (MN2) of medium-to-coarse yellowish-brown sand with cross-laminated beds dipping gently oceanward. These are overwash storm deposits and cross-bedded beach sand facies related to a relative sea-level rise dated 33–35 ka. Beneath the white sand lies another beach deposit (MN4) of poorly sorted coarse sand with localized flaser bedding and lenses of gravel. About 20 m south of the archaeological site at Mira Nascente, the white sand deposit thickens and contains an organic-rich channel fill deposit (MN3c). Radiocarbon and OSL results suggest that the channel was filled by younger beach sand during the relative rise in sea level associated with unit MN2. The affiliation of wide-shallow paleochannels with intertidal and beach deposits suggests that the occupation at Mira Nascente took place near the shore where a small stream emptied into the sea.

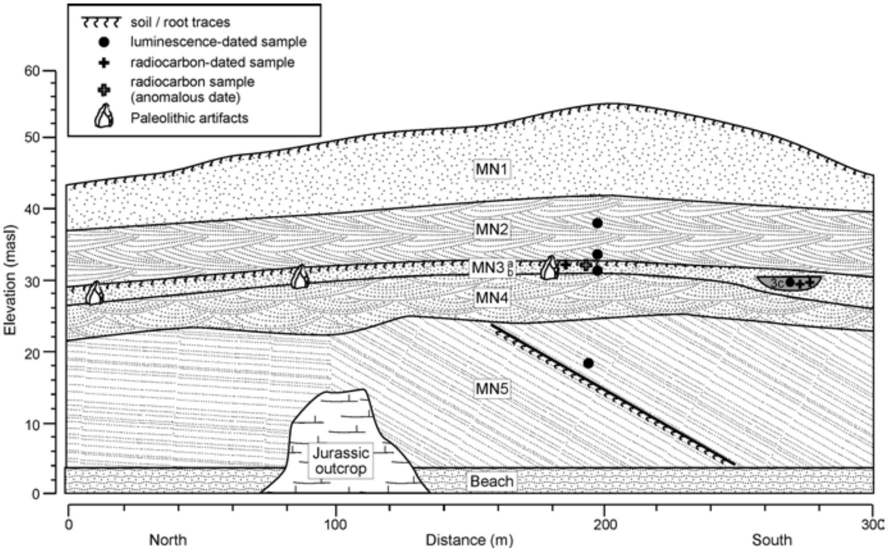

Fig. 9.8 Stratigraphic profiles for Polvoeira and Mira Nascente

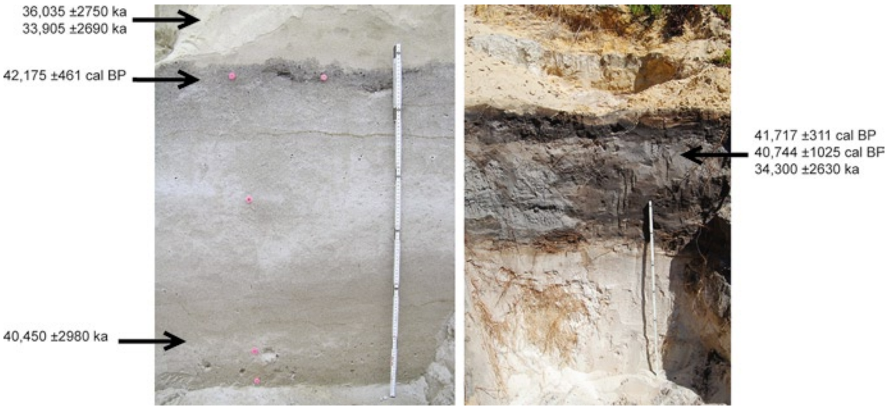

Fig. 9.9 Stratigraphic profile of artifact-bearing white sand layer and nearby channel fill at Mira Nascente

The dating of Mira Nascente places the occupation just prior to H4, which is dated to around 38,5–39 ka off Portugal (Hemming 2004; Vautravers and Shackleton 2006). OSL ages of 33–35 ka for the upper beach sand (MN2, PV2) and 40–42 ka for the artifact-bearing white sand (MN3) agree with the cultural chronology (Table 9.1). Radiocarbon dates provide further support for the OSL ages. Two dates on charcoal agree with the OSL ages on unit MN3: one from the paleosol at the top of unit MN3 (42,624 ±544 cal BP) and the other from the nearby channel fill deposit (41,280 ±656 cal BP). These ages firmly date the white sand layer, and thus the occupation, at 40,000–42,000 cal BP.

Table 9.2 Pollen grains identified from an organic-rich channel fill within the white sand layer at Mira Nascente

Taxon	No. of pollen grains
Ericaceae, (*Calluna* or *Erica*)	60
Poaceae	17
Cistaceae, (*Tuberaria guttata*)	11
Asteraceae, *Anthemis* (chamomile) type	2
Plantago	1
Pinus	5
Quercus	2
Acer	1
Alnus cf. *glutinosa*	1

Table 9.3 Lithic artifacts from Mira Nascente

	Chert	Quartz	Quartzite	Total
Flakes	61	5		66[a]
Flake fragments	15	1	1	17
Blades	6			6
Bladelets	3	1		4
Fragments	1		1	2
Chips	281	44	3	328
Cores	4		1	5
Retouched tools	1			1
Core trimming flakes	2			2
Hammerstone		1		1
Total	374	52	6	432

[a] There are a total of 5 cortical and 6 partially cortical flakes

The pollen spectrum recovered from the organic channel fill at Mira Nascente (MN3c) reflects coastal heath vegetation with some Mediterranean tree stands in the vicinity (Table 9.2). Species such as *Tuberaria guttata* (rockrose; native to western and southern Europe) are indicators for dry, rocky sites close to the sea. They prefer bare patches with a sparse cover of grasses. In the Channel Islands (UK), they are surrounded by peaty areas with *Calluna vulgaris* and *Erica cinerea* (Proctor 1960).

The context of these artifacts and the extraordinary condition of the flake edges suggest a very well-preserved occupation where spatially organized activities took place. The majority of the 432 stone artifacts recovered from the primary locality were made on reddish-brown chert that was transported to the site from primary and secondary sources that exist within 10 km of the site. These sources derive from Cretaceous limestone containing various colors. The reddish brown chert found at Mira Nascente appears as nodules or pebbles with a thin cortex similar to ones found in the immediate uplands near Cós, about 10 km southeast.

Most of the lithics are reduction debris resulting from flake manufacture. There are only five cores, of which three are of centripetal Levallois types (Table 9.3;

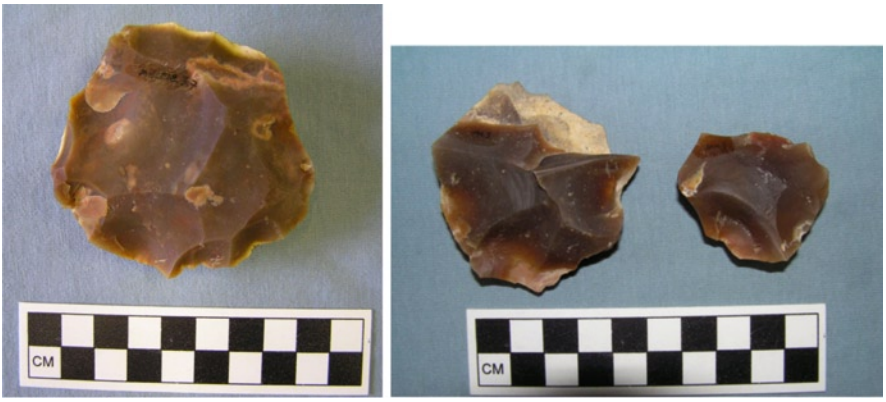

Fig. 9.10 Recurrent centripetal cores from Mira Nascente

Fig. 9.10). The excavation also recovered several Levallois flakes and points (Fig. 9.11). The morphological attributes and the class distribution clearly indicates that cores were brought to the site in a semiprepared form – the number of cortical or semicortical flakes is very low, as is the number of cortical platforms. Also, the presence of a few core trimming flakes and the very high number of chips suggest that core maintenance took place at Mira Nascente, probably to renew the flaking surface to obtain recurrent flakes and, thus, economize the use of chert. Retouched tools are virtually absent at the site with the exception of a small denticulate.

A total of 56 flakes have been refitted to one another or to specific cores. The refits link artifacts within and between most excavated units. The preliminary results of the refitting demonstrate that most if not all of the artifacts at Mira Nascente were deposited at the same time. Use-wear analyses identified patterns on several flakes consistent with soft-tissue cutting, possibly scaling fish. Bone cutting is also evident (Fig. 9.12). Most flakes exhibit no visible traces of use wear, indicating that their use did not result in visible wear or many of the potential tools were lost in the sand by the maker. Thus, the assemblage represents a unique, temporally high-resolution example of Neanderthal behavior in Portugal.

Mira Nascente appears to be a locale within a local Neanderthal seascape (*sensu* Gamble 1999; Bailey and Milner 2003). The lithic assemblage demonstrates a high degree of flexibility in land-use strategies by Neanderthals during the Late Middle Paleolithic. This technological expression suggests differences from the traditional view of land use and raw material exploitation with a disparity between coastal and inland activities and land use. Presently, the coastal sites generally appear to be much smaller than those known from caves and fluvial terraces, with fewer artifacts and very little evidence for retouch. The emergent pattern of Paleolithic settlement

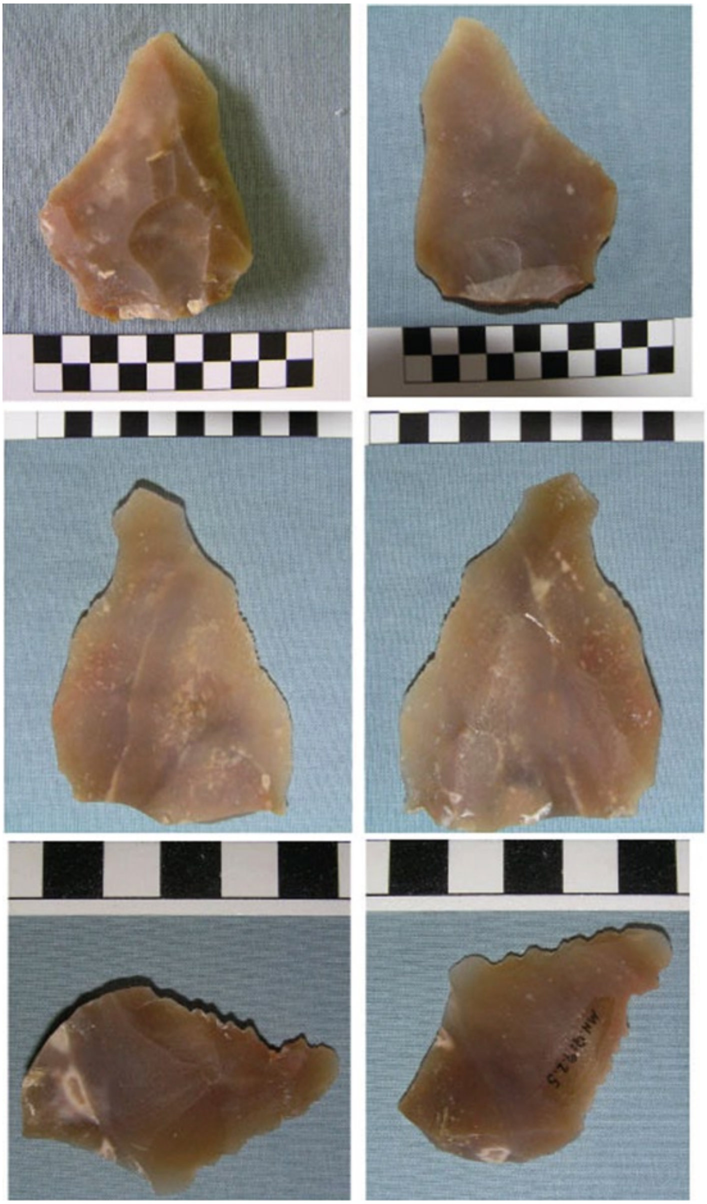

Fig. 9.11 Levallois flakes from Mira Nascente

in central Portugal is one of a continual, if poorly understood, coastal-inland movement of people in Estremadura. The Neanderthal "landscape of habit" included the coastal zone and likely expanded and contracted depending on the "rhythms" of "social and technical activities" and paleoenvironmental change (Gamble 1999: 82).

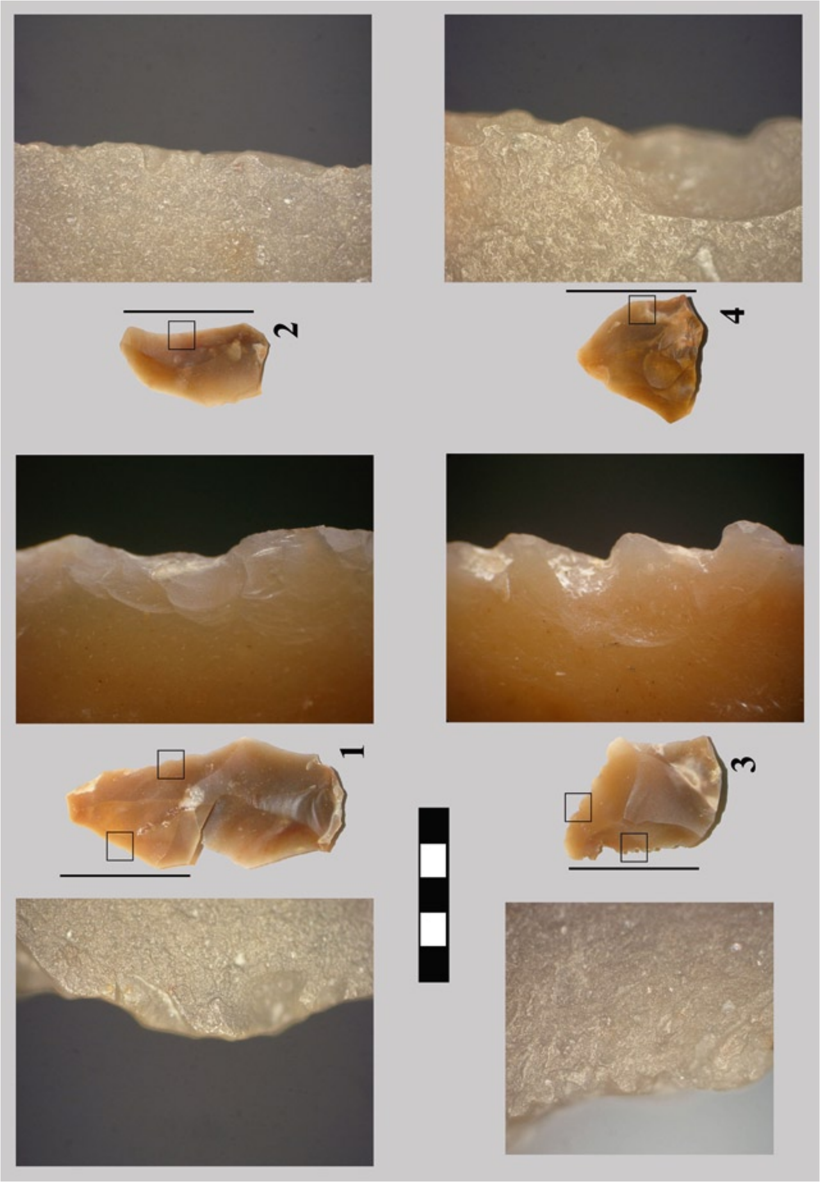

Fig. 9.12 Numbers *1*, *2*, and *4* are tools used for soft matter, possibly fish. Number 3 was used for soft or semihard undetermined matter. Macroscopic photos at 40× and microscopic photos at 200×

The massive white sand layer containing the Mira Nascente locality continues for about 1 km in the cliffs between Polvoeira and Vale Paredes. In 2006, a brief reconnaissance led to a second locality with a Middle Paleolithic sidescraper. In 2008, the survey team systematically tested the white sand layer to the north and found a third locality. One test revealed a large Middle Paleolithic flake tool with a multifaceted platform and unidirectional flake removal scars on the dorsal surface. Based on these finds, there may have been multiple occupations of the Mira Nascente locale in the Late Middle Paleolithic. Research at Mira Nascente has revealed a buried littoral seascape that Neanderthals repeatedly visited and undertook various activities and tasks (Fig. 9.13). This seascape was a "gathering" or "enduring locale" as Gamble (1999: 71) suggests. In this space, "fleeting, or at best short-lived event(s)" occurred that resulted in the accumulation of small scatters of lithic residues (Gamble 1999: 71).

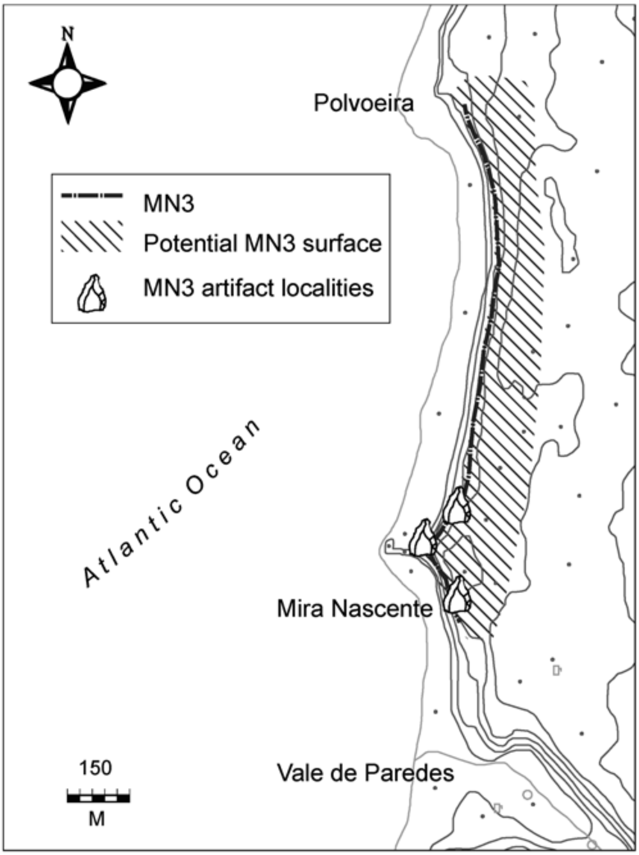

Fig. 9.13 Extent of artifact-bearing deposits and hypothesized buried landscape at Mira Nascente

Praia Rei Cortiço

Approximately 30 km south of Mira Nascente, the archaeological deposit at Praia Rei Cortiço, was found at the base of a 30-m high cliff approximately 200 m south of the Lagoa de Óbidos. This locality is contained in a paleovalley that is deeply incised into Cretaceous bedrock. The artifacts were found within a white sand and organic deposit (PC5a & b) that is sedimentologically similar to the white sand at Mira Nascente (Figs. 9.14 and 9.15). The overlying Pleistocene fill includes an eolian sand (PC4) dated 101,010 ± 7,870 cal BP, a gravelly sand deposit with flaser

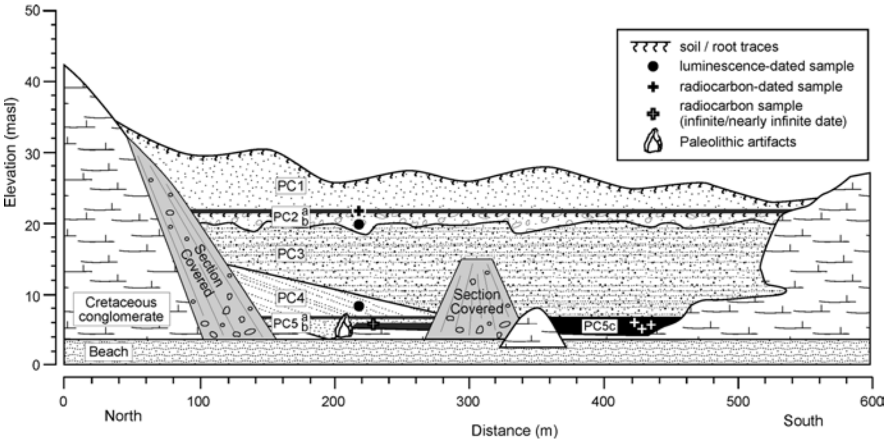

Fig. 9.14 Stratigraphic profile of Praia Rei Cortiço

Fig. 9.15 Archaeological excavation trench at Praia Rei Cortiço

Fig. 9.16 Organic-rich deposit with mineral weathering and charcoal

bedding consistent with an intertidal environment (PC3), and a gravelly fluvial deposit with clearly defined paleochannels (PC2) dated 15,060 ± 980 cal BP (Table 9.1). A thick peat deposit was exposed about 150 m south at the base of the Quaternary sequence, at the same elevation as PC5 (Fig. 9.16). Several radiocarbon determinations at the limit of the technique or of infinite age strongly suggest that the peat is beyond 50,000 RCYBP. The peat traces laterally to the north but disappears under a thick slumped section of the cliff.

The project team undertook an emergency excavation of the site in 2008. Owing to time constraints, the excavated area was very small. The team mapped a 1 × 5-m trench along the exposure. Vertical control for the artifacts was established using a transit and level. The sediments were sieved through a 4 mm and 2 mm mesh to retrieve small flakes and chips. Sediment and charcoal samples were taken from the organic-rich fill (PC5b) that appears to be the edge of the peat deposit exposed to the south. Sedimentological and micromorphological analyses are still pending. Yellow and reddish bands within the fill indicate postdepositional weathering of minerals (Fig. 9.17). This coloring is typical of marsh and tidal flat soils in which redox reaction occurs as a result of wet/dry cycles (Wells 2001). The amount of charcoal present suggests that heat alteration may have been partly responsible.

The recovered artifacts include quartzite, quartz, and chert flakes (Fig. 9.18). Many of these are cortical flakes that imply core preparation at the site. Several flakes derive from Levallois and centripetal or discoidal cores. A few have chapeau and multifaceted platforms characteristic of the Middle Paleolithic. The only retouched pieces are two notched flakes. The artifacts appear in primary context without much evidence for wind or water polishing. This suggests a fairly rapid burial by the overlying sand without lengthy exposure to the elements. Numerous

Fig. 9.17 Peat deposit at Praia Rei Cortiço

pieces of charcoal were recovered from the organic-rich deposit that contained several burned chert flakes displaying fractures and potlids. Two of the potlids remained in direct contact with their parent flakes. One piece returned an uncalibrated radiocarbon date of 46,850 ± 250 RCYBP; however, the OSL age of 101,010 ± 7,870 cal BP from the overlying sands suggests a Last Interglacial age or older (Table 9.1). Preliminary observations point to a Middle Paleolithic site located near a coastal wetland or marsh.

The thick peat deposit exposed to the south appears to have a five-part environmental sequence. The section was sampled at 1–2 cm contiguous intervals and sampled using standard methodology (Faegri et al. 1989). High sedges, heath vegetation, and pines characterized the initial stage. The species identified indicate a freshwater marsh environment with sedges and bog myrtle surrounded by open heath (Ericaceae). Deciduous hardwoods replaced this vegetation community. Nearby woodlands were composed of *Betula*, *Fagus, Corylus,* Rosaceae and other temperate and Mediterranean species. The hardwood forests abruptly converted to pine-dominated woodlands. Tree taxa become minor components and open environments establish with the rise of heath indicators. The final period indicates steppe-like conditions with abundant grasses and herbaceous types. Substantial time depth is likely for the formation of the peat. The record of environmental change suggests alterations of wet dry cycles with changing resource availability.

The accumulated data suggest that the Praia Rei Cortiço paleovalley was incised during a sea-level lowstand (MIS 6 or earlier). The subsequent MIS 5 transgression led to blockage of the valley by beach and/or dune sand. The higher water table allowed a wetland to form behind this barrier. Throughout MIS 5, this wetland witnessed several wet/dry fluctuations that altered the vegetated environment.

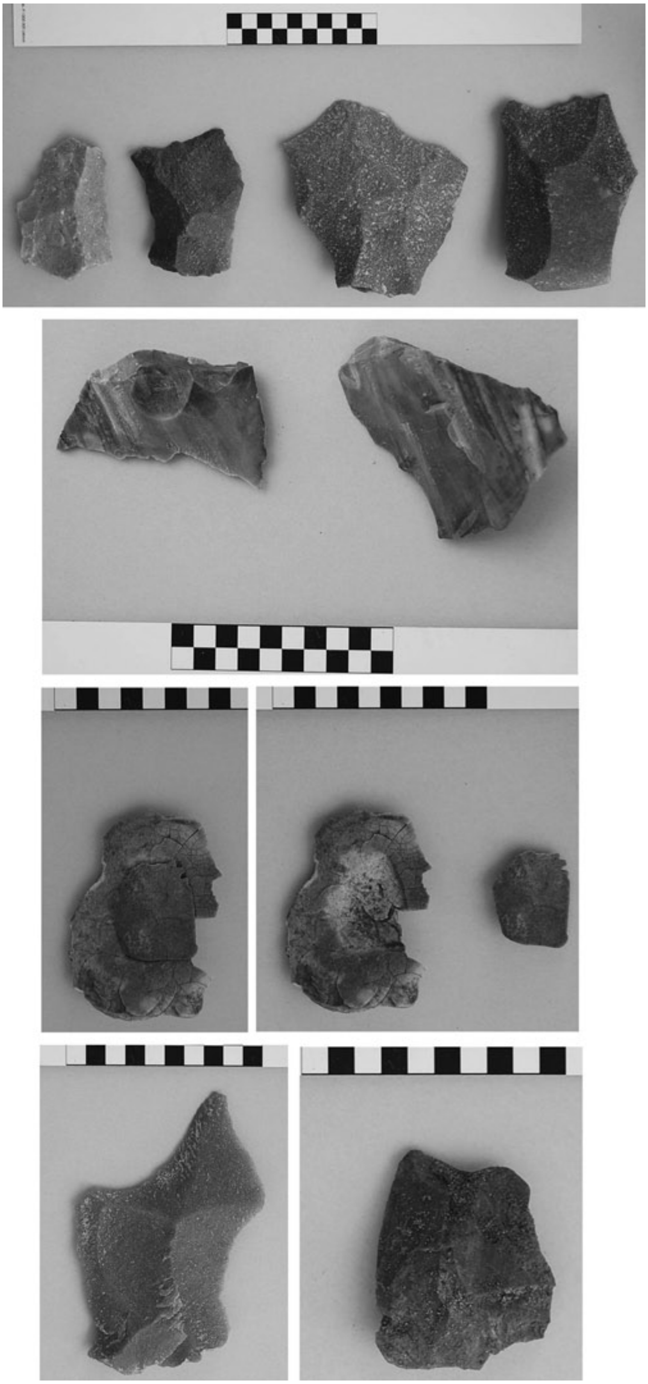

Fig. 9.18 Lithic artifacts from Praia Rei Cortiço

Neanderthals likely occupied the locale toward the latter part of MIS 5 as most of the artifacts were found in PC5a and the uppermost portion of PC5b. Increased aridity noted at the top of the peat sequence may have permitted natural fires that burned the artifacts at PC5 *in situ*. On the contrary, a cultural explanation may be offered if micromorphological analyses indicate that the deposit is a hearth.

Southern Estremadura

South of Peniche, coastal deposits such as marine platforms with gravel beaches have been known since the early twentieth century (Choffat and Dollfus 1904-07). In 1942, Abbé Breuil and Georges Zbyszewski conducted an archaeological and geological reconnaissance of the Estremaduran coast between Peniche and Cabo Espichel, documenting several localities along the coast with ancient beach deposits and cultural artifacts from the Acheulean through the Upper Paleolithic (Table 9.4) (Breuil and Zbyszewski 1945). They attributed ancient marine platforms and gravel beach deposits to a Mediterranean sequence (*Sicilien*, *Milazzien*,

Table 9.4 Localities identified by Breuil and Zybszewski (1945) and the sedimentary contexts of artifact finds

		Early Acheulean (Abbevillian)	Acheulean	Mousterian	Upper paleolithic
Peniche					
	Porto de Lobos	Ancient beach	Ancient beach		
	Praia de Consolação				Gray sands
Santa Cruz			Ancient beach	Brown sands	Gray sands
Ribamar					
	Fort of São Lourenço				
	Praia de Coxo	Ancient beach		Reddish sands	Gray sands
Ericeira					
	Fort of Milregos				
	São Julião		Pebble/gravels	Brown sands	Gray sands
Açafora		Ancient beach	Ancient beach	Brown sands	Gray sands
Magoito					
	Pedras Negras				
Praia da Aguda		Ancient beach			Gray sands
Praia das Maças			Ancient beach	Surface	Surface
Cascais					
	Guincho		Ancient beach	Reddish sands	Gray sands
	Ribeira da Foz				
	Oitavos				

Tyrrhenien, and *Grimaldien*) based on relative elevation. Platforms thought to be *Tyrrhenien* or Last Interglacial occur at 12–30 m asl, *Milazzien* (MIS 7–11?) at 40–60 m asl, and *Sicilien* at 90–100 m asl. Many of the Lower Paleolithic (attributed to the *Abbevillian* and Acheulean) lithic artifacts found in the gravel layers appeared to have been heavily rolled and abraded by the sea during Middle Pleistocene transgressions. Artifacts and pebbles have characteristic boreholes from molluscan *Lithophaga*. Wind-polished Acheulean artifacts occur in sand and gravel layers above. Mousterian artifacts were reported from overlying reddish sands that were capped in some places by gray sands bearing Upper Paleolithic artifacts. At Ribamar, near the Fort of São Lourenço, they describe deposits of yellow sand with limpet shells thought to be *Grimaldien* (*Würm*). None of these Pleistocene localities have been radiometrically dated or described in detail.

As mentioned above, the lack of bone or shell preservation in the sand deposits of northern Estremadura is likely due to higher soil acidity and precipitation that washed carbonates out of the sediments. In southern Estremadura, carbonate sand deposits preserve terrestrial gastropods in eolian dunes and marine invertebrates in raised beaches (Pereira 1987). Carbonate dunes at São Julião and Magoito contain early Holocene shell middens (Pereira and Correia 1985). Older Pleistocene sands with shell preservation occur to the south. Near the Fort of Guincho, Breuil and Zbyszewski (1945) mention in situ Mousterian artifacts with possible association of *Thais* (*Purpura) haemastoma* shells.

Setúbal Peninsula

Raised marine deposits also occur along the Arrábida chain on the southern Setúbal peninsula. Faults and diapiric folds also mark this area of the coast (Regnauld et al. 1994). A cave site, Figueira Brava, is situated above a marine platform covered by a cobbly conglomerate that extends into the cave and lies directly on the bedrock (Pais and Legoinha 2000). Excavations revealed a disturbed Holocene layer followed by three Pleistocene sedimentary layers (2–4) overlying the marine conglomerate (Antunes and Cardoso 2000). The top layers 2–3 produced over 2,000 lithic artifacts, of which 358 were retouched (Raposo and Cardoso 2000). Layer 4 is sterile sands. Most of the stone tools were manufactured on local quartz. The few chert tools were brought in as heavily worked tools made elsewhere on nonlocal raw material. The faunal assemblage shows evidence for Neanderthal use of marine and estuarine resources. A radiocarbon date of 30,930 ± 700 RCYBP on *Patella* shells places the occupation in late MIS 3.

Zybszewski and Teixeira (1949) interpreted the conglomerate as a Tyrrhenian or Last Interglacial beach based on its position approximately 5–8 m asl, an elevation widely accepted as height of the MIS 5e sea-level highstand despite the lack of supporting radiometric dates at the time for this particular locale (e.g., Rohling et al. 2008b). A few kilometers west along the coast, the platform and conglomerate are visible at Forte da Barralha where Breuil and Zbyszewski (1945) described three sand deposits with shells between 5 and 60 m asl. The one at 10–11 m elevation asl in a striking wave-cut notch recently produced radiocarbon dates of ~36,000 RCYBP (Table 9.5) (Figs. 9.19 and 9.20) (Pereira and Angelucci 2004). Therefore, the marine platform and cobbly conglomerate likely record a MIS 3 sea-level highstand instead of a Last Interglacial one if the radiocarbon dates from Forte da Barralha and Figueira are accepted. Further support can be found in the faunal assemblages from both sites.

Figueira Brava also offers tantalizing evidence for late Neanderthal use of a broad range of coastal resources, but the lack of taphonomic analysis for most of the material warrants caution (Antunes 2000c). Mammalian fauna from Figueira Brava include ringed seal (*Pusa hispida*) and dolphin (*Delphinus delphis*) (Antunes 2000b). Callapez (2000) identified 36 species of marine invertebrates of

Table 9.5 Radiocarbon dates from localities of the Arrábida coast

			^{14}C age (BP)	Cal BP
Forte da Barralha 1	ICEN-1127	Marine shell	25,250+3990/−2650	29,050
Forte da Barralha 1	ICEN-1128	Marine shell	31,540+1540/−1290	36,220
Forte da Barralha 2	ICEN-1129	Carbonate	23,810 ± 290	27,741 ± 485
Forte da Barralha 2	ICEN-1130	Marine shell	25,820+900/−810	29,395
Forte da Barralha 3	ICEN-1131	*Mytilus* sp. shells	33,730+3990/−2660	36,869
Figueira Brava	ICEN-387	*Patella* sp. shells	30,930 ±700	32,440–35,060

Adapted from Pereira et al. (2007)

Fig. 9.19 Wave-cut notch (10–11 m) above exposed marine platform west of the Forte da Barralha

Fig. 9.20 Cobbly conglomerate with shell-bearing carbonate sands adhering to the surface lying in front of the wave-cut notch

which mussel, limpet, clam, and crab were at least used as food (Table 9.6). According to his analyses, the presence of *Patella, Mytilus*, *Monodonta*, *Thais*, *Cancer*, *Maja* implies rocky shores with intertidal and infralittoral substrates. *Pecten*, *Anthocardium*, *Laevecardium*, *Lutraria*, and *Callista* indicate soft bottom, sandy banks and shoals inundated even during low tide. *Tapes*, *Solen,* and *Ostrea* prefer muddy sands in brackish estuarine waters. The shellfish from Figueira Brava indicates a diverse coastal setting with rocky shores, intertidal pools, shallow coastal water, and estuaries. Among the birds, Mourer-Chauviré and Antunes (2000) report 30 species from Figueira Brava, *Puffinus holeae* and *Larus fuscus* being the most common (Table 9.7). The Great Auk, *Alca impennis*, is also present and presumed to indicate cool oceanic conditions given its historic distribution (Antunes 2000c; Zilhão 2000). Two tortoises with different present-day habitat preferences provide apparently contradictory paleoclimate indications or perhaps represent nonanalog conditions. The European land tortoise, *Testudo hermanni,* prefers Mediterranean-type warm, dry summers, while *Emys orbicularis* prefers cooler conditions (de Lapparent-de Broin and Antunes 2000). Overall, the fauna from Figueira Brava suggest similar conditions to the present day, but a few inconsistencies point to nonanalog environments due to extended ranges of cold-adapted species.

At Forte da Barralha, Breuil and Zbyszewski (1945) list marine invertebrate shells from three localities listed in Table 9.8. The two lower deposits contain shells from species found in the area today and further evidence of nonanalog associations. *Patella*

Table 9.6 Marine invertebrates from Figueira Brava

Figueira Brava marine invertebrates	Common name	Presence/absence today
Mollusca		
Bivalvia		
Striarca lacteal	Milky ark	Present
Glycymeris glycymeris	Dog cockle	Present
Mytilus galloprovincialis	Mediterranean mussel	Present
Pecten maximus	Great scallop	Present
Anomia ephippium	Saddle oyster	Present
Ostrea edulis	European flat oyster	Present
Loripes lacteus		
Acanthocardia aculeate	Spiny cockle	Present
Parvicardium exiguum	Little cockle	Present
Laevicardium norvegicum	Norwegian egg cockle	North sea
Spisula sp.	White or Atlantic surf clam	Present
Lutraria lutraria	Common otter-shell	Present
Ervilia castanea		Present
Solen marginatus	Grooved razor	Present
Callista chione	Smooth venus clam	Present
Tapes decussatus	Cross-cut carpet shell	Present
Gastropoda		
Patella vulgata	Common limpet	Present
Patella ulyssiponensis	China limpet	Present
Patella intermedia	Black-footed limpet	Present
Patella rustica	Rustic limpet	Present
Gibbula cineraria	Gray topshell	Present
Monodonta lineata	Toothed topshell	Present
Monodonta colubrine		
Phasianella pullus	Sea snail	Present
Littorina saxatilis	Rough periwinkle	Present
Charonia lampas lampas	Triton	Present
Thais haemastoma	Drill	Present
Nassarius reticulates	Netted dog whelk	Present
Arthropoda		
Maja squinado	European spider crab	Present
Cancer pagurus	Edible crab	Present
Portumnus sp.	Small swimming crab	
Echinodermata		
Paracentrotus lividus	Purple sea urchin	Present

Data from Callapez (2000)

safiana is found today off Morocco and the Mediterranean coast of Spain, suggesting warmer waters off Arrabida during MIS 3 or at least an extended range for this particular species. While these assemblages derive from natural deposits, Breuil and Zbyzewski (1945) report Mousterian artifacts on the surrounding surfaces above the raised beaches. Given the association of Neanderthals and shellfish at Figueira Brava, it is possible that they were collecting seafood at Forte da Barralha as well.

Table 9.7 Coast-dwelling birds from Figueira Brava

Birds from Figueira Brava		
Scientific name	Common name	Presence/absence
Shore birds		
Gavia stellata	Red-headed loon	Winter
Podiceps nigricollis	Black-necked grebe	Winter
Puffinus holeae	Shearwater	Extinct
Anas platyrynchos	Mallard duck	Year-round
Melanitta nigra	Black scoter (sea duck)	Winter
Melanitta fusca	Velvet scoter (sea duck)	Winters in northern Spain
Clangula hyemalis	Long-tailed duck (sea duck)	Winters in northern Europe
Milvus migrans	Black kite	Summer
Larus fuscus	Lesser black-backed gull	Year-round
Pinguinus impennis	Great auk	Extinct
Grus primigenia	Late Pleistocene Mediterranean crane	Extinct
Numenius phaeopus	Whimbrel	Winter
Calidris canutus	Knot	Winter

Data from Mourer-Chauviré and Antunes (2000)

Table 9.8 Marine invertebrates from Forte da Barralha

Forte da Barralha marine invertebrates	Common name	Presence/absence today
Level 1 (6m asl)		
Venerupis (Tapes) pullastra	Pullet carpet shell	Present
Chamelea (Venus) gallina	Striped Venus	Rare in northern Portugal
Acanthocardia (Cardium) echinatum	European prickly cockle	Present
Cerastoderma (Cardium) edule	Common cockle	Present
Laevicardium (Cardium) norvegicum	Norwegian egg cockle	Present
Glycymeris bimaculata	Two-spotted bittersweet cockle	Present
Pecten maximus	Great scallop	Present
Mytilus edulis	Blue mussel	Present
Patella safiana	Safian limpet	Off Morocco and Mediterranean Spain
Patella vulgata	Common limpet	Present
Patella coerulea	Mediterranean limpet	Present
Echinus miliaris	Sea urchin	Present
Paracentrotus (Strongilocentrotus) lividus	Purple sea urchin	Present
Level 2 (15m asl)		
Spisula (Mactra) solida	White or Atlantic surf clam	Present
Acanthocardia (Cardium) echinatum	Prickly cockle	Present
Laevicardium (Cardium) norvegicum	Norwegian egg cockle	Present
Cerastoderma (Cardium) edule	Common cockle	Present
Mytilus galloprovincialis	Mediterranean mussel	Present
Mytilus edulis	Blue mussel	Present

(continued)

Table 9.8 (continued)

Forte da Barralha marine invertebrates	Common name	Presence/absence today
Patella vulgata	Common limpet	Present
Patella coerulea	Mediterranean limpet	Present
Paracentrotus (Strongilocentrotus) lividus	Purple sea urchin	Present
Ocenebra (Murex) erinaceus	Oyster drill	Present
Thais (Purpura) haemastoma	Dog winkle (drill)	Present
Pollicipes cornucopiae	Penduncnulate barnacle	Present
Level 3 (62m asl)		
Mactra subtruncata	Cut trough shell	Present
Spisula (Mactra) solida	White or Atlantic surf clam	Present
Donax vittatus	Banded wedge shell	Rare in southern Portugal
Cardium echinatum	European prickly cockle	Present
Pecten maximus	Great scallop	Present
Mytilus edulis	Blue mussel	Present

Data from Breuil and Zbyzewski (1945)

The marine fauna from Figueira Brava and Forte da Barralha indicate a predominance of species found in the area today. The co-occurrence of Arctic and Mediterranean species is not surprising given the climatic instability of MIS 3 and likely overlap of geographic ranges of species that are not associated today. The absence of *Strombus bubonius* shells, common in MIS 5e raised beaches from the Mediterranean to France, suggests that none of the Arrábida shell assemblages and associated marine platforms or beaches (including Figueira Brava) date to the Last Interglacial (Bardají et al. 2009). The species representation in each assemblage is consistent with the radiocarbon dates for an MIS 3 age of the formation of the deposits at both localities.

Given the estimates for MIS 3 sea level, the Arrábida data provide further evidence for neotectonic uplift of sections of the Portuguese coast. Estimates for the rate of uplift have ranged from 7.5 to 0.25 mm year^{-1}. The higher rates were based on two radiocarbon dates (26,500 ± 600, 25,100 ± 720 RCYBP) from the lower (7 m) terrace (Regnauld 1994). Regnauld et al. (1994, 1995) argued for a low rate of 0.25 mm year^{-1} considering the rate of coastal retreat along the Arrábida coast and assuming that the upper (20 m) terrace dates to the Eemian (MIS 5e) and the lower ~7 m terrace dates to the St. Germain I interstadial at about 100,000 RCYBP. Submerged marine terraces have been recorded at depths of −7, −12, and −20 m (Regnauld et al. 1994). The submerged terraces remain problematic because they are undated, yet Regnauld et al. (1994) assume that the −7 m level is mid-Holocene.

Interpretations of the raised Arrábida coastal deposits have been plagued by the continued assumption that the marine features visible in the cliffs must date to the Last Interglacial. The more recent radiocarbon dating of Barralha plus those of Figueira Brava and the paleontological data place these terraces in late MIS 3, confirming significant uplift. The thrust faults and strike-slips visible in the cliffs at Barralha offer definitive evidence for neotectonic activity (Pereira and Regnauld 1994; Pereira et al. 2007). If sea level was at −50 m at 36,000 RCYBP, then that would imply an uplift rate of about 1.7 mm year^{-1} (Pereira et al. 2007). Similar estimates have been suggested by Ribeiro and Cabral (1987) and Benedetti et al. (2009) for other sections of the Portuguese coast.

Alentejo

Quaternary coastal deposits also occur south of Lisbon, along the Alentejo coast near Sines. In the Morgavel area, a composite stratigraphic section includes a Lower Pleistocene beach, followed by Middle Pleistocene fluvial and eolian deposits, a MIS 5 marine platform subsequently deformed and capped by an eolian dune in MIS 4/3 (Pereira and Angelucci 2004). A nearby peat deposit has been dated to 42,519 ± 126 RCYBP. This layer is overlain by Pleistocene and recent unconsolidated dunes. The single radiocarbon date for the peat should be considered with caution given the lack of corroborating OSL ages and the known problems with radiocarbon dating prior to 30,000 years ago (Joris and Street 2008; Briant and Bateman 2009). To date, no archaeological remains have been found in association with these sediments, but no systematic survey has been undertaken.

Algarve

Early evidence for coastal adaptations in Algarve has been found at Gruta da Ibn Amar near Portimão. The cave opens to a large estuary where the Arade River joins the Atlantic. A freshwater spring flowing through a karst system drains into the estuary. Testing near the entrance to one of the chambers revealed Mousterian lithic artifacts in association with mussel, clam, cockle, and limpet shells (Bicho 2004). No radiometric dates have been determined. Fewer than 200 flakes were produced from discoidal reduction on a variety of chert, quartz, and quartzite raw material. The shellfish come from a mix of estuarine and rocky shore settings that suggest a different configuration of the coast during the occupation.

Long-Term Trends in Paleolithic Coastal Settlement

Recognizing Paleolithic coastal adaptations has been made difficult by the dramatic sea-level changes that have continuously altered the configuration and position of the shoreline during the Pleistocene and Holocene. The Dias et al. (2000) relative sea-level curve for Portugal places the LGM shore on the −130 to −140 bathymetric contours. Radiocarbon dates of 10,415 ± 120 RCYBP (12,310 ± 230 cal BP) (on shell samples from the mid-platform (−62 m) and 14,000 RCYBP from the external platform (−120 m) off the coast near Aveiro suggest a slow, steady rise until after H1 when sea level rose rapidly (Dias 1985). These dates were used to extrapolate the paleoshoreline for the rest of the Portuguese coast. Thus, according to Dias et al (2000), approximately 10–20 km of continental shelf may have been exposed during this period. Despite the fact that the shore was further away and much of the archaeological record has been destroyed by postglacial transgression, coastal exploitation is evident through the Upper Paleolithic. The transport of certain marine resources attests to their importance to prehistoric people, especially considering the general rule of thumb that hunter-gatherers do not typically transport these items more than 10 km inland from the shore. The Upper Paleolithic case of Portugal suggests that we need to redefine the concept of "coastal." After all, what is 10 km to a highly mobile forager? The ecotone nature of coastal environments drew Paleolithic people to the coast, and the settlement data for Estremadura demonstrate that it was a focal point due to its mosaic environment and rich resources. Sites such as Vale Boi in Algarve and Lagar Velho in Estremadura contain seafood remains in pre-LGM contexts. Other sites such as Suão, Picareiro, Coelhos, and Caldeirão provide additional direct evidence for visits to the shore throughout the Upper Paleolithic. Numerous open-air Upper Paleolithic sites have been recorded in the coastal Pleistocene sands of Estremadura, suggesting a fairly regular settlement of this coastal region by highly dispersed groups of foragers during MIS 2. Settlements probably occurred more frequently and for longer durations on the now-submerged glacial shoreline where resource availability was much higher. The coastal strip of Portugal during the Pleistocene would have been characterized by:

- Enhanced upwelling and ocean productivity.
- Reduced terrestrial plant and animal availability during cold events.
- Increased freshwater availability on the exposed continental shelf during sea-level lowstands.

While a substantial area of land may have been lost in the last 20,000 years, the impact of earlier relative sea level fluctuations is uncertain and subject to debate. Numerous places along the Portuguese coast have evidence for earlier sea-level highstands long thought to date to periods when eustatic sea level was higher than present. With the application of radiometric dating techniques, many of these features can now be placed in an age-controlled stratigraphic context. The emerging data suggest that many deposits that were assumed to date to the Last Interglacial are much younger, dating to MIS 3. The dating of Late Pleistocene coastal deposits above present sea level indicate that there has been significant neotectonic activity that has uplifted ancient shorelines and associated sediments.

Much of the evidence for Paleolithic coastal settlement is preserved by tectonic activity that has uplifted sections of the coast making them visible on land today. This has important implications for understanding the archaeological record of the region. Praia Rei Cortico and Mira Nascente demonstrate a Neanderthal presence in coastal wetlands during MIS 5 and 3, respectively. These locales offer a glimpse into the Neanderthal "taskscape" that linked the paths and tracks of their "landscape of habit" (Gamble 1999: 68; *cf*. Ingold 1993). Sites such as Mira Nascente and Figueira Brava expand the "scale of the landscape of habit" to include the littoral zone (Gamble 1999:87). The faunal preservation at Figueira Brava confirms Neanderthal exploitation of seafood at least as far back as MIS 3. The available data indicate a fairly broad strategy of exploiting a diverse range of littoral habitats. Neanderthals did not randomly and opportunistically visit the shore. Rather, Neanderthal paths and tracks across central Portugal linked terrestrial, riparian landscapes and littoral seascapes within their socially constructed landscape (Gamble 1999: 85). Thus, the use of coastal wetlands was part of recurrent settlement pattern and not simply a rare occurrence. If one takes a broader regional perspective, the record from Portugal fits into the emerging picture of a coastal stronghold for the last Neanderthals in southern Iberia (Finlayson 2008). The ecologically rich, diverse ecotone settings of the region enabled Neanderthals to persist for several millennia after their extinction in western and central Europe.

Older evidence for coastal adaptations may exist, but further survey and radiometric dating of known Pleistocene coastal deposits with associated artifacts are necessary. The numerous finds of Acheulean bifaces and flake tools on raised marine terraces or platforms in the Minho and Estremadura hint at a coastal focus by Lower Paleolithic humans in Portugal. The wind- and water-worn appearance indicates significant reworking of the artifacts, but their initial deposition must have taken place near the shore. We can speculate given the limited evidence from Terra Amata that *Homo heidelbergensis* favored the Atlantic coast as well. As Fa (2008) has argued, the higher tidal amplitude and productivity of this margin would have made it a favored zone for rapid colonization.

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Chapter 10
Small Game and Marine Resource Exploitation by Neanderthals: The Evidence from Gibraltar

Kimberly Brown, Darren A. Fa, Geraldine Finlayson, and Clive Finlayson

Introduction

Debates surrounding Neanderthals and Anatomically Modern Humans (AMH) tend to focus primarily on discussions of cognitive ability, as exemplified by perceived differences in stone tool technology, behaviour and extinction outcomes. One of the primarily cited differences involves the subsistence strategies practised by these different groups of humans (Brown 2009).

The general consensus is that "archaic" human populations, such as the Neanderthals in Europe and the Middle Stone Age populations in Africa, did not practice any form of systematic and specialised game hunting; in extreme versions, such archaic humans appear to have been inept at capturing the faster or volant of the smaller preys (Stiner et al. 1999, 2000; Richards et al. 2001, 2005; Drucker and Bocherens 2004) or unable to adequately diversify their subsistence base to incorporate other (e.g., marine) resources (Klein 1989, 2001; Klein and Cruz-Uribe 1996, 2000; Klein et al. 2004, 2007). The overall implication is that only the AMHs were capable of more fully exploiting their surroundings, which ultimately gave them an edge over other human groups.

Four main schools of thought have been identified within the relevant literature (Brown 2009):

1. There is the suggestion that Neanderthals were obligate meat eaters, a view which is claimed to have been further substantiated by recent stable isotope analyses of Neanderthal specimens which show them as dependent on a high-protein diet derived mainly from large herbivorous mammalian prey. The comparison has been made with high trophic-level carnivores, (Bocherens et al. 1999, 2005; Richards et al. 2000, 2008; Balter and Simon 2006; Lee-Thorp and

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Sponheimer 2006). This is not an unexpected result, given that the stable isotope analyses were all carried out on Neanderthal specimens that came from sites on the Eurasian Plain, a vast geographical area known for its low resource diversity especially during glacials and stadials; here, in the absence of alternative food typical of more southerly latitudes, human populations would have been forced to consume a high-protein diet (Finlayson et al. 2007). However, by taking the step of claiming a protein-rich diet for *all* Neanderthals, proponents of this scenario are moving beyond what the data they have actually support. It is essentially the same as sampling modern Inuit (who live in a low-diversity environment – Speth and Spielmann 1983; Noli and Avery 1988) and from this stating that all humans today live on a high-protein diet. Diet is known to vary geographically in present hunter-gatherers (Lee and Daly 1999) and there is no reason why we should not expect Palaeolithic subsistence strategies to similarly reflect the resources available in the various environments and habitats they occupied.

2. Data from some Mediterranean sites are used to portray the Neanderthals as scavengers/occasional hunters and gatherers. In this scenario, they are seen behaving similarly to the Spotted Hyaena (*Crocuta crocuta*), both scavenging and hunting regularly, as opposed to the Striped or Brown Hyaena (*Hyaena hyaena* and *Parahyaena brunnea,* respectively), which are obligate scavengers, or wolves and Upper Palaeolithic human populations which were obligate hunters (Stiner 1994). Again, there are problems with this scenario, once more stemming from the over-extension of biogeographically limited datasets to encompass entire species across large time spans. In the example cited above, the comparison of Neanderthals to Spotted Hyaenas and AMH to wolves and other obligate hunters (Stiner 1994) stemmed from an analysis (Coefficient of Anatomical Completeness) carried out on data obtained from some Italian Mediterranean sites. However, application of the same analysis to data from southern France instead showed the Neanderthals as behaviourally closer to wolves and Upper Palaeolithic populations, and not scavengers (Boyle 2000).
3. Although Neanderthals are considered capable of enjoying a fairly diverse diet, gathering small and slow-moving prey species such as tortoises and molluscs, extension of their hunting practices to include the capture of the more agile birds and rabbits would only take place once the sessile prey had been overexploited. Birds and hares are only thought to be exploited systematically and *en masse* during the Upper Palaeolithic (Stiner et al. 1999, 2000; Richards et al. 2001, 2005; Drucker and Bocherens 2004). This is the Broad Spectrum Revolution model.
4. This scenario sees “archaic” populations (such as Neanderthals) as completely inefficient hunters, only capable of hunting the smaller, more abundant, of the large game animals found in the surrounding areas and avoiding large and dangerous animals. They thus secured resources by random encounter. They are considered incapable of exploiting any alternative resources as successfully, if at all, when compared with behaviourally “Modern” populations (Klein 1989; Klein and Cruz-Uribe 2000; Klein et al. 2004, 2007).

There are various methodological and interpretative problems with the scenarios described, but all have one thing in common: they tacitly start from the premise that the Neanderthals were inferior species, in terms of cognitive as well as hunting abilities, when compared with "Modern" populations. Evidence from particular sites is usually then used to substantiate this claim, but these comparisons are invariably set against a backdrop of changing environmental conditions, making such assessments problematic.

In this study, we focus on evidence from Gorham's Cave and other Gibraltar sites to present a case comparing resource exploitation by both Middle Palaeolithic Neanderthals and Upper Palaeolithic AMH populations, which occupied a landscape that changed little between occupation by Neanderthals during MIS 3 and the appearance of AMH in MIS 2.

The Coast

This study presents the results of excavations carried out in Middle and Upper Palaeolithic levels at Gorham's and Vanguard Caves in Gibraltar over the last decade. Despite climatic upheavals and sea-level changes during the Pleistocene, these sites were never more than a few kilometres away from the sea (Finlayson et al. 2008b; Carrión et al. 2008; Fa, in press) and can be considered as "coastal" for the duration of the time period in question, spanning the so-called Middle-Upper Palaeolithic transition.

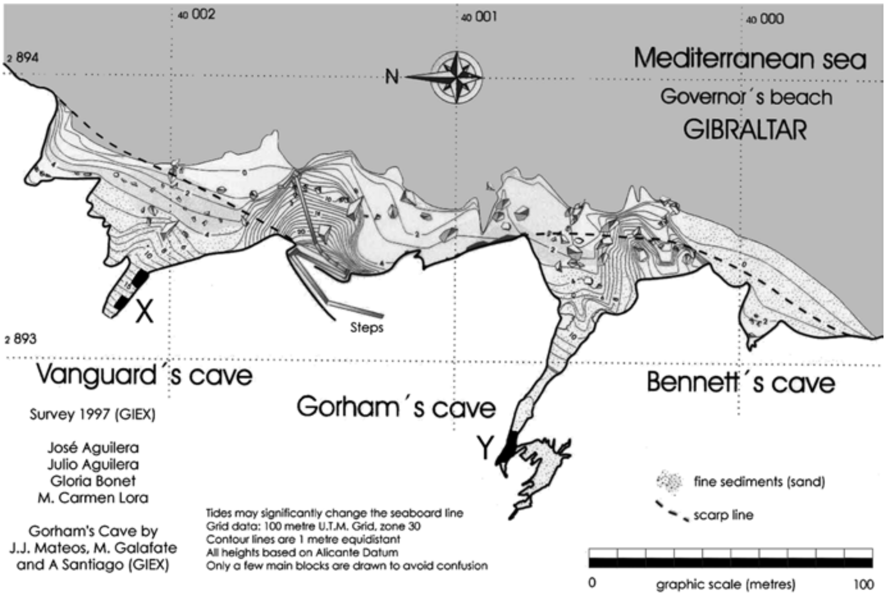
We do not attempt to be prescriptive about what the coast is other than to establish that it is more than the accessible intertidal strip of land at the water's edge. It is an ecotone between land and sea that is of variable width and structurally complex, both in terms of physical characteristics and the environments it contains, incorporating a mosaic of different ecosystems in close proximity and generating a high diversity of both habitats and consumable resources within (Finlayson and Giles Pacheco 2000; Finlayson 2006; Bailey et al. 2008; Fa 2008; Finlayson et al. 2008a). Moreover, we do not presuppose that exploitation of the coastal zone necessarily implies an emphasis on marine resources (Bailey et al. 2008), but rather a region where high productivities and environmental heterogeneity would allow for sustained exploitation by small groups of hunter-gatherers who might vary the relative contribution of the various resources available to their subsistence strategies depending on spatiotemporal availability, as well as possible additional socio-cultural factors.

In particular, we will be focusing on two oft-cited criteria that have been used to exclude Neanderthals from subsistence strategies associated with behavioural modernity: their apparent dependence on exploitation of big game to the exclusion of smaller prey and lack of a "broad spectrum" in their resource exploitation, usually identified by a lack of diversity in prey types such as marine resources (Finlayson 2004; Brown 2009).

Gorham's and Vanguard Caves

Gibraltar (36°7'N, 5°20'W) is a small, 6 km long, 426 m high peninsula situated at the southern extreme of the Iberian Peninsula, 21 km from the coast of North Africa (Morocco). The western coast is sheltered by a large bay, while the eastern side faces the Mediterranean and is subject to increased wave action. This has resulted in the creation of steep cliffs and large sea caverns along the eastern side (Rodríguez-Vidal et al. 2004). This eastern side is also dominated by a large sand dune which was responsible for the sealing, and therefore the preservation, of some sites during the Palaeolithic (Fig. 10.1).

Gorham's and Vanguard Caves are two of these caverns, sections of which have been excavated as part of the Gibraltar Caves Project, under the supervision of the Gibraltar Museum, since 1989. The long occupation of the site of Gorham's Cave by Neanderthals was first brought to light in the 1950s (Waechter 1951, 1964) and a number of subsequent excavations close to the Cave entrance (Stringer et al. 1999; Stringer 2000). More recently, excavations commenced in the interior of the cave in an area not previously systematically excavated. From this area, a stratigraphic Horizon (Layer IV) containing Mousterian implements and a hearth was dated using ^{14}C. The results indicated a late Neanderthal occupation of the site to at least 28,000 RCYBP, and probably as recently as 24,000 RCYBP (Table 10.1). There is no evidence of further human occupation of the site for approximately 5,000 years after which evidence of Solutrean technocomplexes appears in the overlaying



Survey 1997 (GIEX)

José Aguilera
Julio Aguilera
Gloria Bonet
M. Carmen Lora

Gorham's Cave by
J.J. Mateos, M. Galafate
and A Santiago (GIEX)

Tides may significantly change the seaboard line
Grid data: 100 metre U.T.M. Grid, zone 30
Contour lines are 1 metre equidistant
All heights based on Alicante Datum
Only a few main blocks are drawn to avoid confusion

Fig. 10.1 Scale plan of Vanguard and Gorham's Caves. The black areas denote excavations referred to in the text (X – Stringer et al. 2008; Y – Finlayson et al. 2006). Image modified from Finlayson et al. (2000)

Table 10.1 Radiocarbon dates from Gorham's Cave (after Finlayson et al. 2006)

Level/cultural attribution	Laboratory reference	AMS radiocarbon age (year) with 2δ	$^{13}C/^{12}C$ ratio (‰)
III/Solutrean	Beta-185343	10,880±80	–25.4
III/Solutrean	Beta-181895	12,460±100	–24
III/Solutrean	Beta-196777	12,540±100	–24.9
III/Solutrean	Beta-184047	12,640±100	–25.4
III/Solutrean	Beta-196780	13,820±100	–24.6
III/Solutrean	Beta-181896	13,870 ±80	–24
III/Solutrean	Beta-181893	16,420±120	–25.5
III/Solutrean	Beta-184042	18,440±160	–21.7
IV/Mousterian	Beta-196782	23,360±320	–22.4
IV/Mousterian	Beta-185345	23,780±540	–25
IV/Mousterian[a]	Beta-196775	24,010±320	–24
IV/Mousterian	Beta-196785	26,070±360	–25.6
IV/Mousterian[a]	Beta-196773	26,400±440	–23.2
IV/Mousterian	Beta-185344	27,020±480	–25
IV/Mousterian	Beta-196770	28,170±480	–25.9
IV/Mousterian	Beta-196784	28,360±480	–26.1
IV/Mousterian	Beta-196791	28,570±480	–25.2
IV/Mousterian	Beta-184048	29,210±380	–25.2
IV/Mousterian	Beta-196779	29,400±540	–25.4
IV/Mousterian	Beta-196778	29,720±560	–24.8
IV/Mousterian	Beta-196786	29,910±600	–24.7
IV/Mousterian	Beta-196792	30,310±620	–24.7
IV/Mousterian[a]	Beta-196776	30,560±720	–24.5
IV/Mousterian	Beta-184045	31,110±460	–23.7
IV/Mousterian	Beta-196768	31,290±680	–25.8
IV/Mousterian	Beta-196787	31,480±740	–23.7
IV/Mousterian	Beta-196772	31,780±720	–23.1
IV/Mousterian	Beta-196769	31,850±760	–23.5
IV/Mousterian	Beta-196789	32,100±800	–24.5
IV/Mousterian	Beta-196771	32,560±780	–25.1

[a] Samples coming from the hearth horizon

stratigraphic Horizon (Layer III), dated to range between approximately 11,000 to 18,000 RCYBP, which was shown to be mineralogically, geochemically and stratigraphically independent of Level IV. Further details of site excavation, methodologies and results can be found in Finlayson et al. (2006) and (2008b).

Environmental Reconstructions

Works carried out on pollen and charcoal remains have allowed workers to establish the floristic composition of the surroundings (Finlayson 2006; Carrión et al. 2008), and from these and additional climatic indicators, glean an insight into the prevailing environment outside these caves.

The combined data provided by plant macrofossils, pollen (Carrion et al. 2008) and the remains of vertebrates (amphibians, reptiles, birds and mammals) were used by Finlayson (2006) to reconstruct the vegetation and landscape outside Gorham's Cave at the end of MIS 3 and MIS 2. These results permitted an approximation of the climatic conditions and vegetation types available outside the cave at a time when lowered sea levels exposed a sandy plain with the coastline receding up to 4.5 km from its present position. Overall, the conclusion drawn by Finlayson (2006) was that the predominant bioclimate during the late MIS 3 and initial MIS 2 was thermo-Mediterranean, Subhumid, and occasionally meso-Mediterranean, Dry. The annual temperature range predicted was 13–19°C and the annual rainfall 350–1,000 mm. The vegetation was varied, and the results consistently suggest that the sandy substrate of the emerged coastal plain supported a patchwork or mosaic of different habitats within close proximity to the cave, which would in turn imply a high biodiversity within a short interval of space, a feature that would have offered multiple foraging opportunities at different stages of the year.

The main habitat types identified by Finlayson (2006) were:

1. *Stone Pine Pinus pinea open woodland/savannah*. The dominant tree formation was Stone Pine woodland, characteristic then, as today, of shifting sand dune systems. The vegetation of a mobile dune is dependent on the speed at which the dunes are moving and on the depth of the water table and is characterised by the large amount of bare sands that are present. The tree species *Pinus pinea* is associated with the mobile dune, being the only species that matures at a rate that can keep up with the pace of the movement of the dunes. Other plant species such as *Halimium* spp. are found in the dune slacks and were present outside Gorham's Cave. Mammal species support the presence of the parkland habitats: *Cervus elaphus*, *Equus caballus, Bos primigenius*, and *Sus scrofa* (Currant 2000).
2. *Juniper scrub, woodland and mixed Pine/Juniper woodland*. The genus *Juniperus* was found in a large percentage in both the pollen and charcoal records, and today, grows well in more stabilised dunes than those in which the Stone Pines live. Although it is not possible to identify the species at Gorham's, it is likely to be *J. phoenicea* which is found in warm climate and sandy substrates.

   Other plant species are associated with dune woodlands according to the depth of the water table. The presence of *Pistacia lentiscus* characterised the driest areas, while the presence of *Quercus suber* and *Olea europaea* would have been associated with parkland environment (see above), and species such as *Myrtus*, *Arbutus unedo, Smilax* and *Lonicera* suggest areas of wetter dune-lands, with a higher incidence of *Q. suber*, which would have made the vegetation dense and often impenetrable.
3. *Cistus and Erica shrubland*. In the more stabilised sandy substrates, *Cistus*, *Erica* and *Lavandula* would have been associated with the driest scrub, with *Halimium, Calluna vulgaris*, and in the wettest scrublands, by *Erica* and *Ulex*. A number of reptile and amphibian species also reflect sandy areas: *Acanthodactylus erythrurus*, *Pelobates cultipres* and *Hyla meridionalis*. Where the water table was high, there would have been lakes, ponds and bogs with appropriate aquatic vegetation such as *Salix. Mytenus* and *Calicotome* are diagnostic species that are indicative of thermophilic coastal scrub (Carrion et al. 2008).

4. *Cliff vegetation*. The olive *Olea europaea* grows predominantly on the limestone of the Rock itself forming woodlands and is amply recorded from Gorham's Cave. The Spanish Ibex *Capra pyrenaica* was the commonest large mammal at Gorham's and would also have required cliffs or rocky habitats.
5. *Grassland vegetation*. Coastal plains associated with a dune system are composed of the stabilised dunes which usually form a series of arched ridges (old dunes) separated by flat depressions (old slacks), which with shallow water tables would have flooded, filling temporary lakes and ponds. Mobile dunes separate the marshes from the sea. These grasslands and marshes are indicated in the record by species of amphibians which require seasonal water such as *Pleurodeles waltl, Triturus marmoratus pygmaeus*, *Bufo bufo spinosus* and *Bufo calamita*, while reptile species *Mauremys leprosa* and *Natrix maura* require standing water.

The results indicate a high degree of similarity in the thermo-Mediterranean, subhumid environments and associated ecosystems surrounding the caves during the latter stages of MIS 3 and the onset of MIS 2 (Finlayson 2006; Finlayson et al. 2006, 2007). The evidence from the Gibraltar sites points to a dominant habitat of an open woodland "savannah" with mosaic scrub and patches of denser woodland and thickets, with sandy areas, cliffs and rocky outcrops, as well as standing fresh water, the latter probably highly seasonal in nature. Finlayson and Carrión (2007) showed how the environments surrounding Gibraltar did not undergo the same dramatic changes that have been observed in the archaeological record at more northerly, less climatically buffered locations. This result is of particular relevance as it allows the comparison of subsistence strategies for both Neanderthals and AMHs in relatively homogenous environments.

Evidence for Exploitation of Terrestrial Small Game for Consumption

Ethnographical research has shown modern-day hunter-gatherer diets to be subsidised as by small game and plants as by large game (O'Connell et al. 1988a, b; Byers and Ugan 2005). Many authors have begun to accept the fact that Palaeolithic diets may have been the same (e.g. Haws 2004; Hockett 2006).

To date, in the Mousterian levels from Gorham's Cave, two species of amphibian, seven reptiles, 11 large mammals and 44 bird species have been identified (Finlayson et al. 2006; Brown 2009), not including additional species from overlying Solutrean deposits. Moreover, the remains of some taxonomic groups, such as rabbits (*Oryctolagus cuniculus*) and birds in general, achieve very high densities (in the thousands) spanning both Mousterian and Solutrean levels (refer to Brown [in press] for details).

The rabbits and birds recovered from excavations at Gorham's Cave amount to the largest proportion within the terrestrial faunal assemblage. Table 10.2 tallies the mammals recovered between the years 1999 and 2003 (Riquelme Cantal, in press) and clearly shows that rabbit is the predominant mammal recovered from this site. The bird remains present similar proportions to that of the rabbit, for both

Table 10.2 Percentage of prey types present in the faunal assemblages recovered from Gorham's Cave between 1999 and 2003 (Riquelme Cantal, in press)

Prey type	Solutrean (%) $n=4{,}061$	Mousterian (%) $n=1{,}117$
Rabbit	88.52	75.55
Ibex	7.26	15.93
Deer	2.78	6.27
Horse	0.17	0.36
Wild boar	0.12	0.27
Monk seal	0.10	0.09
Auroch	0.05	0.09
Narrow-nosed rhinoceros	0.02	0.00
Carnivores	0.96	1.44

Table 10.3 NISP and MNI values for the sample used

	Level III Solutrean		Level IV Mousterian	
	NISP	MNI	NISP	MNI
Immature rabbits	156 17.8%	20 22.2%	177 37.5%	17 50%
Adult rabbits	721 82.2%	70 77.8%	295 62.5%	17 50%
Immature birds	90 15.8%	37 22.7%	65 10.5%	28 17.2%
Adult birds	478 84.2%	126 77.3%	554 89.5%	135 82.8%

The percentages displayed show the proportions of immature and adult individuals by taxa and occupational level (Brown, in press)

Mousterian and Solutrean levels (Sanchez Marco, personal communication). Table 10.3 shows the sample NISP and MNI values obtained for these two groups by Brown (2009), subdivided into mature and immature individuals.

A review of the literature reveals an apparent contradiction in the role of small prey in Palaeolithic diets. Whereas some argue, based on optimal foraging models, that small games with their small energetic return are a marginal resource exploited only by distressed populations (for a critical review of this model see Haws and Hockett 2004), others see the systematic exploitation of these same resources as a "modern" feat of cognitively superior humans, who thus enjoyed a dietary "broad spectrum" (e.g. Stiner et al. 2000). Researches on the nutritional values of these small prey resources (Hockett and Bicho 2000; Haws and Hockett 2004), which compared the amount of micro-nutrients found within small game with that found in larger game, are summarised in Table 10.4, which incorporates some of these nutritional values for the prey species commonly exploited in southern Iberia.

Table 10.4 shows that, for example, rabbits have more protein per 100 g than large game such as red deer, goat and horse. Ducks, on the other hand, have a much higher fat content than the larger game, second only to pine nuts, the latter being the most nutritionally rich of the food items with both the highest calorific and fat

Table 10.4 Comparative nutritional values expressed in g/100 g (prey items) and in mg/100 g (minerals) commonly recovered from the fossil record in Iberian sites (after Haws 2004)

	Red deer	Goat	Horse	Wild boar	Rabbit	Duck	Partridge	Mussel	Pine nuts	Limpet
Protein (g/100g)	30.2	27.1	28.1	28.3	33	17.4	23	12	26.4	14.3
Fat (g/100g)	1.9	3.03	6.05	4.9	3.51	15.2	1.6	2.2	40	0.7
Carbohydrate (g/100g)	0	0	0	0	0	0	0	4.5	29.2	0.7
Kcal (g/100g)	146	143	175	160	173	211	106	89	510	66
Calcium (mg/100g)	5.0	17.0	8.0	16.0	18.0	5.0	46	20	26	51
Phosphorus (mg/100g)	180	201	247	134	240	168	287	288	508	103
Iron (mg/100g)	3.6	3.7	5.03	1.1	4.9	4.16	7.7	7.3	9.2	5.6
Magnesium (mg/100g)	24	0	25	27	31	20	–	–	299	–
Potassium (mg/100g)	328	405	379	396	343	249	386	273	599	–
Sodium (mg/100g)	61	86	55	60	45	56	93	270	4	–
Zinc (mg/100g)	3.2	5.3	3.8	3	2.4	0.77	–	2.8	4.3	–
C (mg/100g)	0	0	2.0	0	0	5.2	0	–	1.9	–
Thiamin (mg/100g)	–	0.09	0.1	0.31	0.02	0.35	0	0.16	0.81	0.13
Riboflavin (mg/100g)	–	0.61	0.1	0.14	0.07	0.27	0	0.21	0.19	0.04
Niacin (mg/100g)	–	3.95	4.8	4.2	6.4	3.3	–	–	3.6	–
Folic acid (µg/100g)	–	5.0	–	6.0	8.0	21.0	–	–	57.0	–
A (mg/100g)	–	–	–	–	–	88	–	–	–	–
E (mg/100g)	–	–	–	–	0.79	0.7	–	–	3.5	–
B6 (mg/100g)	–	0	0.33	0.42	0.34	0.53	–	–	0.11	–
B12 (µg/100g)	–	1.19	3.16	0.7	6.5	0.65	0	12.0	0	–

content per 100 g, when compared to other food items such as deer or rabbits (Table 10.4). The stone pine (*P. pinea*) is a fairly large tree that is native to the western Mediterranean and is often found in coastal locations. Stone pine seeds or pine nuts have been valued as a food source for thousands of years. In Italy and Spain, stone pine nuts are cultivated or preserved in large stands, and the nuts are still an important commercial food (Gale and Carruthers 2000).

The remains of charcoal and charred seeds from combustion zones and other contexts have been found at Gorham's Cave and Vanguard Cave (Gale and Carruthers 2000). The charred remains were confirmed as comprising stone pine cone scale fragments and stone pine nutshell fragments. Ethnographic examples for the extraction of pine nut kernels by North American Indians using various different species of pines suggest some tribes would roast the cones for an hour in order to facilitate the removal and shelling of the nuts (Gale and Carruthers 2000). Some tribes would also heap the cones up before setting light to them. Once the pitch burnt off, the scales would partially open, allowing the nuts to fall out. Such a large quantity, as recorded from Gorham's and Vanguard Caves, would rule out accidental intrusion and make their use solely as tinder unlikely. It is therefore possible that fire may have been used to help open the cones, suggesting that the Mousterian and Solutrean populations were also actively exploiting this nutritious resource.

Most importantly, these studies show that, in comparison with the smaller game and plants, traditional large game species are generally quite nutritionally poor. When considering subsistence strategies in terms of energetic expenditure, as well as personal risk, the exploitation of small game and plants is much more energetically efficient, requiring less effort to capture and providing a larger range of nutrients, particularly those essential, yet hard to find, micro-nutrients vital for a balanced, healthy diet.

Brown (2009) carried out a detailed taphonomic analysis of this previously unstudied rabbit and bird faunal assemblage from the Mousterian and Solutrean levels of Gorham's Cave, the results of which are outlined below:

(a) *Rabbits.* Rabbits, although common on the ground, given their high reproductive rate, remained endemic to the Iberia Peninsula until their relatively recent worldwide (human-aided) dispersal .Therefore, studies that have previously been conducted on the exploitation of lagomorphs by Palaeolithic populations outside of the Iberian Peninsula deal with the exploitation of hares, and not rabbits (e.g. Stiner et al. 2000). Rabbits and hares exhibit significant behavioural differences, which would have important implications on the ease with which they can be captured. Rabbits are usually much smaller than hares and live in underground burrows or warrens instead of in simple nests above ground, making them much easier to trap. Traditional methods to hunt rabbits have involved either the blocking of all but one of the entrances to the burrows, or by smoking them out. Their methods of avoiding predators are also significantly different – while the rabbit tends to freeze and observe or hides in dense vegetation when confronted with a threat, the hare more commonly tries to outrun its predators, again making the hare much more difficult to capture. The rabbit also gives birth to blind, naked and thus vulnerable young in underground burrows, while newborn hares are born aboveground, with fur and opened eyes, making them much more capable of fending for themselves from a much earlier age. It is clear from this that results on the Palaeolithic exploitation of hares in other regions cannot be directly correlated with the difficulty or ease of capturing rabbits in Iberia.

Figure 10.2 shows the distribution of rabbit skeletal parts reported by Brown (2009) for both Mousterian and Solutrean levels. Brown (2009) reported a bias towards a "lower-limb" assemblage, with a higher proportion of lower limb bones than upper limb bones present. The observed and expected values for each limb element were calculated and compared (χ^2 [Solutrean] = 119.9, $P < 0.0001$; χ^2 [Mousterian] = 76.4, $P < 0.0001$), indicating that the apparent biases in skeletal part representation within levels were not created at random, and a taphonomic agent was therefore responsible for this accumulation.

Detailed analysis of a sample of the rabbit bones from both Mousterian and Solutrean Levels at Gorham's Cave (Brown 2009; in press) showed that such a large proportion of rabbits within the cave could not be explained by natural accumulation alone, and the negligible presence of taphonomic traces attributable to carnivores or birds of prey strongly suggested that the accumulating agent at this site was human.

Although both Solutrean and Mousterian assemblages can be attributed to human predation, it appears that the hunting strategies and processing methods varied significantly across the archaeological horizons. The Mousterian assemblage was dominated by juvenile individuals, whereas in the Solutrean it was by adults. However, both assemblages were found to be dominated by lower limb elements, which would suggest a predator accumulation, as equal proportions of paired elements would be expected in natural accumulations, therefore indicating that an accumulating agent was also responsible for the Mousterian assemblage.

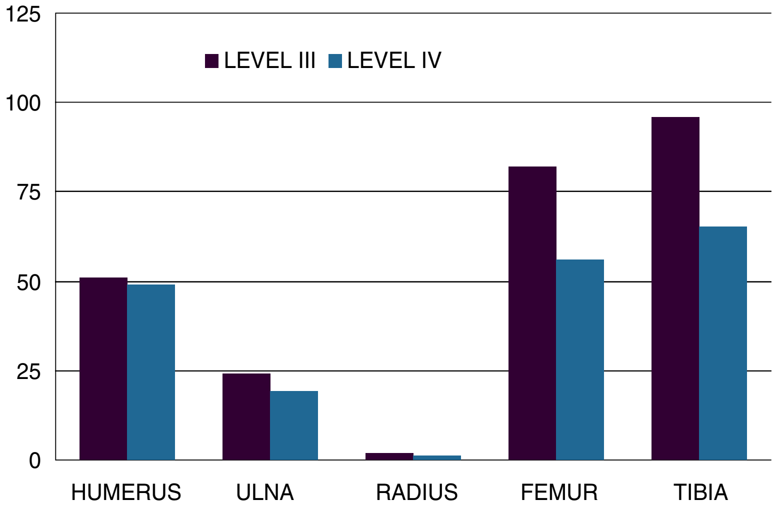


Fig. 10.2 Comparison of skeletal part frequencies of rabbit limb elements from the Solutrean (III) and Mousterian (IV) Levels (Brown, in press)

This was further substantiated by the extensive fragmentation of the rabbit limb elements across archaeological horizons and the abundance of spiral fractures. These, taken together with the absence of significant traces of non-human predation on bone elements, are attributed to human predation (*sensu* Perez-Ripoll 1992), particularly as a result of the exploitation of marrow content from the bones. However, whereas both assemblages were highly fragmented, dominated by epiphyses and shaft fragments, this was much more pronounced in the Solutrean level, again possibly for marrow extraction.

(b) *Birds*. The elevated number of bird species found in Gorham's Cave (compared to other taxa) is probably due to Gibraltar's position within an important migratory route for birds between Africa and Europe, a situation that persisted throughout the Pleistocene. This is further illustrated when data from the four main Palaeolithic sites in Gibraltar (Gorham's Cave, Vanguard Cave, Ibex Cave and Devil's Tower Rock Shelter) were pooled, generating a list of 143 identified bird species, amounting to a quarter of all the known bird species currently found breeding in Europe (Brown 2009). A number of these bird species (e.g. quail *Coturnix coturnix*, corncrake *Crex crex*, and the larks *Lullula arborea, Galerida cristata*) are ground-dwelling and/or cryptic and often tend to freeze when surprised, opting for flight at the last minute, presenting similar behavioural responses as rabbits (Fig. 10.3).

The bird assemblage describes a typical predator assemblage, in this case exhibiting a disproportionate amount of upper limb elements present for the Solutrean and Mousterian periods. There are some differences in the relative frequency of adult vs. immature birds between Levels, with the Mousterian being dominated by adult individuals, compared with a greater abundance of

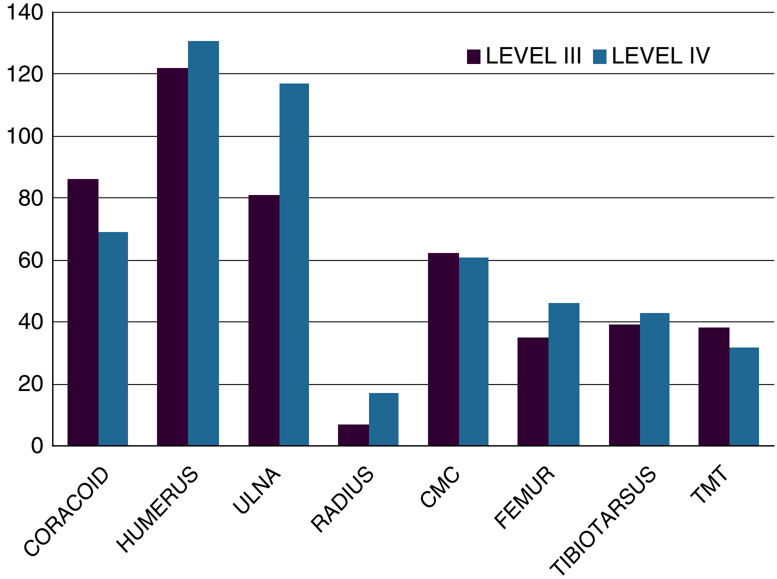


Fig. 10.3 Comparison of skeletal part frequencies of bird limb elements from the Solutrean (III) and Mousterian (IV) Levels (Brown, in press)

juvenile birds in the Solutrean. This may be due to differences in the way these species were exploited by different populations (see Brown, in press for further discussion). However, there is no significant correlation between archaeological period and skeletal part frequency (χ^2 [Solutrean] = 69.3, $P < 0.0001$; χ^2 [Mousterian] = 64.0, $P < 0.0001$), which would again suggest that the same agent acted on the assemblage during both periods.

Bird assemblages were also less extensively fragmented than the rabbit assemblages, with whole limb elements dominating. Elements which were fragmented showed to be predominantly spiral fractures, which would suggest anthropic fracturing of fresh limb bones. These fragmentation patterns remain consistent across archaeological horizons, therefore suggesting similar bird processing techniques by Mousterian and Solutrean populations. The negligible presence of trampling marks on the assemblage further substantiates this thesis that the fragmentation agent was a predator and that the observed patterns were not due to post-depositional movements or pressure.

Direct Evidence of Consumption by Hominins

Burning and cut marks are still considered unequivocal evidence for anthropic accumulations (Laroulandie 2005). However, because of their small size, most small game would not show many of the more typical taphonomic traces, such as cut marks and extensive burning, which would be found on larger organisms (Brown 2009). Small game, such as rabbits and birds, do not require extensive disarticulation and filleting to cook, as would, for example, an ibex or a horse. Disarticulation of large animals would also cause a higher proportion of bone to be exposed before cooking, in comparison with smaller game, which would probably have been cooked whole, thus protecting the bones from the direct heat. They would also require lower temperatures, and/or a shorter cooking time, thus further protecting the bones from changes due to burning.

Given the above-mentioned observations, it is not surprising that Brown (2009) noted that less than 1% of the bird and rabbit bones analysed at each Level showed cut marks. Significantly, a bird bone (Rock Dove *Columba livia* humerus) found within the sample taken from the Mousterian level was found to present evidence of burning while still fleshed (Fig. 10.4).

Evidence for Use of Marine Resources

There is an increasing number of publications citing evidence of exploitation of intertidal marine resources by Neanderthals in the Mediterranean (Stiner 1994; Stiner et al. 1999, 2000; Stringer et al. 2000; Bailey and Flemming 2008) and the Portuguese Atlantic coast (Bicho and Haws 2008). Unfortunately, eustatic fluctuations during glacial cycles have meant that most prehistoric coastlines are now underwater, and therefore lack of evidence to date of a close

Fig. 10.4 A humerus of a Rock Dove (*Columba livia*) that was burnt while still fleshed. Note the slight change of colour and deep fissures as indicated by the *arrow* (Brown, in press)

relationship between people and the coast can be most plausibly ascribed to the limited studies so far on submerged sites (Bailey and Flemming 2008; Fa 2008).

As for terrestrial small game, there still is no established consensus as to the dietary contribution of marine molluscs to early human subsistence economies. Although they are an accessible and predictable food resource (Bailey 1975, 1978, 1983; Fa 2008), their perceived importance ranges from that of a casual food item of minor dietary value (Coles 1971; Bailey 1975), through the notion of their use as a "protein staple" when other meats were in short supply (Yesner 1980; Erlandson 1988, 1994), to the suggestion that they contributed significantly to the diets of coastal populations, at least seasonally (Meighan 1969; Shawcross 1970; Clark 1971; Stiner et al. 2003). Certainly, differing collection methods and inherent biases in these have not helped to clarify matters (Bailey 1975). Some authors have argued that diets based on marine foods would lead to protein poisoning (e.g. Yesner 1987), but Fa (2008) has highlighted how such debates, by tending to focus too much attention on the marine foods themselves, invariably fail to consider that these resources are embedded within a very heterogeneous and varied landscape (Finlayson et al. 2007), fully capable of providing supplementary nutrients which obviate the dangers of nutritionally deficient diets. Although useful in understanding the implications of extreme dietary regimes, arguments based on the physiological ill-effects of doing so are generally unrealistic. Furthermore, work on the nutritional ecology of marine resources (Hockett and Haws 2003) has highlighted the potential supplemental value of these foods beyond their direct calorific contribution.

On the basis that dietary diversity is beneficial to human health, they note that marine foods such as shellfish are rich sources of vitamins D and E, providing additional carbohydrates not usually available from terrestrial mammals (see Table 10.4).

Certainly the collection of such resources, particularly on rocky shores, (where faunal inhabitants are a readily visible, easily collectable and concentrated resource), is relatively inexpensive energetically, requires no particular skills and can be undertaken by all segments of a human population (Yesner 1980; Anderson 1981; Bicho and Haws 2008; Fa 2008). This means that exploitation of such resources could have provided "non-hunting" members of human groups (e.g. children and the elderly) with a collectively important food contributory function.

In Gibraltar, excavations at nearby Vanguard Cave (see Fig. 10.1) have yielded evidence of Neanderthal exploitation of marine resources, including mussels *Mytilus* spp. (Barton 2000), and most recently, additional evidence of consumption of fish (bream – *Diplodus* spp.) and large marine fauna such as monk seals *(Monachus monachus)* and dolphins *(Delphinus delphis, Tursiops truncatus),* the former with cut marks, indicative of de-fleshing for consumption (Stringer et al. 2008). Here we now add unpublished data to further extend the spectrum of marine resources consumed during the Mousterian at this site to bluefin tuna (*Thunnus thynnus*) and numerous sea urchins (cf. Purple sea urchin – *Paracentrotus lividus*), the latter being a species easily collectable in shallow waters and still consumed by humans in the region today. Unfortunately, the importance of coastal areas for Neanderthals has been underplayed in comparison with its significance to AMHs in Africa (Klein 1999), but this situation is slowly changing.

Further work on marine intertidal mollusc exploitation by Fa (in press), focusing on the Mousterian and Solutrean Levels at Gorham's Cave, reported at least 10 species of intertidal and shallow-water molluscs (Table 10.5). In both Mousterian and Solutrean Levels, patellid limpets (*Patella depressa, P. ferruginea, P. ulissiponensis, P. vulgata*) were found to be the dominant intertidal mollusc (Solutrean 59%, Mousterian 56%), followed by mytilid (*Mytilus galloprovincialis, M. edulis),* mussels (Solutrean 18%, Mousterian 15%), and trochid (*Osilinus turbinatus, Gibbula* spp.) (topshells – Solutrean 11%, Mousterian 6%). These three rocky intertidal species make up approximately 80% of the total of rocky littoral species found in each Level (Fa 2008).

Moreover, although relatively scarce, the presence of shallow-water soft-sediment species (tuberculate cockle – *Acanthocardia* sp., smooth/brown venus shell – *Callista chione*, lucine clam – *Lucina borealis*, scallop – *Pecten* sp., thorny oyster or spiny scallop – *Spondylus gaederopus*) is consistently reported by various authors for the Mousterian in Gibraltar (Waechter 1964; Fischer 1928; Barton 2000; Fa, in press) and is therefore of significant interest as it suggests that Neanderthal activities in the sea may have extended beyond the intertidal, as was known to be the case in the Solutrean (Table 10.3). Unfortunately, their persistently low representation, and on occasion, application of erroneous ecological information

Table 10.5 Comparison of results obtained by Fa (in press), Barton (2000), Waechter (1964) and Garrod et al. (1928) in terms of presence–absence of the various species and genera encountered

Common name	Species	Fa (in press) Level IV Mousterian	Barton (2000) Mousterian	Waechter, (1964) Mousterian	Garrod et al. (1928) Mousterian	Fa (in press) Level III Solutrean	Waechter, (1964) Solutrean
Tuberculate cockle	*Acanthocardia* cf. *tuberculatum*		*			*	*
Saddle Oyster	*Anomia* sp.					*	
Smooth/Brown venus	*Callista chione*		*				
Cockle clam	*Cardita calyculata*					*	
Striped venus shell	*Chamelea* sp.					*	
Triton/Trumpet shell	*Charonia nodifera*				*		
Dirty cowrie	*Cypraea spurca*						*
Keyhole limpet	*Fissurella* sp.	*					
Flat/Purple topshell	*Gibbula* sp.					*	
Mediterranean dog cockle	*Glycimeris bimaculata*					*	
Yellow/Flat periwinkle	*Littorina obtusata*	*		*		*	*
Rough periwinkle	*Littorina saxatilis*	*				*	
Lucine clam	*Lucina borealis*				*		
Horse mussel	*Modiolus modiolus*						*
Turban shell/ Chequered topshell	*Osilinus turbinatus*	*				*	*
Topshell	*Osilinus articulatus*			*			
Rock shells/ Whelks	*Muricidae* (other)					*	
Mediterranean and Common/ Blue mussel	*Mytilus galloprovincialis and M. edulis*	*	*	*	*	*	*
Reticulated nassa/Netted dogwhelk	*Nassarius reticulatus*					*	
Atlantic dogwhelk	*Nucella lapillus*	*				*	*

Blue/Rayed Mediterranean limpet	*Patella caerulea*	*	*	*		*	*
Black-footed limpet	*Patella depressa (= P. intermedia)*	*			*	*	
Ribbed Mediterranean limpet	*Patella ferruginea*			*	*	*	*
China limpet	*Patella ulissiponensis*					*	
Common European limpet	*Patella vulgata*	*	*		*	*	
Pilgrim's scallop	*Pecten jacobeus*				*	*	
Great or Giant scallop	*Pecten maximus*	*				*	*
Mediterranean bonnet shell	*Semicassis undulata*			*			
False limpet	*Siphonaria pectinata*					*	
Thorny oyster or Spinous scallop	*Spondylus gaederopus*				*		
Red-mouthed rock shell	*Stramonita haemastoma*					*	*
European/Spotted/Bean cowrie	*Trivia monacha*						*
Calico clam	*Venerupis decussata*						*
	Total no. of species	10	5	6	8	22	13

Common names are included so as to facilitate cross-referencing with other works (Fa, in press) (e.g. Fernández-Jalvo and Andrews 2000) have led to their not being considered as having been collected for consumption.

An analysis of the relative proportions of the main intertidal molluscs found in both Mousterian and Solutrean Levels from Gorham's Cave (Fa, in press) suggests that the mode of exploitation of this resource remained essentially unchanged between the archaeological horizons occupied by the Neanderthals and subsequent AMHs (Spearman's Correlation Coefficient $=0.901$, $P<0.01$, $R^2=0.98$), with no statistically significant differences being found between the relative proportions in the main species collected (Mann–Whitney $U=39$, $P=0.93$; Kruskal–Wallis $\chi^2=0.018$, $P=0.89$).

Discussion

The data from Gorham's and Vanguard Caves are providing compelling evidence for a model of Palaeolithic human subsistence strategies which places both Neanderthals and AMHs firmly within an ecosystem-based, biogeographic and climatic framework.

The palynological work carried out to date has reliably demonstrated the maintenance of a highly diverse, small-scale mosaic of habitat patches in the topographically heterogeneous area surrounding Gibraltar, both throughout most of MIS 3 and the subsequent MIS 2, albeit for a short period of intense climatic deterioration during 22,500 and 25,000 RCYBP (Jimenez-Espejo et al. 2007), which happens to coincide with the disappearance of Neanderthals from the area.

The long-term stability of this region, providing mild Mediterranean bioclimatic conditions that strayed little beyond the range covered by thermo- and meso-Mediterranean thermotypes and subhumid and dry ombrotypes (Finlayson 2006), allowed Neanderthals to pursue a way of life that remained virtually unchanged for many thousands of years. The re-establishment of similar conditions during the subsequent MIS 2 (Finlayson et al. 2007) allowed the later inhabitants of the region, AMHs with Solutrean technologies, to adopt very similar subsistence strategies.

Evidence from Terrestrial Small Game

For the rabbits, the results indicated assemblages biased towards the lower limb elements in both the Solutrean and Mousterian periods. There was a significant difference between the upper and lower limb representation, suggesting that the assemblage was accumulated by a predator, and not at random. This difference is much more pronounced during the Solutrean than the Mousterian periods, which might suggest that other factors may have also acted on the assemblage. One possible scenario is different processing strategies of rabbit carcasses by Solutrean and Mousterian populations. It is possible that Solutrean populations actively exploited the marrow content of rabbits, more so than occurred in the Mousterian, and thus favoured the lower limbs.

With regard to birds, the results suggested a strong and significant association between human occupations and the presence of game birds, ducks, and waders, all of which are potential food types, which are still consumed today. Most significant, however, is the association between hominin occupations and ground-dwelling, skulking, cryptic birds. Birds such as the quail, corncrake, and the larks, although unrelated, all have physical and behavioural similarities. Whereas other species might take flight when threatened, these ground birds freeze, using their cryptic plumage to blend into the background. The over-abundance of these species in association with hominin occupations, particularly during the Middle and Upper Palaeolithic, and not with predatory bird assemblages, could suggest a specific bird-catching strategy by Palaeolithic populations, taking advantage of the behavioural traits of certain species.

Brown (2009) draws two main conclusions:

(1) There appears to have been a close relationship between particular bird species (such as the quail, ducks or pigeons) and human populations throughout Europe in the later Pleistocene, (which could be related to consumption or even to the production of secondary products, such as clothing and symbolism), and a consistent under-representation of predatory bird species in sites associated with hominin occupation.
(2) In the case of Gorham's Cave, Neanderthals do not appear to exhibit subsistence behaviours that are any different from those of the succeeding Solutrean populations, as no significant statistical differences could be distinguished between the two.

A number of authors have suggested approaches to the analysis of small game remains that may provide avenues for future work. For example, Laroulandie (2005), working on bird bones, noted that a light squashing or hole is created on the distal end of humeri at the level of the *fossa olecrani*, as the *olecranon* of the ulna penetrates through the *fossa olecrani* during the disarticulation of the elbow by over-extension, a taphonomic trace that would most likely be overlooked by most analysts as indicative of human predation on birds, yet singularly diagnostic. It would require a degree of ambidexterity to be able to disarticulate a joint by over-extending it, a feat that only humans would be capable of, and therefore any bird remains with such diagnostic modifications could be ascribed to anthropic action. It is intended to revisit the rabbit and bird material from Gorham's Cave to establish whether these evidences are indeed present in the samples studied.

Evidence from Marine Molluscs

Although the sample size from Mousterian deposits was comparatively small compared with the Solutrean (due to the larger volume of excavated deposits for the latter), the results obtained suggest that intertidal and shallow-water marine molluscs were collected for consumption by both the Neanderthal and AMH occupants of

Gorham’s Cave in proportionally equal amounts during both MIS 3 and 2. The almost total absence of other, naturally superabundant, intertidal species (e.g. littorinids) and the close correspondence between present-day densities of intertidal rocky-shore molluscs (Fa 1998) and their representation in these archaeological deposits are indicative that human coastal foragers exploited their environment in a manner proportional to prey abundance and availability (Fa, in press).

The main prey items were limpets, mussels and topshells which are consistent with data from other nearby sites such as the Portuguese coast (Bicho and Haws 2008) or the Spanish Mediterranean coast of Málaga (Cortés-Sánchez et al. 2008), although the relative contributions of the three vary, most probably due to local differences in availability. Although such resources have often been considered marginal due to their low energetic contribution per prey item, such statements need to be considered with regard to a number of caveats (Bicho and Haws 2008; Fa 2008) which include:

(1) Collection and processing costs (which vary between species depending on collecting strategy, on or off-site processing, ability to “keep” for extended periods, etc.).
(2) Nutritional (as different to energetic) value – e.g. marine molluscs provide comparable protein and fat content to terrestrial resources and moreover can provide carbohydrates, trace minerals and vitamins not easily obtained from other foods.
(3) Energetic trade-offs with regard to risk (cost-benefit) and the fact that these resources can be collected by all group members, including children and the elderly.

Fa (2008) proposed that if trends in use of these and other marine resources could be used as a barometer of demographic changes, the close similarities between the results obtained at both Mousterian and Solutrean Levels at Gorham’s Cave would suggest (assuming limited changes due to environmental variations) that both groups of humans were following the same fundamental subsistence strategy at this site. Further excavations, especially in the Mousterian Level of Gorham’s Cave, will doubtlessly help to develop some of the ideas presented here.

Conclusions

Although stone tools can tell us a great amount about the organisation of technology and those all important long-term survival strategies, they cannot tell us much about either intelligence or potential (Gamble 1993:179). Some 50,000 years ago, a massive colonisation of new environments by some members of the genus *Homo* set off a train of events that led to the development of new behaviours to cope with and exploit these new opportunities (Burke 2004; Finlayson 2004). These “modern” behaviours therefore need to be seen as a consequence of this process rather than as its cause (Gamble 1993).

Rather than the rapid cultural, cognitive and/or biological transition usually argued by proponents of the Upper Palaeolithic Revolution, a revision of existing evidence suggests that the apparent revolutionary nature of the European Upper Palaeolithic is more likely due to archaeological discontinuities, mislabelling of phases, layers and time periods, and the dogmatic application of an unsubstantiated view that holds our own species as *de facto* superior over all other contemporary human populations (Brown 2009).

We propose that Gibraltar offered optimal climatic and foraging conditions for both Neanderthals and Anatomically Modern Humans, during the Middle and Upper Palaeolithic, and thus it was not a coincidence that Gorham's Cave saw the last surviving Neanderthal populations. Palaeobotanic and faunistic environmental reconstructions indicate that Gibraltar offered a highly diverse, mosaic landscape, with a large array of resources available for exploitation. The Neanderthal populations which inhabited this landscape took advantage of this diversity, enjoying a much broader diet than has previously been reported for contemporary populations throughout Eurasia, which included small game such as birds and rabbits (previously only reported for Upper Palaeolithic populations) and marine intertidal/shallow-water foods such as limpets, bivalves (mussels, cockles, scallops), sea-urchins, as well as larger prey items including fish (bream, tuna), monk seals and dolphins.

The evidence from Gorham's and Vanguard Caves suggests that, given similar bioclimatic conditions and surrounding environments, both Middle Palaeolithic Neanderthals and subsequent AMHs exploited their environments in very similar ways, i.e., people really did just "*eat what was there*" (Bar-Yosef 2004; Finlayson 2004). Although there are some differences in the processing of terrestrial small game, there is no evidence of marked changes in subsistence strategies between the two groups which could be taken as indicative of significant cognitive differences or behavioural practices. This result reinforces the view that human behaviours during the periods studied were most likely conditioned by the environment they were in and therefore would have varied geographically, even within the same species (Finlayson 2004). It moreover highlights the dangers involved in ascribing behavioural, cultural, and by extension, cognitive associations to the entirety of human groups across entire geographical regions based on evidences from selected sites from distinct biogeographical areas. In other parts of their range, Neanderthals and AMHs may have been doing different things; in Gibraltar, they continued doing the same. Existing models and hypotheses concerning these groups, and indeed subgroups within each, need to be considered within the context of the environment within which they are situated and the resources available to them at the time. The "one size fits all" paradigm needs to be revisited, and if necessary, discarded. We contend that a more local emphasis (concomitant with the limited spatiotemporal scales of operation and information networks available to these groups) is the only way to objectively analyse the Palaeolithic behavioural strategies of these people.

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Chapter 11
Prying New Meaning from Limpet Harvesting at Vale Boi During the Upper Paleolithic

Tiina Manne and Nuno F. Bicho

Introduction

The late Pleistocene record for human exploitation of marine resources is generally accepted as being underrepresented world-wide. The global lowering of sea levels during the last glacial maximum (LGM) extended coastlines, presumably causing much of the evidence for coastal living from that period to be inundated today. The southern coast of Iberia is no exception, having a gently sloping, submerged continental shelf along much of its coastline. During the LGM, this continental shelf would have been partially exposed, with the coastal shore lying a considerable distance south of where it is today. This set of circumstances has no doubt contributed to the lack of known Upper Paleolithic coastal sites in southern Iberia containing records of marine exploitation. However, two key southern Iberian sites provide evidence of long-term marine resource use in this region: Cueva de Nerja and Vale Boi. The southeastern Spanish site of Cueva de Nerja is known for its record of marine fish and shellfish exploitation beginning in the Solutrean (Cortés-Sánchez et al. 2008; Jorda 1986; Morales and Rosello 2008; Serrano et al. 1995). Now the Portuguese site of Vale Boi significantly adds to the evidence of long-term utilization of coastal resources, with its record of marine resource exploitation beginning in the Gravettian.

The recently discovered site of Vale Boi is located in the Algarve region of southwestern Portugal (Fig. 11.1). Today, the site lies less than 2.5 km inland from the present day coastline and is located on the eastern side of a small river valley that runs south to the Atlantic Ocean (Bicho et al. 2003). Containing both open-air and rockshelter components, it is situated on a wide, gentle slope below a low limestone ridge (Fig. 11.2). The site extends downslope from the ridge for approximately 80m. Intensive excavations of the site began in 2000 and continue to the

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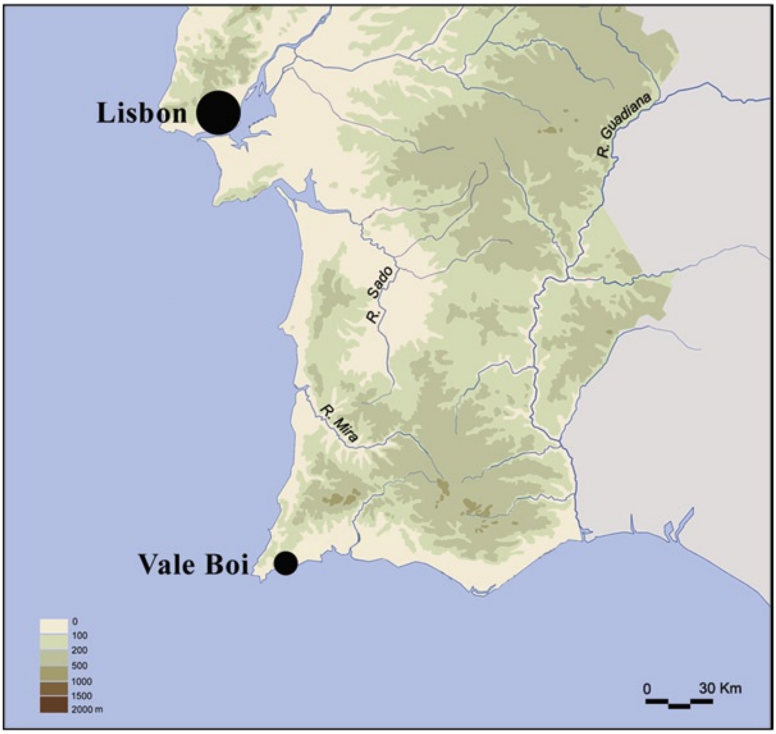

Fig. 11.1 Map of southern Portugal with the location of Vale Boi

Fig. 11.2 Photograph of the east slope. Vale Boi extends 80 m along the slope, down from the white, limestone ridge at the top

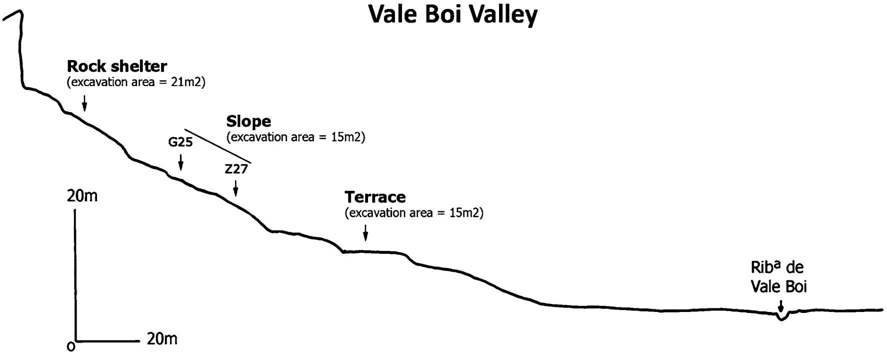

Fig. 11.3 Profile of the Vale Boi site

present, with the focus on three main areas: a flat terrace at the bottom of the slope situated 10 m above the river bed; two areas on the mid-slope region; and a flat area below the ridge that is partially covered by limestone blocks from the collapsed roof of a rockshelter (Fig. 11.3).

Vale Boi is unique in southern Portugal due to its antiquity and long cultural record that spans three culture periods: the Gravettian, Solutrean, and Magdalenian. The earliest AMS radiocarbon date from Vale Boi is for the Early Gravettian at 27,720±370 RCYBP. The majority of excavated material is from the Gravettian and Solutrean deposits, with the Magdalenian deposits being relatively limited. Excavations have revealed numerous lithic artifacts, including burins, endscrapers, and projectile points, along with bone artifacts, shell ornaments, and various pieces of portable art. Preservation and recovery of both marine shellfish and terrestrial animal remains is good, exemplified by the occurrence of aurochs bones and fragile skeletal material from neonate and fetal deer and horse.

This article provides an overview of the Vale Boi faunal assemblage. However, the main purpose of this chapter is to highlight the marine fauna assemblage at Vale Boi, with a particular emphasis on its most abundant type, the limpet (*Patella* sp.). Southwestern Iberia is ecologically distinctive for its juxtaposition of rich Atlantic and Mediterranean marine communities, a set of circumstances which is reflected in the variety of limpet species inhabiting its shores. A short introduction to limpet ecology and behavior is presented in order to understand the nature of limpet predation by humans. Of particular interest in this study are the nutritional benefits to be gained from limpet consumption and the importance they may have held in the diets of foragers, particularly women and children.

Terrestrial Fauna

At Vale Boi, ungulates and rabbits are the key components of the fauna assemblage and the main economic activities appear to have been centered on the exploitation of terrestrial resources (Table 11.1) (Manne and Bicho 2009). The Gravettian and

Table 11.1 NISP values of Vale Boi mammalian and avian fauna

	Gravettian		Solutrean		Magdalenian	
	NISP	% NISP	NISP	% NISP	NISP	% NISP
Mammals						
Bos primigenius	24	0.48	79	1.37	4	0.52
Equus caballus	161	3.24	901	15.62	48	6.27
Equus sp.[a]	16	0.32	54	0.94		
Cervus elaphus	732	14.74	1,788	30.99	211	27.58
Capra/Ovis	4	0.08	9	0.16		
Sus scrofa	1	0.02	2	0.03		
Vulpes vulpes	11	0.22	5	0.09	6	0.78
Canis lupus	4	0.08	4	0.07		
Panthera leo	4	0.08	1	0.02		
Lynx pardina	11	0.22	5	0.09	2	0.26
Oryctolagus cuniculus	3,995	80.45	2,916	50.54	494	64.58
Cetacea	1	0.02				
Aves						
Aquila chrysaetos			1	0.02		
Small sized bird	2	0.04	1	0.02		
Medium sized bird	2	0.04	3	0.05		
Large sized bird			1	0.02		
Totals	4,966		5,770		765	

[a] Possibly the wild ass, *Equus hydruntinus*

Solutrean periods are well represented in the terrestrial faunal assemblage ($n=4{,}966$ and $n=5{,}770$ respectively), whereas the assemblage for the Magdalenian is considerably smaller, with only 765 identified specimens. Based on the number of identifiable specimens (NISP), rabbit (*Oryctolagus cuniculus*) is the dominant terrestrial species throughout all three cultural periods at Vale Boi. During the Gravettian rabbit NISP comprises 80% of the assemblage. Its dominance declines during the Solutrean to 51 %NISP, but then increases again to 65 %NISP of the total Magdalenian assemblage. Red deer (*Cervus elaphus*) composes 15 %NISP of the Gravettian assemblage, but its presence increases to 31 %NISP during the Solutrean and 28 %NISP during the Magdalenian. Horse (*Equus* sp.) is only present as 3 %NISP of the total Gravettian assemblage, but increases during the Solutrean to 16 %NISP. During the Magdalenian, horse composes only 6 %NISP of the total assemblage. Both the red deer and horse assemblages contain fetal and neonate individuals. Apart from these specimens, the assemblage is composed of fully adult individuals. The presence of these very immature animals suggests that humans were hunting herds of maternal deer and small herds of horse during the late spring.

In addition to the rabbit, red deer and horse, small numbers of aurochs, wild ass (possibly *Equus hydruntinus*), ibex, and wild pig are present. Skeletal remains of lion, wolf, fox, and Iberian lynx occur in small quantities. In addition to the mammalian fauna, a minor quantity of bird bones have been recovered from the Solutrean and Gravettian periods, including part of the proximal femur of a golden eagle (*Aquila chrysaetos*). Very little carnivore damage occurs on the bones, and the faunal accumulations appear to be largely, if not wholly the result of human activity (Manne and Bicho 2009).

The highly fractured, yet well-preserved nature of the ungulate assemblage, suggests that the bones were subjected to marrow processing and bone-grease rendering (Manne and Bicho 2009; Manne et al. 2005; Stiner et al. 2003). Bone-grease rendering is a labor-intensive process in which the spongy bones from ungulate limb ends and vertebrae are fragmented. Bone-grease is liberated by placing the fragments into water and dropping heated stones into the mixture. As the grease rises to the top, the relatively pure-layers of fat can be removed and stored. Bone-grease rendering frequently produces archaeological assemblages where there is a higher preservation of elements with reduced bone-grease values (Binford 1978; Brink 1997; Lupo and Schmitt 1997; Munro and Bar-Oz 2005; Stiner 2002; Vehik 1977). The spongy ends of the humeri, femur, and tibia are particularly rich in both saturated and unsaturated fats and theoretically should be underrepresented (in addition to vertebrae) in assemblages that have been subject to bone-grease rendering as the result of preferential crushing. Analysis of the Vale Boi ungulate assemblage indicates that long bone ends and axial elements rich in bone-grease were indeed being systematically exploited (Manne and Bicho 2009). Diagnostic bone modifications resulting from grease rendering, such as localized crushing and impact fractures, are present in the Vale Boi assemblage in high frequencies (18% of total NISP). In addition to these zooarchaeological signals of grease-rendering, heavy hammerstones, heavily pitted stone-anvils and large quantities of fire-cracked quartz rock are present at Vale Boi (Manne and Bicho 2009). Over 400 kg of poor-quality quartz has been excavated at Vale Boi, all of which was transported on to the site from a nearby outside source.

Marine Fauna

The marine shellfish assemblage though small, is an important element of the Vale Boi site. It has the earliest date for economic shellfish remains deposited by modern humans in southern Portugal and clearly indicates that marine resource exploitation was underway in this region by the Gravettian, if not earlier. The close location of Vale Boi to the coast allowed humans to take advantage of not only terrestrial animals, but also access the nutritional benefits of marine resources.

The minimum number of individuals (MNI) for shellfish was based on number of umbos for bivalves (N/2 = MNI) and the number of apexes for limpets. Measurements of intact limpets were recorded at the maximum dimension of the shell. Over 75% of the shell that could be identified to limpet was fragmented and as such, could only be designated as *Patella* sp. and not to species. It is likely that these limpets include the temperate, subtropical species *Patella intermedia;* (Fig. 11.4) Murray in Knapp, 1857 (synonyms *Patella depressa* Pennant, 1777),

Fig. 11.4 Modern *Patella intermedia* attached to substrate in southwestern Iberia

Patella rustica Linnaeus, 1758 (synonyms *Patella lusitanica* Gmelin, 1791), and *Patella ulyssiponensis* Gmelin, 1791 (synonyms *Patella aspera* Röding, 1798; *P. aspera* Lamarck, 1819; *Patella athletica* Bean, 1844), along with the boreal species, *Patella vulgata* Linnaeus, 1758. It is possible that the Mediterranean species *Patella caerulea* (Linnaeus, 1758) may also be present.

Marine remains at Vale Boi comprise of shellfish, one fish vertebra and a single centrum of a vertebra from a small cetacean. The cetacean vertebra is from the Gravettian period and as there are no other cetacean remains, it is difficult to directly relate it to human economic activities, as it may have been picked up from the shore. There is a marked decrease in the total amount of shellfish found in the Solutrean period compared to the Gravettian (Table 11.2). The total shellfish MNI for the Gravettian is 1,053, compared to 484 for the Solutrean and 4 for the Magdalenian. As the Magdalenian deposits on the whole are quite marginal at Vale Boi, the presence of shellfish is best viewed as a sign that marine resources were still being utilized during the Magdalenian, rather than an indication of an economic trend of decreased shellfish consumption.

The vast majority (94 %MNI) of shellfish remains at Vale Boi are from limpet, a rocky shore inhabitant. The remaining shellfish remains are from species inhabiting

Table 11.2 NISP and MNI values of Vale Boi economic marine shellfish

		Gravettian			Solutrean			Magdalenian		
Species	Habitat	NISP	MNI	%MNI	NISP	MNI	%MNI	NISP	MNI	%MNI
Mytilus sp.	r	76	12	1.1	259	25	5.1			
Pecten maximus	s	22	2	0.2	32	3	0.6			
Acanthocardia sp.	s/m/g				11	3	0.6			
Cerastoderma edule	s/m	1	1	0.1	228	11	2.2	3	1	25
Callista chione	s	1	1	0.1						
Ruditapes decussatus	s/m/g	37	5	0.5	30	5	1.0			
Veneridae	s/m/g	4	1	0.1	9	2	0.4			
Patella sp.	r	8,134	1,025	97.2	2,875	437	89.2	142	3	75
Monodonta lineata	r				1	1	0.2			
Nucella lapillus	r	1	1	0.1						
Thais haemastoma	r	2	1	0.1						
Cerithiidae	s	2	1	0.1						
Naticidae	s/m/g	3	1	0.1						
Pollicipes pollicipes	r	3	2	0.2						
Totals		8,286	1,053		3,445	487		145	4	

Habitat type: r=rocky; s=sandy; m=muddy; g=gravel rocky, sandy and muddy environments (Table 11.2). The types of species exploited during the Gravettian and Solutrean periods remain quite similar, suggesting that similar types of coastal environments were available for resource exploitation during both cultural periods, despite changes in sea levels. In fact, the dominance of shellfish in the assemblage that were exploited from rocky shores, with the addition of minor amounts of shellfish from sandy and estuarine environments, reveals a similar blend of habitats to what are found in coastal southwestern Portugal today.

In addition to the economic species represented in Table 11.2, species that were used as ornaments, such as periwinkle (*Littorina obtusata* and *Littorina mariae*), cowrie (*Trivia* sp.), and dentalium have also been recovered from excavations at Vale Boi (Stiner pers. comm.). The abraded condition of some fragments of the great scallop *Pecten maximus* is also quite different from the rest of the economic assemblage, suggesting that they were picked up from the shore and not used as food (Bicho and Stiner 2006).

Only 3 %NISP ($n=354$) of the total shellfish assemblage is burned, with the majority of burned shell fragments being limpet ($n=308$), followed by mussel (*Mytilus* sp., $n=26$), great scallop (*Pecten maximus*, $n=9$), checkered carpet shell (*Ruditapes decussatus*, $n=9$), and common cockle (*Cerastoderma edule*, $n=1$). However, the incidence of burning is higher on mussels (8 %NISP) than limpets (3 %NISP). When examining the maximum length of limpets, there is only a slight decrease in size from 36 mm during the Gravettian ($n=257$) to 34 mm during the Solutrean ($n=108$). Only nine limpets had lengths greater than 50 mm with 55 mm being the maximum length recorded.

The decrease in shellfish numbers between the Gravettian and Solutrean is likely to be a result of changing coastline dynamics, as sea levels fell during the LGM. Bathymetric maps off southern Portugal indicate a drowned coastal plain (Fig. 11.5). Though an understanding of sea level change in this region is complicated by the active tectonics of the region, it is likely that this plain was exposed during the

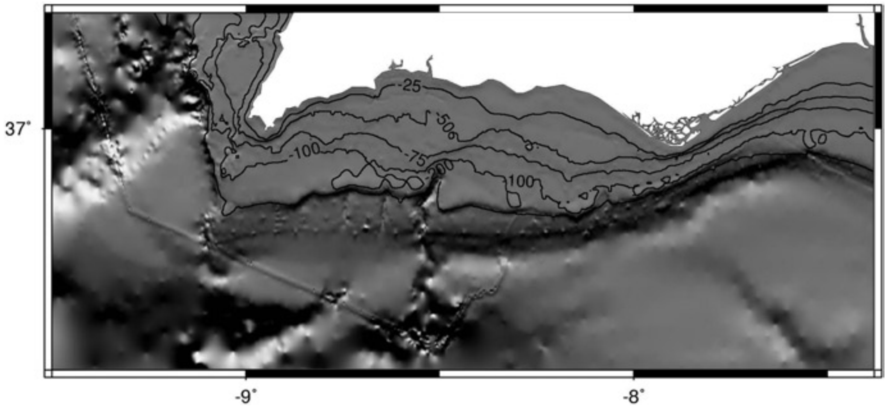

Fig. 11.5 Bathymetric map indicating drowned continental shelf off the coast of southwestern Iberia (cartographic base made by Joaquim Luís, Universidade do Algarve)

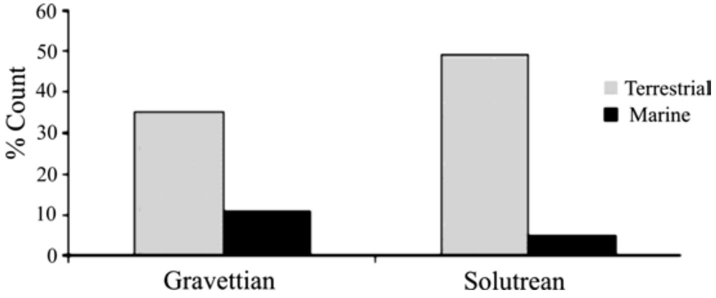

Fig. 11.6 % Count of terrestrial and marine resources. Terrestrial % count based on NISP and marine % count based on MNI

LGM, when global sea levels dropped up to −130 m. During the height of the LGM, the coastline was not more than 20 km away from Vale Boi (Bicho 2004; Bicho and Haws 2008). During the Solutrean, activities at Vale Boi appear to become increasingly focused on the exploitation of terrestrial resources (Fig. 11.6), as the distance to the shoreline increased and it became less feasible to bring back shellfish.

Limpet Productivity and Exploitation

The western coast of Portugal is rich in marine resources largely due to the coastal upwelling that occurs a short distance offshore. Coastal upwelling brings cold, nutrient-rich waters up from the deep ocean, replenishing warm, nutrient-depleted waters at the surface. It is estimated that 80–90% of new ocean productivity occurs in these coastal upwelling zones, areas that comprise only 10% of the worlds' oceans (Abrantes 2000). Diatom records recovered from ocean cores are able to indicate fluctuations in past ocean productivity. These records demonstrate that the greatest productivity seen in oceans through the last 200,000 years, occurred during the LGM (Abrantes 2000). Diatom records recovered off the Atlantic coast of Portugal indicate a boost of productivity during the LGM of one order in magnitude greater than seen today (Abrantes 2000).

Though the relationship of bottom-up effects in marine food chains are complex and unresolved, there is evidence suggesting intertidal grazers such as limpets, benefit from coastal upwelling (Menge 2000). Correlations between increased nutrients from coastal upwelling and increased productivity of intertidal grazers on rocky shores have been documented in several areas of the world, including Oregon, New Zealand, South Africa, and the Canary Islands off Northwest Africa (Bustamante et al. 1995; Menge 2000; Tuya et al. 2006). In South Africa, the limpet *Patella granularis*, was found in greater numbers and larger physical sizes in areas adjacent to upwelling (Bustamante et al. 1995). The increased productivity in *P. granularis* is attributed to the high in-situ primary productivity of algae that are benefiting from the nutrient upwelling.

In the Northeast Atlantic, limpets are considered fundamental to intertidal ecosystems, where they control the growth of algae through grazing (Coleman et al. 2006). Limpets are found abundantly along the Portuguese coast in exposed to moderately exposed environments as either solitary individuals or in loosely aggregated groups (Boaventura et al. 2002; Guerra and Gaudencio 1986). During the LGM, when the intensity of nutrient upwelling increased (Abrantes 2000), it is highly likely that intertidal communities benefitted from the increased flow of nutrients to shore. Primary productivity of algal communities would have been boosted, resulting in better forage for limpet communities. Southwestern Portugal is likely to have served as an excellent habitat for limpets, an area with good exposure, abundant grazing opportunities and water temperatures suitable for supporting a variety of limpet species.

Limpets are an attractive food source, since they are highly visible in the intertidal. However, due to their visibility to potential predators, limpets have evolved an excellent defense mechanism: they have an exceptional ability to grasp or clamp to the substratum. Limpets are considered to have the greatest tenacity in the entire gastropod group (Grenon and Walker 1981). The aggregating behavior of limpets at first glance, would seem to be a beneficial behavior for a predator, reducing the time needed for searching out additional prey. However, research suggests that limpet aggregation appears to be a helpful mechanism against predation. The clamping behavior of a limpet can be initiated when a vibration is detected within a 0.32-m radius of the limpet (Coleman et al. 2004). Thus a limpet in a closely aggregated group is able to perceive an attack on another limpet within its group through vibrations, causing it to clamp down onto the substratum. Though limpets are best collected when they are unaware of a potential predator, experiments carried out on understanding the best angles to detach a limpet have shown that a shear pull, where the limpet is removed in a peeling action is the most efficient (Grenon and Walker 1981).

Foraging costs of limpet harvesting are somewhat significant for humans and thus it is interesting to observe when in the Paleolithic they first emerge as an important food source. *P. vulgata* is particularly abundant in archaeological shell deposits in northern Spain, from the Solutrean through to the early Holocene (Bailey and Craighead 2003; Clark 1971; Craighead 1999). The presence of large shell middens on the Cantabrian coast in northern Spain and along the coast of southern Portugal during the terminal Pleistocene and early Holocene, indicate that humans developed an effective technique to remove limpets in large numbers by this time (Bailey and Craighead 2003; Dean and Faustino-Carvalho 2011; Stiner et al. 2003).

Once limpets have been removed from the substratum, they are relatively easily consumed. The small percentage of burnt shell at Vale Boi (3%) is not unusual, when considering that the majority of the assemblage is composed of limpet, a species that needs neither heating nor cooking in order to be removed from its shell. All but five fragments of burned shell were located from a section on the mid-slope that has been interpreted as an ash dump. A possible explanation for the burned limpets is that after the removal of the flesh, the empty shell was tossed into a hearth and then later dumped with the rest of the hearth material.

Nutritional Benefits of Limpets

Marine shellfish contain long chain polyunsaturated fats (LCPUFA) that are important to the human diet, particularly to pregnant and nursing women (Broadhurst et al. 2002; Uauy and Dangour 2006). The most beneficial of the LCPUFA are within the Omega 3 and Omega 6 series and are known as docosahexaenoic acid (DHA) and arachidonic acid (AA or ARA). DHA and AA both contribute to the growth and development of brain tissue and vascular tissue (Broadhurst et al. 2002). Although small quantities of AA and DHA may be synthesized from short-chain polyunsaturates (linoleic acid and alpha-linolenic acid), humans and other mammals are relatively inefficient in carrying out this conversion (Broadhurst et al. 2002; Jensen 2006; Milligan and Bazinet 2008). Instead, most AA and DHA needs to be introduced to the body directly, rather than through synthesis of short-chain polyunsaturates. DHA and AA are found in foods such as fish, shellfish, egg yolk, organ and muscle meat, bone marrow and in the case of AA, nuts, grains, and pulses (Broadhurst et al. 2002; Howe et al. 2007; Milligan and Bazinet 2008). Some marine shellfish can thus serve as either a seasonal additive to existing sources or as important contributors when terrestrial sources of these LCPUFA are not available.

While DHA is deemed more beneficial for pregnant women, infants, and human health in general, AA is also considered to be invaluable for the growth of vascular tissue during fetal and postnatal periods (Arterburn et al. 2006; Mozaffarian et al. 2005; Uauy and Dangour 2006). This is particularly the case during the third trimester and the 4 months following birth, when brain and visual development increases the need for DHA and AA fatty acids (Clandinin 1999; Uauy and Dangour 2006). Research indicates that while increased consumption of foods containing DHA and AA may increase the availability of these fatty acids to the fetus and new born, much of the essential fatty acids needed for brain and retinal development appears to originate from existing adipose stores of the mother (Arterburn et al. 2006). This suggests that pregnant (and nursing) women not only should increase the amount of LCPUFA in their diet during the third trimester, but that pregnant women should proceed this period by a sustained consumption of DHA and AA-rich substances, allowing for the storage of these fatty acids in their adipose tissue. Fetuses and new born babies are able to synthesize short-chain polyunsaturated fatty acids into LCPUFA, but in only negligible amounts (Arterburn et al. 2006). Following birth, most DHA and AA is continued to be provided by the mother, in the form of breastmilk (Innis 2007).

Ethnographically, gathering shellfish is often cited as a task that women and children undertake (Bliege Bird 2007; Broadhurst et al. 2002; Buchanan 1988; Chapman 1987). When considering the sustained energetic and nutritional needs of pregnant and lactating women, as well as of growing children, the gender roles of shellfish harvesting take on a new significance. Shellfish not only represent a reliable source of food that can be taken back to the camp to be shared with others, but a rich and reliable source of essential fatty acids required for the healthy growth and development of young children. Some shellfish, such as limpets, may be processed and eaten in the field thus providing convenient, nutritious snacks for both children and adults.

Limpets seasonally contain considerable quantities of lipids, particularly in the period leading up to spawning. Prior to spawning (Blackmore 1969) 30% of *P. vulgata* total fatty acids consists of AA and DHA LCPUFA (Gardener and Riley 1972). Generally, marine bivalves contain a relatively high percentage of DHA – for example, *M. edulis* total fatty acids consists of 12.3% DHA and 12.4% AA (Brazão et al. 2003; Gardener and Riley 1972). Limpets however, like other prosobranch gastropods, have relatively large quantities of AA and only small amounts of DHA (Brazão et al. 2003; Gardener and Riley 1972). For example in *P. vulgata*, 25.8% of total fatty acids consist of AA, while only 3.8% of total fatty acids are DHA LCPUFA (Gardener and Riley 1972). The elevated level of AA in limpets is attributed to their herbivorous diet of macroalgae, organisms that are rich in AA (Brazão et al. 2003).

Lipid quantities in limpets are related to gonad development (Blackmore 1969; Gardener and Riley 1972). Increase in lipids begins with the development of gonads and reaches maximum quantities at gonad maturity. Once the release of lipid-rich eggs and sperm begins during spawning, lipid quantities within limpets begin to drop, reaching minimum levels once spawning is completed. A period where gonads are at the neutral "resting" stage follows, until gonad development begins again. The seasonality of spawning varies between species as well as with water temperature, causing the timing of spawning to vary depending on latitude (Guerra and Gaudencio 1986). For example, in northern Britain, spawning of *P. vulgata* begins in August/September, whereas in Portugal, spawning starts in December/January (Guerra and Gaudencio 1986). Some limpet species, such as *P. ulyssiponensis* have an annual spawning event during autumn (August to November) when located in southwest Ireland, but an extended period of spawning in southern Portugal (between August and April) (Guerra and Gaudencio 1986). Other limpet species appear to not exhibit a clear spawning period when inhabiting a zone located in waters with a median temperature range. For example *P. intermedia* has distinct spawning events in Britain (spring and sometimes late autumn) and southern Portugal (late autumn through early spring) (Guerra and Gaudencio 1986). However in central Portugal, spawning appears to occur year-round with *P. intermedia* individuals in the neutral, resting stage found alongside ones with large, mature gonads (Guerra and Gaudencio 1986).

What do we know about the timing of human occupation at Vale Boi with respect to limpet harvesting? Based on the evidence of fetal and neonate ungulate remains, humans were at Vale Boi during the spring. The age cohort structure of the red deer remains suggests that hunters were targeting maternal herds. The low altitude, warm southern exposure of the site, and the preponderance of fetal, neonate and fully adult red deer and horse individuals suggests that the site was used periodically during late spring and not while juveniles were maturing in the fall.

An added complexity to assessing the timing of limpet harvesting by humans is the seasonal spread of limpet spawning cycles. Climate changes during the Upper Paleolithic are likely to have affected local sea-surface temperatures, causing subtle shifts in the timing and duration of limpet gonad maturation. Past sea-surface temperatures (SSTs) for the western coast of Portugal have been reconstructed using data from the deep marine cores SO75-26KL and MD95-2042 (Boessenkool et al. 2001; de Abreu et al. 2003; Pailler and Bard 2002; Sanchez-Goñi et al. 2002, 2008). Prior to the LGM, SSTs on the Portuguese margin may have been comparable or slightly higher than temperatures today (Boessenkool et al. 2001; de Abreu et al. 2003, but see also Pailler and Bard 2002), while during the LGM, SSTs appear to have ranged between 12 and 15°C (Cayre et al. 1999; Pailler and Bard 2002; Sanchez-Goñi et al. 2002). Palynological data from MD95-2042 suggest that terrestrial conditions during both the Gravettian and Solutrean culture periods were colder and more arid than today (Roucoux et al. 2005). These conditions may also explain the increase in *Equus* (and *E. hydruntinus*) remains at Vale Boi. The continuing cold conditions during the LGM may have lead to a local expansion of grasslands, beneficial for grazers like the horse and wild ass. However, though decreases in overall numbers of thermophile plants are noted at the end of MIS3 and into MIS2, stands of *Quercus*, Ericaceae, and *Pinus* continued to persist in southwestern Portugal. This indicates that southwestern Portugal is likely to have experienced increased moisture relative to neighboring regions, such as northwest Portugal and southern Spain (Roucoux et al. 2005; Sanchez-Goñi et al. 2008).

Research into modern southern Iberian coastal SSTs indicates that water temperatures off Cabo São Vicente (the southwestern most point of Iberia) stay cool year-round (Vargas et al. 2003). This is particularly the case between the months of May and November, when coastal water temperatures at Cabo São Vicente are 2–4°C colder than SSTs to either the South or East (Vargas et al. 2003). This situation of colder SSTs is a result of coastal upwelling and as mentioned above, diatom records indicate that a significant increase in coastal upwelling occurred during the LGM (Abrantes 2000). The increased intensity in upwelling may have also resulted in colder coastal water temperatures than what occur today. Though at present it is difficult to ascertain what coastal SSTs may have been like in the past, a useful avenue of future research may be to use oxygen isotope records from shellfish to examine regional environmental and ecological changes (Fenger et al. 2007; Mannino and Thomas 2007; Mannino et al. 2008). Recent work by Fenger et al. (2007) indicates excellent potential for using *P. vulgata* shells as a proxy for understanding both changes in sea-surface temperatures and ocean upwelling intensity.

In any case, temperature fluctuations during the Gravettian and Solutrean culture periods most likely meant subtle shifts in the seasonality of spawning for the various limpet species, but a more bountiful molluskan community overall. If coastal water temperatures were similar to what are experienced today, past and present seasonality of spawning is likely to have been comparable. However, a drop in coastal water temperatures may have caused some limpet species, such as *P. intermedia* to undergo gonad development during spring, similarly to what is seen in more northerly latitudes today. Other species, such as *P. ulyssiponensis* and *P. vulgata* may have matured during autumn. This may have resulted in limpets rich in lipids being available for a good portion of the year, including the late spring, a time when we know that Vale Boi was occupied.

Conclusion

The paucity of Upper Paleolithic shellfish assemblages in southern Iberia should not be taken as an indication that marine resources were not an important part of the diet in this region. The Vale Boi assemblage indicates that already by the Gravettian, modern humans were taking advantage of nearby marine resources. The southwest of Portugal poses an excellent habitat for limpets that prefer exposed to moderately exposed coasts and nutrient-rich waters for the growth of algae. In addition, the juxtaposition of Vale Boi between warm Mediterranean and colder Atlantic waters produces an environment in which a variety of limpet species could be exploited. The different species' over-lapping stages of gonad development may have allowed for many months supply of important lipids.

Southern Portugal with its xeric climate regime has a moist, cool, winter growing season and a hot, dry summer where there is rapid decomposition of vegetation (Haidouti et al. 2001). Evidence points to Vale Boi being a spring camp. Its low altitude location and warm southern exposure would have made it an attractive location during the colder months of late winter and early spring. During the summer months, however, it may have been advantageous to move to higher altitudinal regions containing upland pastures. These would have experienced cooler and moister conditions, providing browse for ungulates as vegetation in the lowlands became unpalatable. The evidence of resource intensification that is observed at Vale Boi, both in the form of a broadening diet and the intensive processing of ungulates, suggests behavioral efforts to alleviate environmental stress. However, though particular favored foods may have become more difficult to secure overall, the unique location of Vale Boi allowed for a diverse range of foods to be exploited in the spring. As conditions became cooler and more arid with the onset of the LGM, larger expanses of grasslands are likely to have opened up for ungulate grazers and the increased intensity of ocean upwelling would have boosted oceanic productivity on the nearby coastlines. Foragers had access to edible plants (Haws 2003), the flesh of large and small mammals, the marrow and bone-grease of large game, and the nearby nutrient-rich coast, with its plentiful supply of marine shellfish. Despite considerable environmental change, Vale Boi remained a site to which people returned to for many millennia; a "good place" to come back to, whether for the diversity of its natural resources, or the persistence of cultural tradition.

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Chapter 12
Surf and Turf: The Use of Marine and Terrestrial Resources in the Early Neolithic of Coastal Southern Portugal

Rebecca M. Dean and António Faustino Carvalho

Introduction

Southern Portugal is an interesting case study in the spread of the Middle Eastern Neolithic complex. Similar to sites along the Mediterranean coast, the Portuguese Neolithic was the result of the longitudinal movement of agricultural adaptations. Plants and animals that originally evolved in southwest Asia, therefore, did not have to adapt to extreme changes in the length of the growing season, summer temperatures, or rainfall, as was the case with the latitudinal movement of agriculture into interior and northern Europe. Unlike their contemporaries along the Mediterranean, however, the Mesolithic and Neolithic inhabitants of Portugal had access to the rich marine resources of the Atlantic Ocean upwelling along the western coast of Europe allowed extensive exploitation of fish and shellfish by relatively complex and sedentary groups of foragers throughout the late Pleistocene and early Holocene, from Portugal to Scandinavia (Arias 1999). The large *concheiros* (shell midden sites) of Mesolithic Portugal are just one example of this phenomenon (Zilhão 1997).

The introduction of agriculture into areas dominated by well-established foraging societies was a complex process. The success of marine-based economies may well have delayed the adoption of agricultural products by local foragers, or the colonization of the coast by immigrant farmers, in many areas of Mediterranean Europe (Zilhão 1993; Arias 1999). Although Mesolithic lifeways based on coastal resources were remarkably long-lived, they were eventually replaced by intensive agricultural economies throughout the region. Classic archaeological models relating to the adoption of agriculture frequently point to food stress and declines in foraging efficiency as causal factors in this transition (Binford 1968; Cohen 1977; Flannery 1969; Rindos 1984). It remains to be demonstrated whether this was the case in Portugal, and in what way such a decline may have been realized.

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Coastal southern Portugal, namely the Algarve region, has never been subject to systematic research on the Mesolithic-Neolithic transition, despite the occasional discovery, during the last 30 years, of some important sites dating to these time periods. To remedy this situation, the University of Algarve led a multidisciplinary project in 2002–2005. Summaries of the main results and their implications for the understanding of the neolithization of Southwestern Portugal have been published elsewhere (Carvalho et al. 2005; Carvalho 2010). The faunal assemblages recovered during the excavation of some Mesolithic sites have been published by Valente and Carvalho (2009), and a preliminary analysis of the early Neolithic faunas was already presented by Dean (2006) and Carvalho et al. (2008).

The main aim of this paper is therefore to present a more detailed analysis of the early Neolithic fauna from two sites, Rocha das Gaivotas and Vale Boi, both located in the westernmost part of the Algarve (Fig. 12.1), and to discuss the early Neolithic subsistence strategies in this region, particularly as they relate to changes in foraging efficiency during the introduction of agriculture.

Rocha das Gaivotas is a shell midden located on the edge of a cliff 50 m above the sea (Sagres, Vila do Bispo). It contains a long stratigraphic sequence. The four earliest occupations, found in layer 3, are dated to 8,600–8,000 RCYBP (Epipaleolithic). Within layer 2, there are two main occupations. The earlier occupation, dating to 6,900–6,700 RCYBP, during the Mesolithic, is a very dense stratum composed of shells and three fireplaces of complex typologies, including stones of various sizes. Together with the high number of faunal and lithic remains, this may represent a relatively stable, although probably seasonal, settlement. The most common species present are limpets (*Patella* sp.), mussels (*Mytilus* sp.), dog wilks (*Thais haemastoma*), and an edible barnacle, *Pollicipes pollicipes*, called goose barnacle in English and perceve in Portugal, where it is widely eaten as a delicacy. The limpets and mussels were the predominant species.

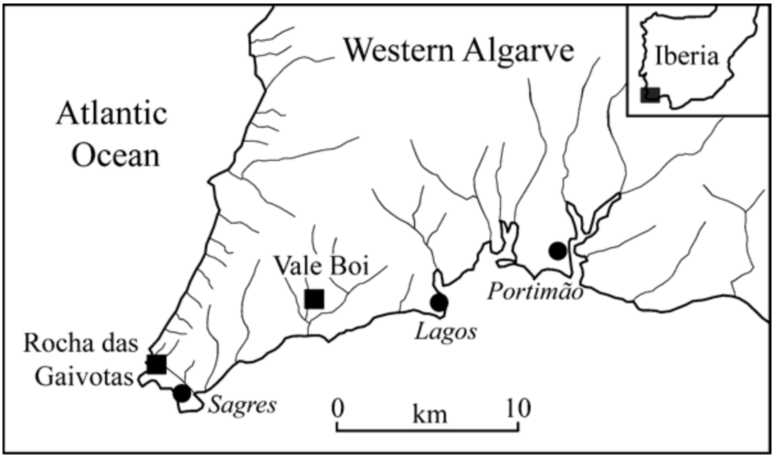

Fig. 12.1 Sites mentioned in the text

An Early Neolithic context, dating to 6,400 RCYBP, was identified immediately above the Mesolithic deposits and contained a scattering of diagnostic pottery. This occupation seems less intensive than the previous one: there are no features of any kind and the shell midden itself is thin and stratigraphically less coherent. With the exception of a few small and unidentifiable fragments of bone, marine invertebrates are the only faunal remains present.

In contrast to Rocha das Gaivotas, the site of Vale Boi (Budens, Vila do Bispo) is located some 2 km from the coast, in an area that favored the exploitation of terrestrial resources. Vale Boi is a large archaeological site, located on a west-facing slope, near the narrowing of a valley opening onto the ocean. It would have been an ideal spot for hunting, and indeed, this site is already known for its important Upper Paleolithic occupations, with abundant faunal remains, in the so-called “area 1.”

The testing of “area 2,” at the base of the slope, revealed an Early Neolithic occupation very different from the one recorded at Rocha das Gaivotas. It included a single level defined by an irregular pavement with domestic structures. Associated with this pavement were pottery, chipped stone, and bone tools. Several AMS dates on mammal bone have consistently indicated an age of around 6,050 RCYBP for the Neolithic levels at Vale Boi. No direct evidence of agriculture was found. The faunal assemblage was largely composed of mammals, which will be discussed below, but a small number of bird and fish remains were also found, including eagle (*Aquila* sp.), quail or chukar (*Alectoris* sp.), and tope shark (*Galeorhinus galeus*). This was published by Carvalho et al. (2008).

The majority of faunal remains from Vale Boi and Rocha das Gaivotas were identified using the small comparative collection housed at the University of Algarve. Specimens that could not be identified with this collection were taken to Lisbon for identification at the Instituto Portugues de Arqueologia, Lisbon. Measurements made on the remains followed the standards suggested by von den Driesch (1976) for mammals and Claassen (1998) for shellfish. Length and width measurements were also taken on individual perceve specimens. MNI counts for shellfish were based on the number of umbos, for bivalves, and the pinnacle of limpets. Each individual perceve barnacle produces 18 small shell shields, called scuta or terga; the “beak-shaped” scuta that is found at the keel of the head was counted as an MNI marker in these assemblages.

Faunal Remains from Vale Boi

The faunal assemblage from the Early Neolithic occupation levels at Vale Boi is dominated by rabbit and ungulate specimens (Table 12.1). A total of 216 identifiable pieces of mammal bone were recovered from the deposits. Of these, 40% ($n = 150$) belonged to the European rabbit (*Oryctolagus cunniculus*) or hare (*Lepus* sp.). The vast majority of these lagomorph remains were from the smaller rabbit species. Hare is only represented by four pieces.

Table 12.1 Faunal Remains from Vale Boi

Order		NISP	%NISP
Lagomorpha	European rabbit (*Oryctolagus cuniculus*)	146	68%
	Hare (*Lepus* sp.)	4	1.9%
Artiodactyla	Cattle (*Bos* sp.)	2	0.9%
	cf. *Bos* sp.	2	0.9%
	Ovicaprid (*Capra/Ovis* sp.)	31	14%
	cf. *Capra/Ovis* sp.	10	5%
	Goat (*Capra* sp.)	3	1%
	Red deer (*Cervus elaphus*)	4	2%
	cf. *Cervus elaphus*	12	6%
	Pig (*Sus scrofa*)	2	0.9%
	Total	216	

European rabbit may be intrusive in archaeological sites, since these are burrowing animals. The remains from Vale Boi, however, appear to be culturally deposited. Many of the rabbit remains were found in or under large rock concentrations, which would be unlikely areas for burrows. Furthermore, the distribution of lagomorph remains, as shown below, is very similar to that of ungulates, which are clearly anthropogenic. None of the faunal remains from Vale Boi have cut marks, but a high proportion of the rabbit remains are burned. Thirty-five percent ($n=150$) of the lagomorph specimens were partially or fully burned, compared to only 23% ($n=91$) of the artiodactyl remains.

Most of the remaining mammalian remains from Vale Boi were ungulates, including cattle (*Bos* sp.), red deer (*Cervus elaphus*), ovicaprids (*Capra/Ovis* sp.), and pig (*Sus scrofa*). The most common identifiable ungulate remains belonged to sheep or goat. They comprised 66% ($n=44$) of the ungulate NISP that could be identified to genera or better. Sheep and goat are very difficult to distinguish on the basis of postcranial remains. It was possible, however, to identify three specimens as definitely goat. Two specimens are more similar to sheep, but the identifications cannot be confirmed because, in one case, the bone comes from a very young animal, and in the other, the range of intraspecies variability for the element is too high. The presence of sheep at the site, if it could be confirmed, would be a proof that the animals at Vale Boi were domestic, because sheep are not found wild in Europe.

Red deer were the next most common species, making up 24% ($n=16$) of the ungulate remains identifiable to genus or better. Cattle and pig remains were present in small numbers. There were also a large number of bones ($n=157$) that could be identified only to the category of medium-sized ungulate. Based on their size, the majority of these bones probably belonged to ovicaprids or possibly to red deer, but it was not possible to identify them more specifically.

A number of marine shell fragments were recovered at Vale Boi. These comprised an MNI of 12, divided between five different mollusk species, in addition to 94 shell

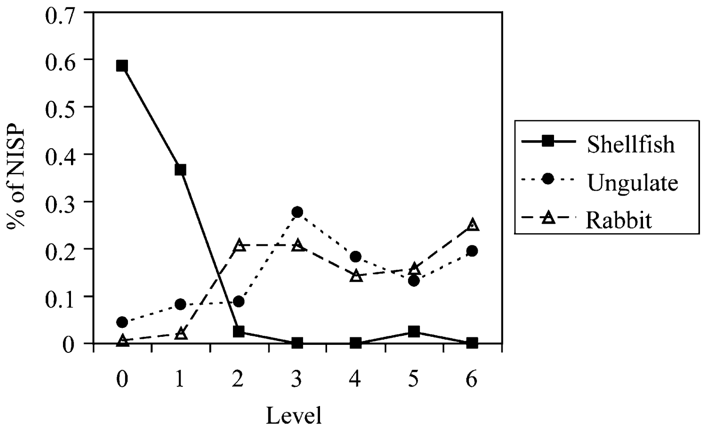

Fig. 12.2 The proportion of specimens found in each artificial level for each of the three major taxonomic groups at Vale Boi: shellfish, ungulates, and rabbit. Note that all shell pieces are included here, not just those containing identifiable portions. Specimens from the original test pit were not included. One artiodactyl specimen was not included because it belonged to either level 2 or 3

fragments that could not be included within the MNI counts. It appears, however, that the shell is unrelated to the Neolithic occupation of the site. Direct dating of the shell suggests that some, at least, are modern. Furthermore, the stratigraphic distribution of shell is quite different from the distribution of mammalian remains (Fig. 12.2). In total, 56.9% (*n*=41) of shell NISP came from the top 5 cm of the excavations (artificial level 1), which is more likely to represent a mixed archaeological context than the lower levels. Shell is very common in those earlier deposits, and indeed, a higher number of shell pieces (*n*=57) were found in the disturbed sediment directly overlying the excavation units than in any of the Neolithic levels. The amount of shell drops off precipitously in the lower, more securely dated, levels. In contrast, land mammal specimens follow the opposite pattern. Fewer ungulates and rabbits are found in the highest excavation level; only 3.3% (*n*=5) of rabbit remains and 6.2% (*n*=16) of ungulate remains are found in the top artificial excavation level. Both taxonomic groups are much more common in the more secure Neolithic contexts.

It is likely, therefore, that the large number of shell pieces from the highest excavation levels do not reflect Neolithic resource use, although undoubtedly some of the shell, particularly from lower excavation levels, do date to the Neolithic period. One goose barnacle, one carpet venus, and three small pieces of limpet shell were identified from these deposits.

The overall picture that emerges of the Vale Boi Neolithic economy is one dominated by mammalian resources, despite its relative proximity to the coast. In particular, the assemblage is largely comprised of the smaller mammalian species available in the region, including rabbits and the smaller ungulates. Larger terrestrial resources, such as cattle, are represented by only a few bones.

Fauna from Rocha Das Gaivotas

In marked contrast to the faunal assemblage from Vale Boi, the assemblage from Rocha das Gaivotas is almost entirely comprised of marine resources, specifically shellfish and edible barnacles (Table 12.2). Three small pieces of unidentifiable mammal bone were found, but the remainder of the assemblage reflects an economic focus on gathering the sea. The sample contains a total of 8,189 fragments, with a total minimum number of individuals of 2,761. Although 12 species of marine resources were identified at the site, the vast majority of the assemblage is made up of limpets and the edible barnacles, perceves. Perceves attach themselves to rocks in the tidal zone and are easily gathered on the beach, which undoubtedly made them an attractive food source. The animals are quite small, however, at only 5 cm in length on average, and only the foot is edible (Saldanha 1995:121). Therefore, they produce very little food per individual. Limpets and perceves together comprise 76% ($n = 2{,}105$) of the assemblage at Rocha das Gaivotas. The only other species found in significant amounts is the mussel, which made up 16% ($n = 437$) of the assemblage.

The other species of marine animals found at Rocha das Gaivotas combined for less than 8% ($n = 219$) of the assemblage. Most of these other specimens represent animals that were carried to the site as passengers on shellfish. This, for example, is the most likely explanation for the relatively large number of nonedible barnacles that were found in the Neolithic levels. Other edible species, such as the cockle (*Cerastoderma edule*) and the dog wilk, were present in only tiny numbers compared to perceves, limpets, and mussels.

The picture of Neolithic economies that emerges from the analysis of Rocha das Gaivotas, therefore, is one focused entirely on marine resources, with no use of terrestrial resources at all. The smaller marine resources, the edible barnacles, were particularly prevalent at the site, with some larger species, such as mussels, less commonly represented.

Table 12.2 Faunal remains from Rocha das Gaivotas

Order	Species	MNI	%MNI
Pollicipedidae	*Pollicipes pollicipes*	1,115	40%
Balanidae	*Balanus* sp.	154	6%
Archaeogastropoda	*Patella* sp.	990	36%
Basommatophora	*Siphonaria pectinata=algesirae*	16	0.6%
	Monodonta lineata	4	0.1%
Neogastropoda	*Nassarius=Hinia reticulata*	2	0.1%
	Ocinebrina edwardsi	16	0.6%
	Stramonita=Thais haemastoma	21	0.8%
	Urosalpinx cinerea	1	0.04%
	Nucella lapillus	4	0.1%
Mytiloida	*Mytilus* sp.	437	16%
Cardiidae	*Cerastoderma=Cardium edule*	1	0.04%
	Total	2,761	

Changes Through Time in the Faunal Assemblages

Figure 12.3 shows changes in the proportion of the three major marine resources in the arbitrary excavation levels at Rocha das Gaivotas. Level 5, the lowest excavation level, probably dates to the Mesolithic period or represents a mixed Mesolithic and Neolithic context. Levels 1 through 4 are more securely dated to the Early Neolithic. In the earliest occupation levels, larger mussel species are more common. In Level 5, they make up 22% of the minimum number of individuals. In the Neolithic levels, however, they make a much less significant contribution to the assemblage. In Levels 1 through 4, mussels are never more than 14% of the assemblage. In the most recent levels, they are only 12% of the assemblage, just over half their representation in the Mesolithic.

Changes through time in the use of limpets and the small barnacle, perceves, are also visible, with the use of perceves consistently increasing at the expense of limpets. Perceves comprise 58% of the minimum number of individuals in the highest level, a rise from 41% in the lowest level. Limpets, on the other hand, decline from 35% of the assemblage in level 5–26% of the assemblage in level 1. As can be seen from this graph, however, the decline in limpet use is not gradual, but instead a categorical change that occurs between levels 3 and 2, when the percentage drops from 35 to 29%.

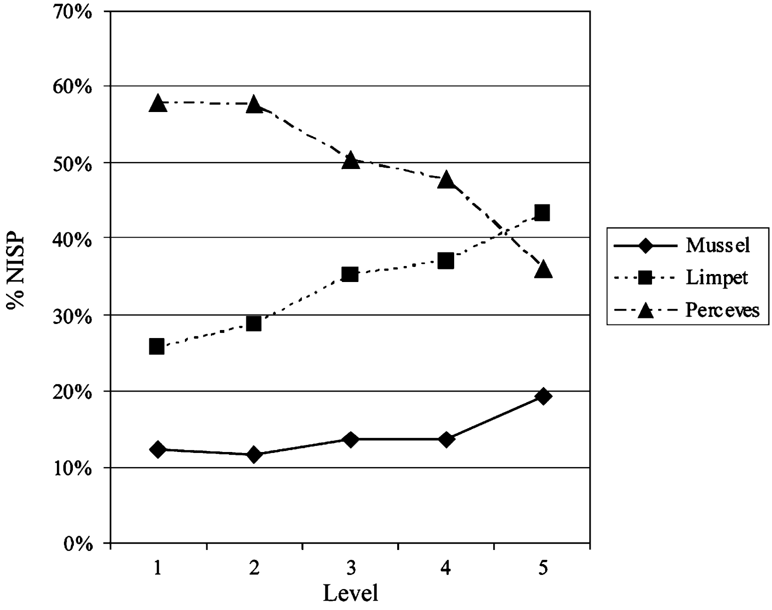

Fig. 12.3 Genus representation across arbitrary levels in the main Neolithic excavation areas at Rocha das Gaivotas. Level 1 is the most recent. Level 5, the earliest, is a mixed Neolithic/Mesolithic layer

Table 12.3 Changes in average shell size across arbitrary excavation levels

	Patella		Pollicipes	
Nivel	Length	Width	Length	Width
1	16.49	11.75	13.56	7.08
2	21.73	14.95	14.17	7.34
3	27.17	21.03	14.47	7.40
4	26.71	20.28	14.75	7.63
5	25.29	19.48	15.08	7.70

The decline in limpet representation and the increase in perceve use cooccur with declines in average size for both genera (Table 12.3). Average length and width for limpet specimens decline sharply between levels 3 and 2, from an average of 27 mm in length and 21 mm in width to averages of 21 and 15, respectively. It should be noted, however, that this analysis groups together more than one species of limpet, and changes in limpet species representation would affect average specimen size. Perceves shows a similar decline in the average length and width of the small shell-like scuta or terga that protects the head of the animal. The average length of perceve scuta/terga in the lowest level was over 15 mm, which declines to 13.5 mm in lower levels. Average width also declines, although not as significantly, from 7.7 in level 5 to 7.08 in level 1.

Overexploitation of marine resources could account for changes in both species representation and in average size of animals. This is difficult to prove, however, since the reaction of shellfish to minor fluctuations in local environments makes it particularly difficult to identify overexploitation in shellfish resources (Claassen 1998:45). Regardless of cause, however, the increasing use of small barnacle species, and the concurrent decrease in average shell size, represents a decline in foraging efficiency throughout the Neolithic period at Rocha das Gaivotas. Similar analyses from other sites will be needed to show whether the decline was limited to this particular point along the coast or if it is a pattern generally present in Early Neolithic shell midden sites.

The site of Vale Boi, although dominated by terrestrial resources that are quite different from the marine species found at Rocha das Gaivotas, none the less exhibits a similar pattern of subsistence change. Unfortunately, comparisons with earlier Holocene deposits are difficult, as there is no evidence of a Mesolithic occupation at Vale Boi, except for the presence of an individual human molar dating to that period. However, the site was occupied for many thousands of years during the Paleolithic, and there is a rich faunal record from these earlier periods that can be compared to the Neolithic occupations at the site (Manne et al. 2006, 2011).

Figure 12.4 shows the proportion of major species found in the Paleolithic and Neolithic occupations at Vale Boi. Data from the Gravettian, Solutrean, and Magdalenian levels are from Manne et al. (2011; personal communication). Small game, specifically rabbits, are more common in the Neolithic period than in the preceding Magdalenian and Solutrean, although levels of exploitation were high

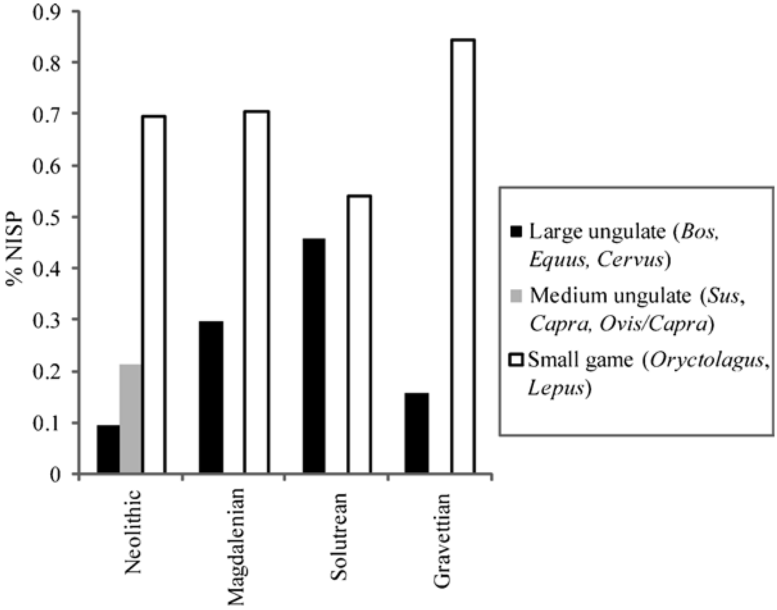

Fig. 12.4 Taxa as a proportion of NISP at Vale Boi

throughout prehistory. Rabbits are 69% (*n*=150) of NISP in the Neolithic levels at Vale Boi, compared to 70% (*n*=480) in the Magdalenian, and 54% (*n*=2,466) in the Solutrean. They comprised 84% (*n*=2,751) of the Gravettian assemblage, however.

The most striking difference in faunal exploitation during the Neolithic is seen in the changes in ungulate exploitation. Larger animals, such as cattle, horse, and red deer, were much more common in the Paleolithic than Neolithic levels. These larger ungulates make up 30% (*n*=202) of the Magdalenian fauna, 46% (*n*=2,089) of the Solutrean fauna, and 16% (*n*=506) of the Gravettian fauna. In contrast, they are less than 10% (*n*=20) of the fauna from the Neolithic occupations.

The large ungulates that were common in the Paleolithic were largely replaced in the Neolithic by medium-sized ungulates, including sheep/goats and pig. In the Paleolithic assemblages, these smaller ungulates were virtually absent, comprising less than 1% of all faunal specimens in each of the early periods of occupation. In the Neolithic levels, however, the majority of ungulates are ovicaprids. Goats (and possibly sheep) are 20% (*n*=44) of all faunal specimens in the Neolithic occupations. Pigs, another medium-sized ungulate, were a negligible portion of the assemblage.

The significant increase in ovicaprids in the Neolithic levels likely reflects the introduction of domestic sheep and goats into the region and their integration into the economic system at Vale Boi. Since the domestic status of these animals cannot, however, be proven, it is possible that the predominance of medium ungulates in the assemblage instead reflects the greater importance of hunted wild goat.

These animals may have gained greater prominence in the diet due to the decreased availability of larger game in later time periods, whether that decreased availability was the result of overhunting, larger human populations, or changing climates in southern Portugal.

Conclusions

Although the faunal assemblages from the Neolithic occupations at Rocha das Gaivotas and Vale Boi are entirely different in terms of the species present, they both represent economic strategies based on the consumption of smaller taxa, whether that smaller game is represented by barnacles or smaller ungulates and rabbits. The implication is that early Neolithic adaptations in southern Portugal, as in many other parts of the world, were characterized by resource depression, in comparison to earlier occupations in the same region. It is not clear, from the data in these sites alone, whether this resource depression preceded the Neolithic, and therefore may have been one of the driving factors in the adoption of the new agricultural technologies, or if resource depression was a result of larger populations or more intensive occupations brought about by the agricultural revolution. The gradual changes in taxa size seen at Rocha das Gaivotas support the idea that resource depression increased during, and not before, the early Neolithic. However, the size and abundance of shellfish can be highly variable, influenced by a variety of ecological conditions, so the evidence from one site is not conclusive.

Changes in animal exploitation at the sites may also have been influenced by changes in prey availability, which were not caused by human agency, but rather by fluctuations in marine climates or changing terrestrial environments in the early/mid Holocene. Whether or not the prehistoric inhabitants of the Algarve *caused* the reduction of foraging efficiency by overexploitation of resources, the Neolithic herder/foragers certainly had to deal with the consequences of decreased availability of higher-ranked prey. The greater reliance on smaller animals, which was the result of this change, may have heightened the attraction of the newly introduced domestic resources.

The exclusive focus on coastal or terrestrial resources at each site also has interesting implications for the degree of residential mobility practiced by early Neolithic peoples. Isotopic studies on human bones by Lubell et al. (1994) show that Mesolithic people in Portugal ate a diet that balanced terrestrial and marine resources, in contrast to early Neolithic populations that were almost entirely dependent upon terrestrial sources for their protein. Isotope analysis of the Mesolithic human molar from Vale Boi, mentioned above, also revealed a balanced consumption of marine and terrestrial foods (Carvalho et al. 2008). Therefore, the sites of Rocha das Gaivotas and Vale Boi suggest that early Neolithic people in the western Algarve did not increase the diversity of their diet by pooling resources in central locations, but rather by following residential mobility patterns that took advantage of particularly rich collection areas.

The discovery of the important site of Castelo Belinho (with burials, storage pits, and possible large, rectangular wooden houses), dating to the early Neolithic, is testimony that more permanent habitation sites existed in the hinterland and that a broad spectrum of resources may have been exploited in sites such as this (Gomes 2008). On the other hand, the existing data suggest that early Neolithic sites near the coast represent short-term occupations where only local resources were harvested. In any case, high mobility would not exclude the possibility of significant economic focus on agriculture. The planting, tending, and harvesting of domestic grains, for example, are seasonal activities, and therefore could be coordinated with seasonal mobility.

There is nothing in the archaeological record of Rocha das Gaivotas and Vale Boi, however, to suggest a strong reliance on agricultural products, whether animal or vegetable. A heavy focus on sheep and goat transhumance, for example, would presumably be reflected in a high ubiquity of ovicaprids in all types of Neolithic sites, rather than their complete absence from shell midden sites like Rocha das Gaivotas. Nor is there an obvious indication of heavy reliance on domestic plants in the form of groundstone or storage features at either site.

The data from these two sites, therefore, suggest they were logistic occupations associated with a much larger and more substantial village. The focus on local resources in the faunal assemblages from Rocha das Gaivotas and Vale Boi reflects their specialized functions more than the overall economic system of which they were a part. These sites are good examples of the incomplete picture that could be drawn of Neolithic subsistence strategies if based solely on one site, without an understanding of the regional context. The discovery of several permanent Cardial Neolithic open-air sites (such as La Marmotta, near Rome, La Draga in Catalonia, or Mas d'Is in Alicante) is gradually changing a long-lasting perception of this time period in the western basin of the Mediterranean as characterized by small, high mobile groups of hunters and shepherds living in caves near the sea, in contrast to the pattern of more sedentary communities with more intensive economic practices, as recognized in the early Neolithic of the Danube (e.g., Guilaine 1976; Whittle 1985).

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Part II

South America, Africa, and Oceania

Chapter 13
Pinniped Zooarchaeological Studies in Southern Patagonia: Current Issues and Future Research Agenda

A. Sebastián Muñoz

Introduction

Sea lions have been one of the main resources used by Holocene hunter–gatherers in Southern Patagonia, but many aspects of their exploitation still remain to be studied if we are to understand the variability involved in human-pinniped relationships since the human peopling of the region at the end of the Pleistocene. In this chapter, Southern Patagonia is defined as the southern tip of South America, from Santa Cruz river (50°S) to Cape Horn (55°S). The main pinniped species in this region are the Southern sea lion (*Otaria flavescens*) and the South American fur seal (*Arctocephalus australis*). The former weighs 300 kg (males) and 150 kg (females), and the latter, 140 kg (males) and 50 kg (females). Besides their body size, these two species differ in the *loci* they use for mating and pupping, as well as in the waters where they feed (King 1983; Jefferson et al. 1993; Bastida and Rodriguez 2003).

Pinnipeds have been relevant to the human populations in Southern Patagonia throughout the Holocene for several reasons, among which, the amount of grease they offer, which is a critical substance at these latitudes (Borrero 1986); the energetic subsidy from the marine to the terrestrial environment they represent (Schiavini 1993), and their predictability in time and abundance in certain areas of the Patagonian landscape (Lanata and Borrero 1994). Pinnipeds can be found year-round in certain localities along the coast, the permanent colonies, and temporally in the seasonal ones. Isolated individuals can also be found along the coast (King 1983; Grandi et al. 2008).

Several studies carried out during the last decades have questioned the past validity of the ethnographically derived model according to which marine hunter–gatherers inhabited West and South of Southern Patagonia and terrestrial ones

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occupied the Eastern insular and continental sectors. According to this ethnographic model, the former foraged the marine space around the archipelago by means of canoes while the latter were terrestrial hunters, and both groups shared a nomadic way of life and very simple technologies (Menghin 1952; Steward and Faron 1959).

Based on archaeological data, more recent studies have shown that in preethnographic times, human strategies in Fuego-Patagonia were more varied than previously thought (e.g., Yesner 1990; Legoupil 1993–1994; Borrero 1997; Yesner et al. 2003) and hence that a new round of investigation aiming at recognizing the whole range of variation in the interactions between hunter–gatherers and their prey is needed (e.g., Borrero 1997, 2001). Regarding pinnipeds, such variation involves different strategies, ranging from the sporadic, occasional exploitation of these mammals (see Legoupil 2003) to their intensive and specialized use by hunter–gatherers (see Orquera and Piana 1999).

In this chapter, the current state of the arte regarding human-pinniped relationship in Southern Patagonia during the Holocene is reviewed. Several key issues are analyzed, such as methodological research tools, taphonomic criteria and data available, and the nature of the regional zooarchaeological database available for this region. This review is a starting point to discuss a future research agenda that will lead us to go deeply into the variability involved in such relationships in different geographical areas across Southern Patagonia.

What We Know and What We Do Not Know: Current State of the Art in Pinniped Zooarchaeological Studies in Southern Patagonia

During the Holocene, humans in Southern Patagonia have had virtually no competitors to exploit pinnipeds in land, unlike other regions where carnivores compete for this resource (as in South Africa, Klein et al. 1999). This situation does not necessarily imply that pinniped populations would have reached its potential maximum in Patagonia, since human predation would have entailed a selective pressure on them (Brothwell and Dimbleby 1981; Vidal and Winograd 1987). According to Vidal and Winograd, this impact could have taken place early in this relationship and the pressure might have affected not just the annual increase rate but also their maximum density and the mode of landscape occupation. This way, pinniped response to predatory pressure would have been a nonhomogeneous landscape use and, hence, one only partially dependent on the environmental aptitude of available spaces (Vidal and Winograd 1987).

That is, although historical distribution of pinniped colonies does not necessarily mirror their prehistoric exploitation, the latter would have impinged upon pinnipeds, especially by diminishing intra- and interspecific competition (Lyman 1988, 1991a, 1995) and by increasing the spreading of pinniped populations[1] (Vidal and Winograd 1987; Hildebrant and Jones 1992; Klein et al. 1999).

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[1] See for instance the case of marine elephants and the aboriginal population of Tasmania (Bryden et al. 1999).

In historical times, a different pressure was exerted upon pinniped populations that lead to over killing by sealers. Such exploitation, promoted at a global scale, often caused the disappearance of local populations which eventually lead to the near extinction of different species (see for instance Bonner 1978, 1982; McClung 1978; King 1983; Lyman 1988; and for the region, Winograd 1984; Orquera 2002).

Historical distribution of these pinniped colonies in Patagonia is poorly known. For the XX century, there are the censuses by Carrara (1952) in the Atlantic coast and by Sielfeld (1983) and collaborators (Sielfeld et al. 1978) in the Chilean archipelagos. More recent studies carried out on *O. flavescens* populations surveyed on the Atlantic coast show a decrease in numbers relative to what Carrara observed in the forties in Southern Patagonia. This reduction, it is argued, results from sealing during the XX century (Schiavini et al. 2004). Nevertheless, a recolonization process is having place in several areas (see Grandi et al. 2008).

At a regional scale, Tunez et al. (2008a, b) found no differences in the location of *O. flavescens* nor *A. australis* breeding colonies since Carrara's census, being protected areas with good access to deep water the *loci* preferred by the latter species (Tunez et al. 2008b). This suggests that, even under heavy or sustained pressure, certain places could have been important in the past for pinniped aggregation while others were not. In this regard, it is important to note that Tunez et al. (2008a:198) mention a lack of colonies in Southern Patagonia Atlantic coast probably because of the extreme variation in tide width south of Santa Cruz river to Tierra del Fuego.

In sum, it can be postulated that hunting implied a pressure which may have modified pinniped distribution and behavior in Southern Patagonia, but the picture is still not clear (Vidal and Winograd 1987). Even when human-pinniped relationships would have been stable in certain regions through time (Orquera 2005), variations in this relationships at a larger scale remain to be fully understood and this would benefit from different kinds of approaches (e.g., Borrero 2001; Barberena et al. 2004; Muñoz 2005; Fiore and Zangrando 2006; Moreno 2008). The more recent impact of sealers on pinniped colonies was certainly stronger, impinging upon both pinniped and local human populations (see Orquera 2002). The specifics of this process and its consequences to previous human-pinniped relationships are yet to be studied.

In order to evaluate the current state of the art of studies on human-pinniped relationships in Southern Patagonia, three issues are reviewed: methodological, taphonomic, and zooarchaeological ones.

Methodology

A first aspect to evaluate is the methodological basis available for the study of South American pinniped bone remains. As Legoupil (1989–1990) clearly states, the main problem zooarchaeologists have to face is the absence of identification keys, particularly for the postcranial skeleton, and the fact that the two most common otarid species in Southern Patagonia have very similar skeletons. These makes distinguishing *O. flavescens* from *A. australis* bones a difficult task, being *O. flavescens* adult males and *A. australis* newborns the only categories that can be clearly told apart when bones of the two species are deposited together (Legoupil 1989–1990). With the exception of the *O. jubata*[2] anatomy and osteology by Murie (1870) no complete description of Southern sea lions skeleton is available. Also, we are still not fully aware of intraspecies variation, something that has already been explored in other parts of the world, like in the case of North Atlantic seals (Hodgetts 1999), although a good description sexual dimorphism based on *O. flavescens* canine teeth and cranial bones has been available for a long time (Crespo 1984).

Almost 20 years ago, Legoupil concluded that it was possible to differentiate both species from bones other than the palatine and maxilla, namely fossa masseterica and process coronoideus and to a lesser extent, in young individuals, the canine teeth shape. Regarding morphometry her results showed an important overlap between the two species in individuals from 2 to 150 kg (measurements taken on the mandible and femur), and hence it is necessary to identify age and sex in the specimens considered. This is usually difficult to establish in postcranial bones. Canine size and the presence of the baculum may allow sex identification, and bone size and fusion stage and tooth growth layers and eruption stage can help in age determination. Nevertheless, problems derived from bone measurements and fusion stages impose some difficulties (Legoupil 1989–1990).

Another important contribution to methods in pinniped zooarchaeology at that time was Schiavini's (Schiavini et al. 1988; Schiavini 1992, see also Crespo et al. 1994), who contributed to the taxonomic and sexual differentiation of southern otarids based on osteological features. He considered shape and size of otarid bones and differences in rostral and mandibular width and canine size and shape, concluding that these criteria were useful to differentiating species and sex in the Southern Patagonia archaeological sample studied by himself – Tunel I site (Schiavini 1992). A detailed description of the methodology for age and seasonality determination applied to southern otarids was published (Schiavini 1992) as well as its application to various archaeological assemblages (Schiavini 1993).

Several studies, now in progress, are oriented towards filling some of the gaps already mentioned. That's the case of the *O. flavescens* osteometry guide for subadult individuals (L'Heureux et al. 2011) and its implications for seasonality studies (Borella and L'Heureux 2011). Also *O. flavescens* economic anatomy studies have been published recently (San Roman 2009).

In brief, although an increase in pinniped zooarchaeology methods and research tools in Southern Patagonia is noticeable (see also next section), the current methodological basis, as a recent concise methodological review done by San Roman suggests (San Roman 2008), is similar to that available in the early nineties. Hence, the future research agenda in pinniped zooarchaeological methods should consider the refinement of available approaches and the exploration of different lines of evidences, such as bone fusion sequence. Research resources such as detailed osteological guides and reference collections with several individuals representing different ages, sex, and provenience are also necessary. Fortunately, some of these topics are already in progress.

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[2] Currently *O. flavescens* (Scheffer 1958).

Pinniped Taphonomy

A taphonomic approach is a necessary step towards the evaluation of human-pinniped interactions trough time in the region but only recently has it been addressed (e.g., Borrero 2004; Borella and Muñoz 2006; Borella et al. 2008; Muñoz 2008). A taphonomic perspective on pinniped bone accumulations is necessary not only to understanding the formation history of archaeological samples but also to evaluate the accumulation odds and nature of natural pinniped bone concentrations in the Patagonian coast. As Borella and Muñoz (2006) suggest, the lack of systematic studies and observations is still a problem on this field of enquiry, and that includes not only the specifics of bone modification processes in pinniped remains but also the study of natural disarticulation (Muñoz 2008). The latter could be of importance since natural bone accumulations that has been already studied showed that differences in anatomical completeness indexes could be of help when trying to differentiate natural from anthropogenic assemblages (see Muñoz 2008: Fig. 13.4).

The lack of taphonomic criteria was a common problem for Patagonian pinniped zooarchaeology (e.g., Schiavini 1993) before the last decade, making it necessary to consider the use of taphonomic tools originally developed for terrestrial mammals (e.g., Muñoz 1996). By then a taphonomic project on marine mammals started in Tierra del Fuego (Borella 1996, 2004) and criteria became available to understand the taphonomy of organisms that involved marine and terrestrial environments.

A first approach to study the specifics of pinniped natural bone accumulations in Southern Patagonia and their implications to Patagonian zooarchaeological record was carried out by Borrero (2004) and Borella and Muñoz (2006). Borrero (2004) addressed the need of a taphonomic approach to pinniped zooarchaeology in Patagonia, and presented preliminary data to prepare future research agendas. The author applied a regional taphonomic perspective for evaluating possibilities of mixture between archaeological and natural pinniped bones from Tierra del Fuego and Isabel islands, and to identify the natural deposition of pinniped carcasses. His goal was to develop taphonomic criteria to address taphonomic questions (Borrero 2004). The results show that possibilities of bone mixing in some of the studied beaches exist, being it very difficult to distinguish archaeological from nonarchaeological bones in a same deposit with the current knowledge (Borrero 2004).

Borella and Muñoz (2006) explored different scenarios of coastal bone accumulations according to differences in beach features. The latter correlated to some extent with bone modifications on the studied bones, such as weathering, fragmentation, and burial, as well as anatomical representation. On comparing these results against archaeological bone assemblages, Muñoz (2008) found that they differ at different levels, such as anatomical composition, age and weathering profiles, being axial and flipper bone representation, fragmentation, and carnivore marks ambiguous indicators to distinguish each type of assemblage.

At present, a new round of taphonomic studies has followed to the first series of exploratory enquiries, aimed at overcoming the gaps of the previous ones. Such is the case of pinniped carcass disarticulation studies in Northern Patagonia (Borella and Borrero 2010) and long-term studies on bone modification and carcass disarticulation in Southern Patagonia (Muñoz and Cruz 2010).

An important contribution to the understanding of pinniped bone taphonomy is the study of South American otarid mineral bone density done by Borella et al. (2008). They studied the skeletons of one individual of each taxon, *O. flavescens* and *A. australis*, and found a high correlation between them and less variation across the skeleton than in the case of the terrestrial guanaco (*Lama guanicoe*). The latter presents a broader range of values, with higher and lower values in certain bones (Borella et al. 2008). These results led the authors to disregard previous suggestions that considered pinniped bones as denser than ungulate ones (see Lyman et al. 1992, in Borella et al. 2008) and to conclude that, under similar taphonomic conditions, pinniped bones will tend to keep higher anatomical integrity than ungulates.

Summing up, pinniped taphonomic research is not fully developed but important steps have been taken recently. These include exploratory approaches to evaluate conditions and places where bones can be deposited or be mixed with archaeological materials, bone modifications capable of discriminating natural from anthropic accumulations, mineral bone density values and anatomical part representation. Long-term systematic observations on carcass disarticulation processes, as well as the weathering sequence of pinniped bones, are now under progress.

The Southern Patagonia Pinniped Zooarchaeological Record

In this section, a three level analysis of the available pinniped zooarchaeological data is presented. The first one, based on NISP and temporal allocation (Tables 13.1 and 13.2, Fig. 13.2), covers a broader geographical area and time span, although imposing a vague grain of analysis. The second level, more detailed, includes assemblage composition, and specifically pinniped contribution to assemblage mammal diversity and species, age and sex classes represented in different geographical zones and time allocations (Tables 13.3 and 13.4, Figs. 13.3 and 13.4). Finally, a more detailed bone composition analysis will be presented for those archaeological sites for which anatomical information from the complete skeleton has been published (Tables 13.5 and 13.6, Fig. 13.5).

Southern Patagonian coast can be divided in four geographical zones: Western inner channels (Otway Sea and Magellan Strait), Southern inner channels (Beagle channel), Fueguian Atlantic coast, and Continental Patagonia Atlantic coast (Fig. 13.1). For analytical purposes we have split the pinniped zooarchaeological database in two temporal groups. Temporal Group 1 (TG 1) involves archaeological assemblages dated between 3000 and 100 RCYBP. Temporal Group 2 (TG 2) groups archaeological assemblages dated between 6500 and 4000 RCYBP.

Table 13.1 Regional pinniped data base considered for Temporal Group 1 (3000–100 RCYBP), based on published data

Archaeological site	Geographical area	Radiocarbon date (RCYBP)	NISP	References
Cerro Mesa	Atlantic Tierra del Fuego	ND	74	Muñoz (1996)
San Pablo 7	Atlantic Tierra del Fuego	ND	3	Borrero and Lanata (1988)
Túnel 7B	Beagle channel	100 ± 450	8,953	Orquera and Piana (1999) and Zangrando (2009)
Imiwaia	Beagle channel	150 ± 70	313	Zangrando (2009)
Río Verde 1	Skyiring sea	280 ± 60	2	San Román et al. (2002)
San Pablo 1	Atlantic Tierra del Fuego	290 ± 70	119	Borrero and Lanata (1988)
San Génaro 2	Atlantic Tierra del Fuego	250 ± 80/1483 ± 80	9	Horwitz (1995) and Borrero et al. (2008)
Shamakush X	Beagle channel	500 ± 100	9	Zangrando (2009)
Punta Baja	Otway sea	280 ± 70	7,367	Legoupil (1989)
Lancha Packewaia B	Beagle channel	280 ± 85	1,127	Orquera and Piana (1993–1994, 1999)
Punta María 2a	Atlantic Tierra del Fuego	300 ± 100/720 ± 50	254	Borella et al. (1996) and Muñoz (2005)
Lancha Packewaia C	Beagle channel	455 ± 85	281	Orquera and Piana (1993–1994, 1999)
Lancha Packewaia D	Beagle channel	470 ± 50/1590 ± 50	461	Orquera and Piana (1993–1994, 1999)
Túnel 1 beta	Beagle channel	670 ± 80/450 ± 60	113	Zangrando (2009)
Bloque Errático	Atlantic Tierra del Fuego	785 ± 120	1	Borrero et al. (1985)
Bahía Valentín 42	Atlantic Tierra del Fuego	984 ± 32	32	Vázquez et al. (2008)
Shamakush I	Beagle channel	1020 ± 80/940 ± 110	102	Zangrando (2009)
María Luisa A3	Atlantic Tierra del Fuego	1020 ± 80	524	Savanti (1994)
San Génaro 1	Atlantic Tierra del Fuego	1070 ± 100	17	Horwitz (1995)
Cabo Vírgenes 2	Atlantic Patagonia	1050 ± 70	20	Barberena et al. (2004)
Túnel 2	Beagle channel	1120 ± 90/1140 ± 90	562	Orquera and Piana (1999)

(continued)

Table 13.1 (continued)

Archaeological site	Geographical area	Radiocarbon date (RCYBP)	NISP	References
Cabo Vírgenes 6	Atlantic Patagonia	1190 ± 60/1170 ± 50	64	Barberena et al. (2004)
Punta María 2b	Atlantic Tierra del Fuego	1230 ± 50	274	Borella et al. (1996) and Muñoz (2005)
Monte León cch4	Atlantic Patagonia	1330 ± 60/1700 ± 690	115	Caracotche et al. (2005)
Cabo Vírgenes 1	Atlantic Patagonia	1380 ± 180	43	Barberena et al. (2004)
Rancho Donata 7	Atlantic Tierra del Fuego	1500 ± 50	456	Lanata (1993)
Isla El Salmón 5	Beagle channel	1765 ± 25	2	Figuerero Torres and Mengoni Goñalons (1986)
Túnel 1 C1	Beagle channel	1920 ± 80	707	Zangrando (2009)
Punta María 2c	Atlantic Tierra del Fuego	2300 ± 90	164	Borella et al. (1996) and Muñoz (2005)
Túnel 1 alfa-X	Beagle channel	2690 ± 80/2660 ± 100	780	Zangrando (2009)

Table 13.2 Regional pinniped data base considered for Temporal Group 2 (6500–4000 RCYBP), based on published data

Archaeological site	Geographical area	Radiocarbon date (RCYBP)	NISP	References
Lancha Packewaia D′	Beagle channel	Similar to LP X/Y	180	Orquera and Piana (1993–1994, 1999)
Lancha Packewaia X/Y	Beagle channel	4020 ± 70	408	Orquera and Piana (1993–1994, 1999)
Camden 2	Otway sea	4030 ± 80	370	San Román et al. (2002)
Ponsonby B	Skyiring sea	4100/4500	504	Legoupil (2003)
Túnel 1 D f VI	Beagle channel	4590 ± 130	4,764	Zangrando (2009)
Túnel 1 C3	Beagle channel	4380 ± 80	983	Zangrando (2009)
Laguna Arcillosa 2	Atlantic Tierra del Fuego	4440 ± 60/3690 ± 70	2	Salemme et al. (2008)
Ponsonby C	Skyiring sea	4600/5400	37	Legoupil (2003)
Lancha Packewaia E	Beagle channel	4980 ± 70	618	Orquera and Piana (1993–1994, 1999)
Bahía Colorada	Otway sea	5500 ± 70	4,297	Legoupil (1997)
Los Noruegos	Otway sea	5585 ± 65	26	San Román et al. (2002)
Túnel 1 D f IV	Beagle channel		11,346	Zangrando (2009)
Túnel 1 D f V	Beagle channel	5840 ± 185/5630 ± 120	5,067	Zangrando (2009)
Túnel 1 D f VII	Beagle channel		4,434	Zangrando (2009)
Túnel 1 D f VIII	Beagle channel		3,398	Zangrando (2009)
Imiwaia I	Beagle channel	5872 ± 147	633	Orquera and Piana (2000)
Bahía Buena	Magellan strait	5895 ± 65	4,071	Ortiz Troncoso (1978) and San Román (2008)
Río Chico 1	Atlantic Tierra del Fuego	5856 ± 44	31	Santiago et al. (2007)
Túnel 1 D f III	Beagle channel	5950 ± 170	3,288	Zangrando (2009)
Túnel 1 D f II	Beagle channel	6410 ± 150	6,645	Zangrando (2009)
Túnel 1 D f I	Beagle channel	6470 ± 100/6020 ± 120	2,223	Zangrando (2009)
Ponsonby D	Skyiring sea	6690 ± 130/7450 ± 80	12	Legoupil (2003)

Table 13.3 Pinniped zooarchaeological information from sixteen archaeological assemblages corresponding to the Temporal Group 1

Archaeological site	Geographical area	Pinniped representation	*O. flavescenes* representation	*A. australis* representation	Age classes	Sex proportions	References
Túnel 7B	Beagle channel	Dominant	Present	Dominant	Mostly youngs	Male dominated	Orquera and Piana (1999) and Zangrando (2009)
Río Verde 1	Skyiring sea	Present	ND	ND	ND	ND	San Román et al. (2002)
Punta Baja	Otway sea	Dominant	Dominant	Present	Mostly youngs	Female dominated	Legoupil (1989)
Lancha Packewaia B	Beagle channel	Dominant	Present	Dominant	Mostly youngs	Male dominated	Orquera and Piana (1993–1994)
Lancha Packewaia C	Beagle channel	Dominant	Present	Dominant	Mostly youngs	Male dominated	Orquera and Piana (1993–1994)
Punta María 2a	Atlantic Tierra del Fuego	Similar to guanaco	Present	Present	Mostly youngs	ND	Borrero (1986) and Muñoz (2004a, 2005)
Lancha Packewaia D	Beagle channel	Similar to guanaco	Present	Dominant	Mostly youngs	Male dominated	Orquera and Piana (1993–1994) and Schiavini (1993)
María Luisa A3	Atlantic Tierra del Fuego	Secondary	ND	ND	Mostly youngs	Not informed	Muñoz (2005)
Punta María 2b	Atlantic Tierra del Fuego	Secondary	ND	ND	Mostly youngs	ND	Muñoz (2005)
Monte León cch4	Atlantic Patagonia	Dominant	Present	Present	Mostly youngs	ND	Caracotche et al. (2005)
Punta María 2c	Atlantic Tierra del Fuego	Similar to guanaco	ND	ND	Mostly youngs	ND	Muñoz (2005)

ND no data

Table 13.4 Pinniped zooarchaeological information from seven archaeological assemblages corresponding to the Temporal Group 2

Archaeological site	Geographical area	Pinniped representation	*O. flavescenes* representation	*A. australis* representation	Age classes	Sex proportions	References
Lancha Packewaia D′	Beagle channel	Similar to guanaco	Present	Dominant	All classes in similar proportions	ND	Orquera and Piana (1993–1994)
Lancha Packewaia X/Y	Beagle channel	Similar to guanaco	ND	Dominant	ND	Male dominated	Orquera and Piana (1993–1994) and Schiavini (1993)
Camden 2	Otway sea	Dominant	Present	ND	ND	ND	San Román et al. (2002)
Ponsonby B	Skyiring sea	Secondary	Present	Present	New born and adult dominated	ND	Legoupil (2003)
Lancha Packewaia E	Beagle channel	Dominant	Present	Dominant	Mostly youngs	ND	Orquera and Piana (1993–1994)
Túnel 1 D	Beagle channel	Dominant	Present	Dominant	All classes	*A. australis* male, dominated, *O. flavescenes* female dominated	Zangrando (2009)
Ponsonby C	Skyiring sea	Secondary	ND	ND	Mostly adults	ND	Legoupil (2003)
Bahía Colorada	Otway sea	Dominant	Present	Dominant	Mostly adults	Male dominated	Legoupil (1997)
Los Noruegos	Otway sea	Secondary	ND	ND	ND	ND	San Román et al. (2002)
Bahía Buena	Magellan strait	Dominant	Present	Dominant	Mostly adults	Male dominated	San Román (2008)
Ponsonby D	Skyiring sea	Secondary	Present	Present	All classes in similar proportions	ND	Legoupil (2003)

Túnel 1 D includes fases I to VIII
ND no data

Table 13.5 Anatomical regions represented through NISP in Western Channels and atlantic Tierra del Fuego

	Complete individual	Punta Baja	Bahía Colorada	Bahia Buena	Punta María 2a	Punta María 2b	Punta María 2c	María Luisa A3	Cerro Mesa
Head	4	882	187	575	15	10	9	11	11
Axial – including innominate	70	3,696	1,396	2,157	87	112	51	259	35
Forelimb	8	373	275	364	22	15	11	38	1
Rearlimb	6	223	171	174	13	18	17	20	6
Flippers	270	1,069	1,859	621	52	89	57	137	9
Total	358	6,243	3,888	3,891	189	244	145	465	62

Data from Legoupil (1989: Tables 4 and 9) for Punta Baja and Legoupil (1997: Table 1) for Bahía Colorada, San Román (2008: Tabla 2) for Bahía Buena and Muñoz (2004a; Table 13.4) for María Luisa and Punta María 2a, Muñoz (2003: Cuadro V.18) for Punta María 2b, Muñoz (2003: Cuadro V.28) for Punta María 2c and Muñoz (1996) for Cerro Mesa

Table 13.6 Anatomical regions represented through NISP in Beagle channel

	Complete individual	LP B	LP C	LP D	LP D′	LP XY	LP E
Head	4	61	25	42	17	25	51
Axial – including innominate	70	411	116	196	111	238	349
Forelimb	8	179	62	71	19	44	68
Rearlimb	6	101	28	56	12	38	44
Flippers	270	375	50	96	21	63	106
Total	358	1,127	281	461	180	408	618

Data from Orquera and Piana (1993–1994: Cuadro XII)
LP Lancha Packewaia

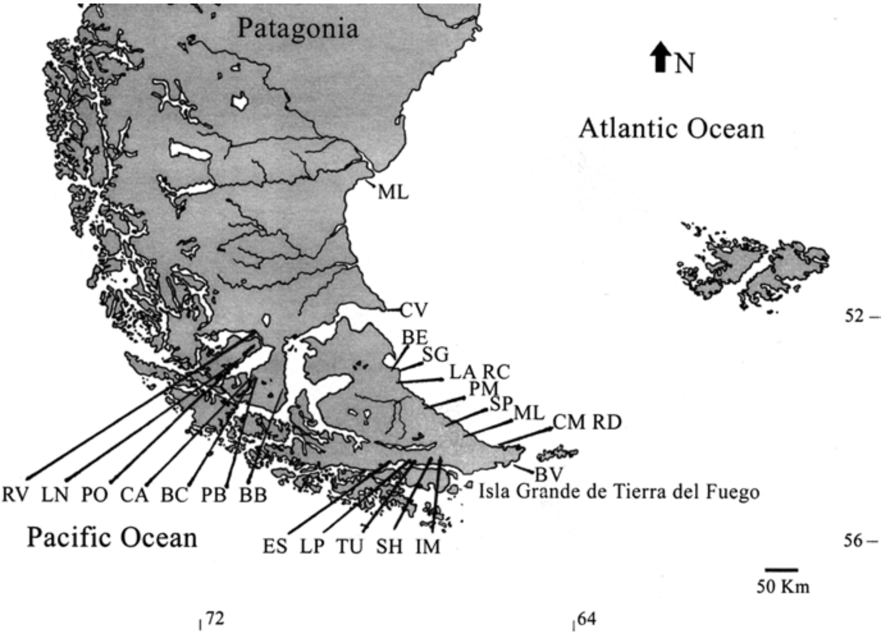

Fig. 13.1 Geographical provenience of the zooarchaeological database analyzed. *ML* Monte León; *CV* Cabo Vírgenes; *BE* Bloque Errático; *SG* San Génaro; *LA* Laguna Arcillosa; *RC* Río Chico; *PM* Punta María; *SP* San Pablo; *ML* María Luisa; *CM* Cerro Mesa; *RD* Rancho Donata; *BV* Bahía Valentín; *IM* Imiwaia; *SH* Shamakush; *TU* Túnel; *LP* Lancha Packewaia; *ES* Isla El Salmón; *BB* Bahía Buena; *PB* Punta Baja; *BC* Bahía Colorada; *CA* Camden; *PO* Ponsonby; *LN* Los Noruegos; *RV* Río Verde

Based on published data, Tables 13.1 and 13.2 which present the regional pinniped data base are considered here. It consists of 52 assemblages from 31 archaeological sites. Sites with less than one square meter sampling were not considered in the analysis. At this general level of analysis it can be seen that zooarchaeological information on pinnipeds is quite uneven. At a first glance, this database (see Tables 13.1 and 13.2, Figs. 13.1 and 13.2) shows that available information is more abundant in Tierra del Fuego island (20 sites), both in the atlantic and Beagle fronts (Lanata and Winograd 1988; Schiavini 1993; Horwitz 1995, 2004; Estevez Escalera 1996; Muñoz 1996, 2004a, b; Estévez Escalera and Martínez Moreno 1997; Orquera and Piana 1999; Zangrando 2009) and more limited in continental Southern Patagonia (11 sites, see Legoupil 1989, 1993–1994, 1997, 2003; Borrero and Franco 2005; Mansur 2008; San Roman 2008). Nevertheless, data quality is not necessarily in agreement with this distribution. For instance, temporal allocation shows a bias towards the West and Southern channels where older assemblages are more abundant (16 out of 18 cases), while larger assemblages are only represented in this area as well (Fig. 13.2). The former partly relates to differences inherent to each kind of coast. The Pacific and Beagle channel lack an important continental platform, and therefore did not suffer the consequences of Quaternary see level oscillations as much as the Atlantic one, which was substantially modified (see Salemme and Bujalesky 2000). This imposes some difficulties when trying to study old records in the Atlantic coast since the coastline is rapidly moving west (see Horwitz 2004: 31 for an example). The latter probably derives both from the involved sampling techniques and the nature of the more abundant archaeological deposits in each region, although this assumption remains to be confirmed.

As Fig. 13.2 shows, the continental and Fueguian Atlantic front are dominated by small recent assemblages, while in the western channels there are both small and big assemblages with a broader temporal span. The Beagle channel displays almost an even distribution of assemblage sizes and temporal allocations.

In sum, a reasonable number of archaeological sites have been found in all areas where pinniped presence has been documented through their bones. Since bone assemblages are not distributed homogeneously across space and time, a first conclusion would imply that the kind of research questions that can be approached from this database is not even geographical or chronological.

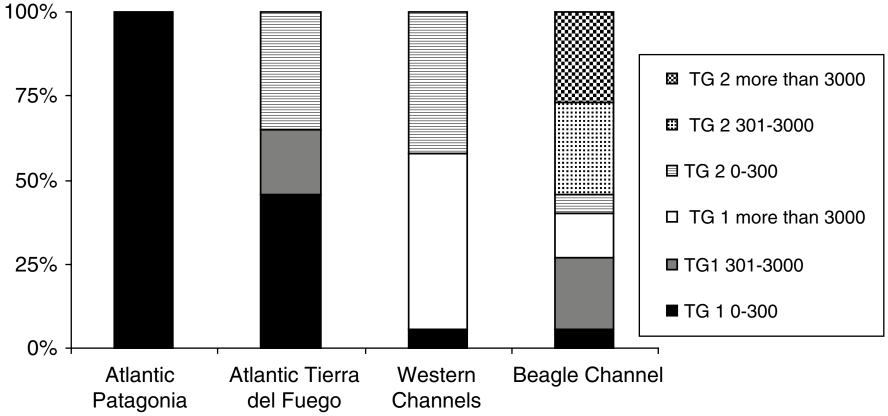

Fig. 13.2 Zooarchaeological assemblages according to size (NISP) and temporal group. $N = 49$ assemblages

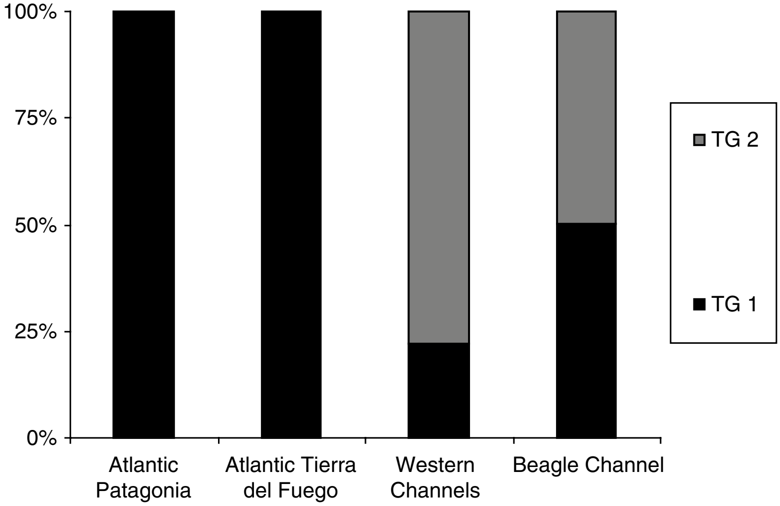

Fig. 13.3 Pinniped assemblages with bone composition data according to temporal groups defined in this study. $N = 22$ assemblages

If we take a step beyond assemblage size and temporal allocation and introduce data on bone assemblage composition, the sample is limited to 22 assemblages from 12 archaeological sites (Tables 13.3 and 13.4). When considering pinniped contribution to taxonomic diversity, species representation, and age and sex proportions the sample clusters in two groups (Fig. 13.3). Assemblages from the Atlantic front display this kind of information for TG 1 only. Assemblages from Western and Southern channels display data for both temporal groups, although it is slightly more abundant for TG 2.

More interesting, if we consider pinniped contribution to mammal diversity according to geographical zone and time allocation we can find different patterns (Fig. 13.4). It is noticeable that each geographical area has it own peculiarities, although similarities can be found among very different settings, such as Atlantic Patagonia TG 1 and Beagle Channel TG 2. These similarities can be extended to the rest of the sample from these two geographical areas (including Beagle Channel TG 1) since pinniped share similar proportions with guanaco bones when they do not dominate. This is different to what can be found in the Western channels where pinnipeds have a secondary place whenever do not have a clear dominance (Fig. 13.4). Finally, Atlantic Tierra del Fuego shows a different scenario since pinnipeds have a secondary place or equals guanaco bones in all the available samples.

Tables 13.3 and 13.4 show that only one assemblage is dominated by *O. flavescens* (Punta Baja). This is the only female dominated assemblage as well. As it will be seen later other lines of evidence also differentiate this assemblage from the rest of the database, suggesting that it represents a segment of the range variation not frequently represented in the region.

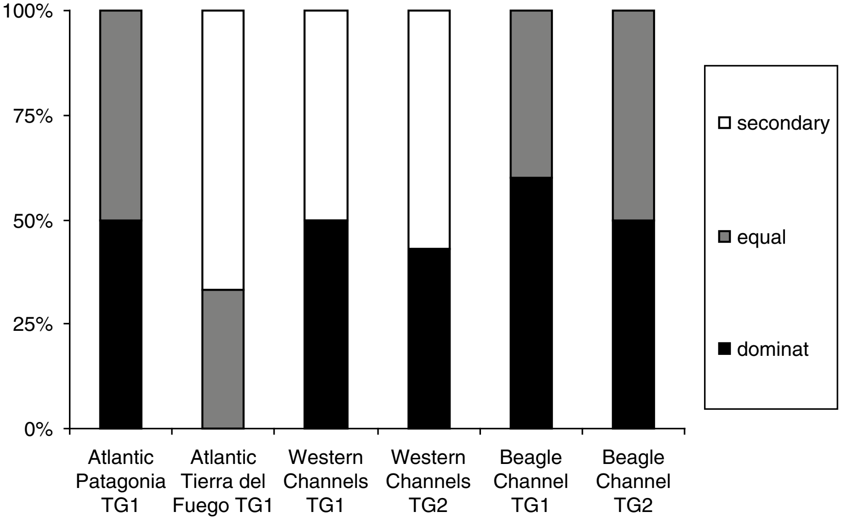

Fig. 13.4 Pinniped contribution to mammal diversity represented in assemblages from different geographical areas and temporal groups, as defined in this study

When age classes' representation is considered it can be noticed that both temporal groups differentiates clearly. TG 1 display a young dominated profile independently of the geographical zone considered. TG 2, instead, presents a more diverse scenario: all classes are represented in similar proportions in assemblages where pinnipeds are equal or less than guanaco, but there is no pattern in assemblages where the pinniped share varies relative to the complete mammal assemblage (Tables 13.3 and 13.4). Finally, sex classes representation show that most assemblages display a male dominated profile.

In sum, when species, age classes and sex data are included (Tables 13.3 and 13.4), it can be observed that pinnipeds are important but not necessarily the dominant mammalian taxon in the TG 2. Guanaco MNI equals that of pinnipeds in two of eleven assemblages and have a secondary place in other four assemblages. Among pinnipeds, *A. australis* is the most frequent species in archaeological assemblages but *O. flavescens* is also represented to some degree. Age classes also vary, some assemblages being dominated by adults, but some others by young or have an even representation of different age classes. Where sex of prey was identified, male is the most frequent category. Regarding TG 1, pinniped bone representation ranges from dominant to equal or even secondary in comparison to guanaco. There are no assemblages in the Fueguian Atlantic coast for which pinnipeds are the dominant taxon. Regarding intrataxonomic differentiation, available information is uneven. It is scarce for the atlantic coast assemblages and diverse for other samples. It shows one assemblage dominated by *O. Flavescens* and four others by *A. australis*, but both species are usually represented at the same site as previously noted. Age representation in these samples shows a different picture than the earlier group, since all assemblages present a young-dominated profile. Finally, males are important in bone samples where *A. australis* is the dominant pinniped taxon, while female individuals outnumber males where *O. flavescens* prevails.

A step beyond this basic assemblage composition level requires to consider pinniped anatomical representation per assemblage, although it must be said that complete list of anatomical parts represented is only rarely available (see Legoupil 1989–1990, 1997; Orquera and Piana 1993–1994; Muñoz 1996, 2004a; San Roman 2008). This situation creates some restrictions and, hence, the following analysis should be taken as exploratory, aimed at generating working hypotheses to be tested as new data becomes available.

The comparison of the anatomical composition of the assemblages considered has to be made at the NISP level because only some of them have informed MNE values. This could overestimate axial bones due to fragmentation and unfused bones, particularly in assemblages dominated by young individuals, but as can be seen below this was not the case in most samples.

Figure 13.5 shows the relationship of head to appendicular bones – excluding flippers – in one axis and the relationship of appendicular to flippers bones in the other. The rhomboid dot represents the expected proportions according to what is found in a complete individual, based on MNE counts. The square dots are Late Holocene assemblages and the triangular ones the earlier assemblages.

The general pattern when considering all assemblages may be described as one with fewer flippers than appendicular bones as compared to what can be expected if individuals had been deposited and preserved complete. Secondly, head bones tend to be well represented in relation to what we expect in complete individuals, with three exceptions: Bahia Buena, Punta Baja and Cerro Mesa, where head bones outnumber the appendicular ones. This is interesting because both assemblages differ in size and correspond to different temporal groups and to different environmental settings (Magellan Strait and Fueguian Atlantic coast, respectively). This suggests that a similar zooarchaeological signature can be found under different

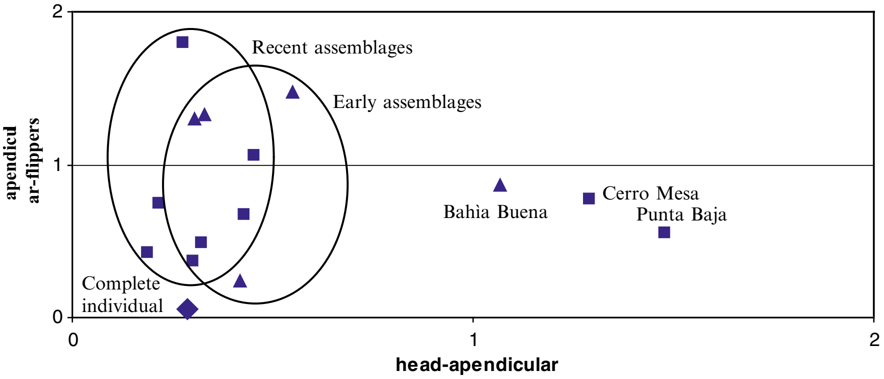

Fig. 13.5 Pinniped bone assemblages anatomical representation compared

temporal, environmental and cultural contexts, at least when bone representation is considered. The assemblages closest to the expected value are Bahia Colorada and Punta Maria 2b.

A third general observation has to do with anatomical representation according to chronology. Figure 13.5 show that both datasets overlap quite well having both datasets outliers in the same direction, probably showing similar biases. Nevertheless, it can be noticed that recent assemblages embrace a bigger spread of dots.

In sum, analyzed data cover a great deal of Southern Patagonia although not the whole area. Where information is available, it shows that pinnipeds are the dominant mammalian taxon in almost half of the assemblages. Both pinniped species are present in almost every assemblage, with varying proportions of each. Recent assemblages show a young-dominated pattern while earlier ones display a more varied picture. It should be noticed that a young-dominated profile has also been found in different contexts in other regions of the world, such as Mid-Holocene Baltic sea (Lŏugas 1997) and Holocene North American West coast (Porcasi et al. 2000), and could be the result of predating on defenseless individuals and privileging yield maximization rather than resource preservation. Sex composition is more difficult to interpret (see Section "Methodology"), and while available data suggest male captures could have been more important than female ones, it should be explored if this depends on pinniped species.

Head-appendicular ratios vary but generally head bones tend to be well represented in all assemblages and outnumbering appendicular ones in part of the sample. Bahia Colorada and Punta Maria 2b display the anatomical composition closest to complete individuals, suggesting that there are conditions under which a similar zooarchaeological signature can be obtained in spite of contextual differences. Some other characteristics are common two all assemblages regardless temporal, geographical and cultural variation, namely the low representation of flippers. This is something to be expected according to zooarchaeological assemblages from New Zealand, Tasmania, South Africa, and elsewhere (Anderson 1988; Bowdler 1988; Klein et al. 1999). This could have a taphonomic explanation such us its fragility, derived from the cartilaginous nature of carpal and tarsal bones of young individuals (Legoupil 1989), the small size of flipper bones which may be lost or not recovered (Muñoz 2005), the result of carnivore consumption (Orquera and Piana 1999), or even a cultural bias due to differential refusal (San Roman 2008).

Discussion

A great deal has been learnt so far on Holocene human-pinniped relationships in this region (Lanata and Winograd 1988; Legoupil 1989, 1993–1994, 1997, 2000; Borrero 1990; Lanata and Borrero 1992, 1994; Schiavini 1992, 1993; Estevez Escalera 1996; Estévez Escalera and Martínez Moreno 1997; Orquera and Piana 1993–1994, 1999; Muñoz 1996, 2004a, b; San Roman 2008). Nevertheless, the variation involved in the dichotomy between marine vs. terrestrial hunter–gatherers is zooarchaeologically poorly known, and the complexity of these strategies and the degree to which they might overlap remains to be fully understood.

It should be noticed that zooarchaeological evidence suggests no clear partition between marine and terrestrial foragers in Southern Patagonia. This is suggested by bone assemblages with variable importance of terrestrial and marine mammals attributable to each of these economic strategies throughout the Holocene (see Orquera and Piana 1996; Borrero 1997; San Roman et al. 2002). Hence exploring the reasons why this happens could help to elucidate zooarchaeological criteria to understand the whole spectrum of human-pinniped relationships in this region. The analysis of the regional database done in the previous section show that information is not distributed evenly across Southern Patagonia geography. New samples with more standardized data in all this geographical areas will probably help to elucidate if patterns emerging after this review can be maintained, particularly the range of variation in *O. flavescens* exploitation and the condition under which these resources become dominant or secondary for human foragers strategies.

A general approach to overcome difficulties derived from generalizations made upon economic types such as terrestrial and marine hunter–gatherers can be derived from the way marine resources, and especially pinnipeds, contribute to the reliability of human strategies (Yesner 1987). The author considers that it is precisely spatial-temporal reliability what differentiates marine resources from terrestrial ones. Understanding their impact on human strategies requires considering environmental variables such as the relationships between terrestrial and marine resources, the kind of coasts available, differences in pinniped social groups, and prey availability (isolated individuals, colonies, washed up carcasses, etc.).

Different aspects have to do with the relationships between terrestrial and marine resources. It has been stressed that Southern Patagonia's gradient of insularization, derived from its peninsular shape, has specific biological and ecological consequences and, hence, that climatic and ecological conditions do not conform to the pattern generally expected for such a high latitude (Muñoz 2004a, 2005). Additionally, an important area of Southern Patagonia is archipelagic, with islands differing in size and distance from mainland. As a consequence, space and resources are not homogeneous and biogeographical expectations should vary accordingly, as well as resource spatial and temporal predictability (Muñoz 2004a, 2005). In this context, pelagic fauna such as pinnipeds represents an energy subsidy as it does not depend on littoral waters to feed, and thereby comprises a seasonally critical energy input when littoral and inland productivity decreases (Schiavini 1993).

Coastal morphology is also relevant since it has to do not only with the potential zooarchaeological record to study but also with resource distribution (pinnipeds and also shell banks and fresh water). As previously noted, historical distribution of pinniped colonies shows a patchy pattern along the Patagonian coast and, consequently, pinniped zooarchaeological record in certain areas, such us the continental Atlantic front, should be different from areas where the resource was more widely available (e.g., eastern tip of Tierra del Fuego). This does not imply that areas with probably less pinnipeds, such as the former, will not bear a diverse record, as research in Punta Entrada (Cruz et al. 2009; Muñoz et al. 2009), Monte Léon (Caracotche et al. 2005; Muñoz et al. 2009), Punta Bustamante (Mansur 2008), and Cabo Vírgenes (Borrero and Franco 2005) indicates.

Pinniped availability and behavior also involves distinguishing between archaeofaunal assemblages originated by preying on isolated individuals, reproductive colonies and rockeries, as has been highlighted in literature (e.g., Lyman 1988, 1991a, b). This distinction has implications when discussing adaptive and technological questions (e.g., Hildebrant and Jones 1992; Jones and Hildebrant 1995) and even evolutionary ones (e.g., Marean 1986a, b; Binford 1984, 1986). Exploitation of isolated individuals on the coast has often been related to the utilization of carcasses deposited by the sea, through scavenging, or by capturing subadult or ill individuals for instance; see Marean (1986a, b), Stockton (1982 in Bryden et al. 1999) and Klein et al. (1999). Exploitation of colonies, instead, would have been carried out mostly through hunting. Establishing whether it was colonies that were exploited and distinguishing among their different types – reproductive or resting – though, requires inferring age and sex representation in archaeological collections (Lyman 1991a, b; Jones and Hildebrant 1995; Bryden et al. 1999). It should be noticed that Borella (2006) has proposed that predating on *O. flavescens* breeding colonies would derive in a different sex and age pattern from that inferred by Lyman (1991a) for the North American coast, due to differences in the pinniped species involved.

Regarding butchery, Muñoz (2005) has found that final carcass disorganization is more important a source of variability than is differential transport in four pinniped zooarchaeological assemblages from the Fueguian Atlantic coast, usually considered as belonging to terrestrial hunters. Interestingly, zooarchaeological data show similarities with pinniped assemblages from the Southern coast of the island, an area considered to be of maritime hunter–gatherers (Estévez Escalera and Martínez Moreno 1997). This suggests that other variables, such as sharing among social units, can result in an overlapping of zooarchaeological signatures, making it difficult to distinguish among different general economic strategies.

A Future Research Agenda

Zooarchaeology and taphonomy can make a substantial contribution not just to decomposing the dichotomy between marine vs. terrestrial Patagonian hunter–gatherers, but also to comprehending the whole range of variation between and within the strategies encompassed in these categories. In order to do so, refinement of conceptual tools is necessary so as to be able not just to infer human responses different from those witnessed in recent times through the ethnographic record, but also to integrate available taphonomic and zooarchaeological knowledge.

Several issues can be derived from the previous sections to propose a future research agenda. Research is needed on pinnipeds as palaeoecological indicators (see Borrero 2004) as well as isotopic tracking to understanding pinniped past distribution (Burton et al. 2002). Exploring if predation on *A. australis* on the Atlantic coast represents a distinct pattern as compared to *O. flavescens* would also help to discuss if different pinniped species involve varying predation strategies.

The impact of sealing on past pinniped distribution requires a more thorough exploration in order to model present pinniped distribution data and its consequences to past human-pinnipeds relationships. As previously mentioned, zooarchaeological methods applied to pinniped studies would be improved by refining research tools such as those identifying intra- and interspecific variability, bone fusion sequence and weathering in different depositional environments. Pinniped taphonomy also requires long-term systematic observations on carcass disarticulation.

This way, research in this part of the world can contribute to the study of current perspectives on human-pinniped interactions worldwide, by integrating new instances of them from a context quite different from those where most information comes from.

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Chapter 14
The Use of the Space in the Pampean Atlantic Coast and the Adjacent Plains (Argentina, South America): A Comparative View

Mariano Bonomo

Introduction

The archaeological record from different Atlantic littoral regions of Southern South America shows a clear intensive use of marine resources mainly since 6000 RCYBP, after the global Middle Holocene Marine Transgression. This evidence became observable in the shell mounds of Southern Brazil (Gaspar et al. 2008; Lima 1999–2000), Uruguay (Castiñeira et al. 2010; Inda et al. 2006), and Patagonia (Borella and Favier Dubois 2009; Gómez Otero 2007; Moreno 2008; Sanguinetti de Bórmida 1999, among others). Moreover, in the island zone of Southern Patagonia, the Beagle Channel, and the Magallanian Strait were inhabited by coastal populations that also formed shell mounds. These societies were adapted to the exploitation of marine fauna with special technological equipment prepared for that purpose (i.e., harpoons and canoes) (Legoupil 2003; Orquera and Piana 1999; Vila et al. 1995; Zangrando 2009). Unlike the Atlantic sector, the Pacific coast of South America shows that maritime adaptations are very nearly as old as the presence of human groups in the continent (Sandweiss 2008:145). The coast of Peru and Northern Chile presents evidence of marine mollusks consumption dated to the Late Pleistocene and the Early Holocene (Jackson and Báez 2005; Llagostera 1992; Sandweiss 2003).

In the specific case of the Pampean coast, several authors claimed during the twentieth century the hypothesis that human groups living on the Atlantic coast primarily exploited the available marine resources, especially shellfish (e.g., Ameghino 1910; Bórmida 1969; Menghín 1963; Mesa and Conlazo 1982). According to this idea, these coastal populations were different from the terrestrial hunter-gatherers inhabiting inland Pampean plains. However, detailed studies to test this hypothesis had not been carried out on the Pampean coast until 1999, when a systematic

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regional archaeological research begun (Bonomo 2004). The aim of this paper is to evaluate the use of the Pampean seashore and more specifically the importance of coastal resources in the subsistence and technology of Middle and Late Holocene hunter-gatherers. Taking into account the South American evidence in a supraregional scale, an occupational model of the Pampean coast is proposed.

The South American Background

The Pampean coast is located between two vast Atlantic littoral areas that reveal a clear economic utilization of marine fauna: Brazil–Uruguay in the North and some sectors of Patagonia in the South (Fig. 14.1). On the coast of Central and Southern Brazil, large and numerous archaeological accumulations of marine mollusks distributed from Baia de Todos os Santos to Rio Grande do Sul States have been recorded (Gaspar et al. 2008; Lima 1999–2000; Prous 1992). These shell concentrations denominated *sambaquis* reach heights from 2 to 50 mts and maximum sizes of 200 mts. The *sambaquis* have been formed by the progressive and intentional accumulation of tons of mollusk waste with other materials such as fish, crustacean and mammal remains, seeds, lithic and bone tools, adornments, human bones, etc.

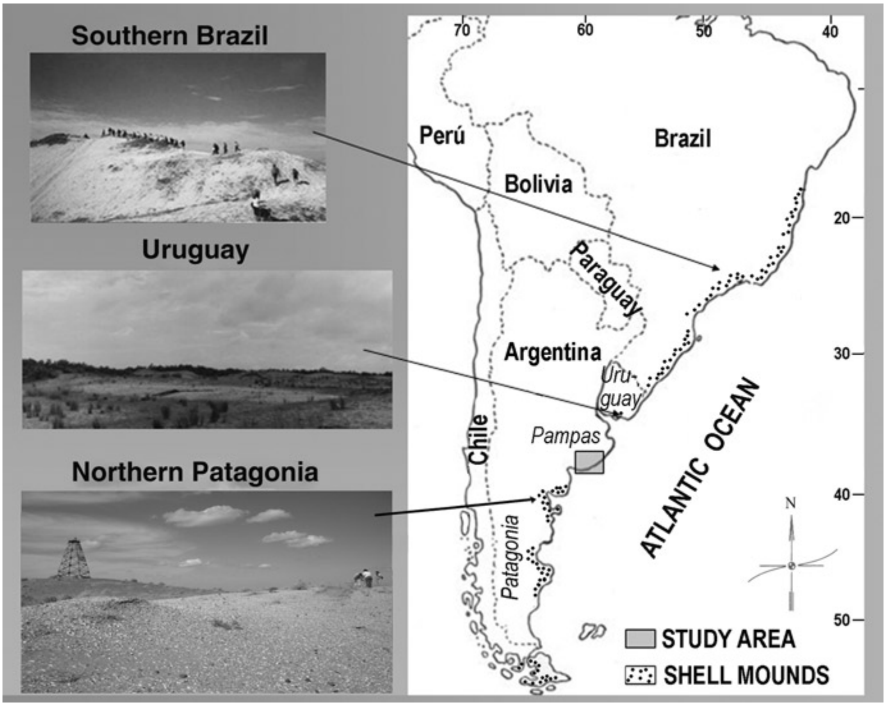

Fig. 14.1 South American Atlantic littoral region. Shell mounds of Southern Brazil (Garopa do Sul), Uruguay (La Esmeralda), and Northern Patagonia (Faro San Matías)

Most of these coastal sites yielded ages between 6,000 and 1,000 RCYBP (Lima 1999–2000), although new information from underwater shell mounds shows dates of 8,000 RCYBP (Calippo 2006), indicating a chronological bias due to the shoreline fluctuations during postglacial sea-level changes (see Angulo et al. 2006).

In general, the Brazilian shell middens were simultaneously domestic and collective funerary spaces and the product of successive and long-term occupations by marine-specialized hunters, gatherers, and fishers (Gaspar 2000). Although a great diversity of mollusk species were intensely utilized for feeding purposes (*Anomalacardia brasiliana*, *Mytilus perna*, *Phacoides pectinatus*, *Olivancillaria brasiliensis*, *Donax hanleyanus*, *Brachidontes purpuratus*, *Anadara* sp., *Cardium* sp., *Ostrea* sp.; Horn Filho et al. 1995), they did not constitute the prime resource exploited by these populations, which was the fish (e.g., Figuti 1993). In addition, the mollusks gathered were used for multiple purposes like mound-building elements and raw materials for tools (Figuti and Magalhães Klökler 2000; Lima 1999–2000). New research recognized that people who constructed the *sambaquis* were *sedentary societies that evolved toward more complex patterns of social organization* (Gaspar et al. 2008:323; see also DeBlasis et al. 1998; Lima and López 2000).

In Uruguay, coastal contexts linked to inland groups named "constructores de cerritos" show evidence of exploitation of marine mollusks, otariids, cetaceans, crustaceans, and fish from 4,500 RCYBP (López 1994–1995). The bivalve anthropic concentrations of La Esmeralda coastal site (Department of Rocha) is the most outstanding context (Fig. 14.1). These shell mounds, known as "concheros," are on average 40 cm thick and are constituted mainly by surf clams (*D. hanleyanus*). However, other mollusk taxa, fish, marine or terrestrial birds and mammals, lithic artifacts, bone tools, and charcoal remains have been found (Inda et al. 2006). La Esmeralda has been interpreted as a result of seasonal occupations where marine shellfish banks have been intensively exploited between 3,000 and 1,000 RCYBP (Castiñeira et al. 2010).

In different zones of the Patagonian Atlantic coast, numerous *concheros* composed of marine bivalves and gastropods show the systematic exploitation of shellfish. Within the sedimentary matrix of these invertebrate deposits archaeological materials such as lithic artifacts, pottery, shell tools, hearth features, and remains of terrestrial mammals, otariids, cetaceans, birds, fish, and crustaceans are included. In Northern Patagonia (extending from San Blas Peninsula to San Matías Gulf) surface shell accumulations of few centimeters to 5 mts of maximum thickness and 4–80 mts long were observed (Fig. 14.1). They are mainly constituted by clam and mussel shells (*Mesodesma mactroides*, *Eurhomalea exalbida*, *Mactra isabelleana*, *Brachydontes* sp., *Mytilus edulis platensis*, *Aulacomya ater*) and found to be chronologically ranging from 5,300 to 570 RCYBP (Borella and Favier Dubois 2009; Bórmida 1964; Sanguinetti de Bórmida 1999). The *concheros* of Central Patagonia (from San Jose Gulf to Blanco Cape) display the regular consumption of mussel and clam intertidal bivalves (*Aulacomya* sp., *Mytilus* sp., *Brachidontes* sp.) and gastropods (*Patinigera* sp., *Buccinanops* sp.) between 7,400 and 400 RCYBP (Gómez Otero 2007). The coastal contexts of Southern Patagonia (North of Santa

Cruz) were also composed of high proportions of *Patinigera* and *Mytilus* and have chronologies from 6,300 to 900 RCYBP. It has been proposed that the mollusks were not the main resource of the population diet but a necessary food reserve for coastal occupation of the area (Moreno 2008; Zubimendi et al. 2005).

The Northern Patagonia *concheros* have been interpreted by Bórmida (1964, 1969), as the result of intense and continuous occupations of waterside environments by Patagonian and Pampean groups with a subsistence based on marine resources. These societies were pushed aside to the coast by the expansion of more "technologically evolved" inland hunters. This kind of marginal characterization of coastal environments and their populations have been recently criticized, and the importance of marine habitats along the evolution of *Homo sapiens* have been remarked (Bailey and Milner 2002; Bicho and Haws 2008; Erlandson 2001).

The Pampean Coastal Archaeological Record

To start with the analysis of the use of space on the Pampean coast, a brief characterization of both the key environmental elements and the main resources available is needed. The geographical area of study (38°2′–38°55′S, 57°30′–60°30′W; Fig. 14.2) has a temperate humid climate moderated by the Atlantic Ocean with average temperatures of 14°C and mean yearly precipitations of 850 mm. Located between the Tandilia and Ventania mountain ranges, this area spans more than 290 km along the Atlantic coast of the *Interserrana* area in the *Pampas* grassland plains in Argentina. In most fluvial systems of this zone, the Middle Holocene sea-level rise invaded a narrow border of land (ca. 2–10 km) from the present shoreline of the Argentine Sea (Isla 1995). A lower coast with a continuous barrier of dunes was formed since 6,000 RCYBP (Isla et al. 2001), after the Middle Holocene eustatic regression. This dune barrier named as *Barrera Austral* is up to 3.5 km maximum width and is separated into three longitudinal landforms parallel to the shore (Frenguelli 1931). The first zone adjacent to the sandy beach is classified as a moving dune line with scarce herbaceous communities, which continuously changes its shape due to wind action. The next zone toward the hinterland consists of semifixed dune fields with moderate vegetation. The third zone is composed of a larger region of fixed sandy sediments, which is more stable and heavily vegetated than the middle zone.

Coastal resources include secondary lithic deposits of abundant volcanic beach cobbles (basalt, andesite, dacite, ignimbrite, rhyolite, tuff, etc.) with oblate and laminar shapes and maximum diameters of 15 cm (Bonomo and Prates 2009 and references cited therein). The lithology, shape, size, and the particular cortex formed by mechanical weathering permit a clear identification of the coastal origin of these cobbles. Faunal resources include seals (*Arctocephalus australis*) and sea lions (*Otaria flavescens*) otariids, as well as intertidal or estuarine shellfish (*M. mactroides*, *D. hanleyanus*, *Brachidontes rodriguezi*, *Tagelus plebeius*, *M. isabelleana*, among others). Within the dune zone, there is terrestrial fauna such as the *tuco-tuco* rodent

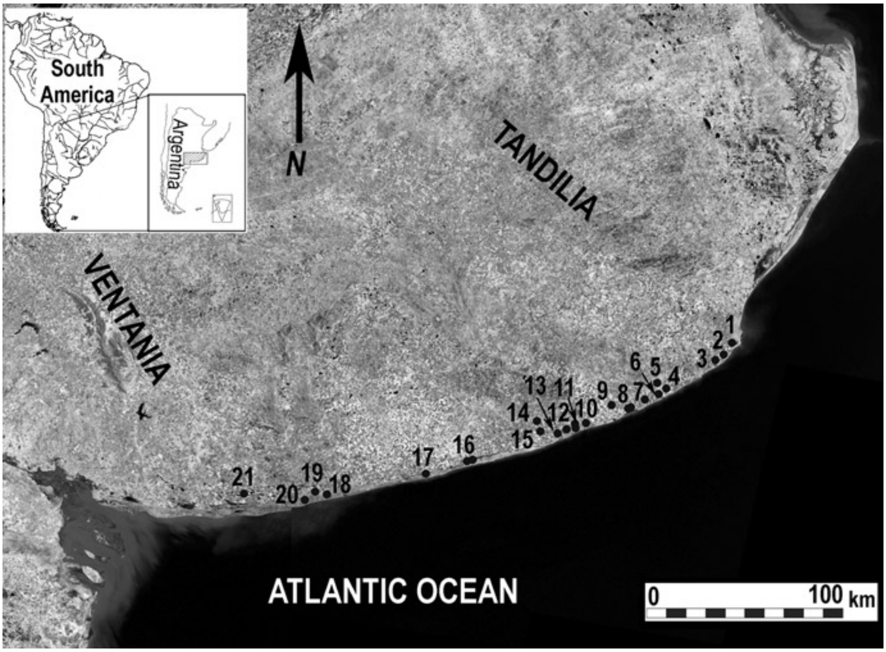

Fig. 14.2 Geographical distribution of the archaeological sites detected on the study area mentioned in the text. *1* Alfar; *2* Playa Las Palomas; *3* La Estafeta 1; *4* Laguna La Ballenera; *5* Arroyo La Ballenera; *6* Mar del Sur; *7* La Eufemia; *8* Bellamar 1, 2 and 3; *9* Nutria Mansa 1 and 2; *10* Moromar; *11* El Moro 1 and 2; *12* Arenas Verdes 1 and 3; *13* Playa Verde; *14* Quequén Grande 1; *15* Quequén Grande 2; *16* Los Médanos 1, 2, 3 and 4; *17* Faro Guaraní; *18* Pozo Alonso; *19* Claromecó 1; *20* Caracolero; *21* Quequén Salado 1

(*Ctenomys talarum* and *Ctenomys australis*), the *ñandú* flightless bird (*Rhea americana*), and probably in the past the *guanaco* wild camelid (*Lama guanicoe*).

Apart from that, in the interior of the Tandilia Mountain Range, there are localized sources of Precambrian/Paleozoic sedimentary rocks. In these primary sources, there are fine-grained quartzite (named *Grupo Sierras Bayas* ortoquartzite; Bayón et al. 1999), which is the most abundant raw material in inland Pampean sites. There is also chalcedony or chert, especially from the base of *Cerro Largo* Formation (Messineo et al. 2004). The outcrops and archaeological quarries are located more than 80 km from the coast. The human groups that occupied the coastal sites also used these inland sedimentary lithic raw materials.

In addition to the clear distinctions in fauna and lithic raw material distributions, it was observed that the zones of moving dunes, semifixed and fixed dunes and plains also presented distinctive archaeological patterns (Bonomo 2004). In order to evaluate this observation, 30 surface and buried sites detected during systematic survey as well as 28 museum collections were analyzed.

The Dune Line Record

Lithic materials without chronological control constitute the majority of the existing evidence to understand the past human occupation of the dune line. Surface sites are widely extended across the moving dunes in close relation with the present shoreline. They are located in blowout depressions overlying sediments consolidated by calcium carbonate. About all of the sites ($n = 16$) detected in the dunes contain mostly lithic artifacts of coastal raw materials (90%; Table 14.1). These sites are related to workshop activities, consisting of an abundance of cores and flakes produced by bipolar reduction of volcanic beach cobbles. Unifacial flake tools with minor retouch confined to the edges, anvils and hammers of these coastal materials were also recorded, as well as a few tools and flakes manufactured from inland quartzite and chalcedony. Based on the analysis (Bonomo 2004), most places located within the dune line sector were used for conducting specific tasks. More specifically, such activities included the reduction of local cobbles to produce tools with minimal modification as an expedient technological strategy (*sensu* Binford 1979). Except for *ñandu* eggshells, faunal remains were not recovered during our research in the dune zone. The presence of *ñandú* eggshells found in several of the studied contexts suggests that at least some of them were occupied in spring or summertime.

Table 14.1 Lithic artifacts from the archaeological sites of the dunes

	Tools		Cores		Flakes		
Site	C	I	C	I	C	I	Total
MDS	8	1	62	0	141	13	225
LEU	4	0	21	0	112	38	175
Be1	6	5	77	0	1,018	26	1,132
Be2	6	2	14	0	50	2	74
Be3	11	15	366	0	669	164	1,225
Mo	4	0	212	0	72	7	295
EM1	0	0	2	0	28	58	88
EM2	1	0	11	0	27	2	41
AV1	1	12	10	1	16	55	95
AV3	1	0	48	0	461	0	510
PV	0	0	15	0	18	8	41
LM1	0	0	12	0	33	0	45
LM2	0	0	8	0	35	4	47
LM3	1	0	17	0	29	3	50
LM4	2	0	15	0	43	2	62
FG	2	0	43	0	75	2	122
PA	1	0	24	0	41	0	66
Car	0	1	4	0	80	17	102
Total	48	36	961	1	2,948	401	4,395

MDS Mar del Sur archaeological site; *LEU* La Eufemia site; *Be1* Bellamar 1 site; *Be2* Bellamar 2 site; *Be3* Bellamar 3 site; *Mo* Moromar site; *EM1* El Moro 1 site; *EM2* El Moro 2 site; *AV1* Arenas Verdes 1 site; *AV3* Arenas Verdes 3 site; *PV* Playa Verde site; *LM1* Los Médanos 1 site; *LM2* Los Médanos 2 site; *LM3* Los Médanos 3 site; *LM4* Los Médanos 4 site; *FG* Faro Guaraní site; *PA* Pozo Alonso site; *Car* Caracolero site; *C* coastal lithic raw materials; *I* inland raw materials

The human groups that occupied the coast might also have exploited marine fauna and terrestrial animals that inhabited this arid ecological zone. In addition to flake tools, the presence of bola stones ($n = 30$) and arrow size projectile points (more than 18 Late Holocene small triangular points) in museum collections from the dune line suggests that past societies may have hunted and processed marine and terrestrial animals. The practice of sealing with bola stones has been described in post-Hispanic documents (Sánchez Labrador [1772] 1936). On the contrary, at Monte Hermoso coast, which is directly adjacent to the study area, La Olla 1 stratified site provides evidence of butchering and processing of a great number of otariids (minimal number of individuals – MNI = 41) chronologically dated between 7,300 and 6,600 RCYBP (Bayón and Politis 1996). Bone tools made of sea mammals' long bones for butchery and hide preparation purposes have also been recovered (Johnson et al. 2000). In addition, the study area faunal record of some surface dune sites reported by other authors (e.g., Aparicio 1932; Hrdlička 1912; Torres and Ameghino 1913) and the new evidence from Alfar stratigraphic site (General Pueyrredón District) present otariids' bone remains.

The Alfar archaeological site (Fig. 14.3; Bonomo and Leon 2010) is located on the right margin of Corrientes stream and 0.65 km northwest from modern littoral, next to a historical colony of sea lions. Recently, in 2006 a total surface of 17 m^2 has been excavated, where more than 3,433 lithic artifacts and 8,945 faunal remains

Fig. 14.3 Alfar archaeological site. (**a**) Excavation view; (**b**) flake and core tools made of coastal cobbles and (**c**) humerus of Otariidae with cut marks

Table 14.2 Radiocarbon dates obtained from the coastal archaeological sites of the study area

Site	Lab. No.	Material	^{14}C dates (RCYBP)	δ ^{13}C (‰)	References
Alfar	AA82081	Seal tooth	5,704 ± 64	−11.5	Bonomo and Leon (2009)
Nutria Mansa 1	AA55114	Guanaco teeth	2,705 ± 66	−25.3	Bonomo (2004)
Nutria Mansa 1	AA55115	Guanaco teeth	3,080 ± 110	−25.9	Bonomo (2004)
Nutria Mansa 1	AA55116	Guanaco tooth	2,920 ± 110	−24.6	Bonomo (2004)
Claromecó 1	AA64621	Mammal bone	800 ± 34	−21.2	Bonomo et al. (2008b)
Quequén Salado 1	Beta-169820	Guanaco bone	360 ± 40	−18.6	Madrid et al. (2002)
Quequén Salado 1	Beta-157398	Guanaco bone	790 ± 40	−19	Madrid et al. (2002)
Quequén Salado 1	Beta-157397	Guanaco bone	940 ± 40	−19.1	Madrid et al. (2002)
Quequén Salado 1	Beta-169821	Guanaco bone	960 ± 40	−18.9	Madrid et al. (2002)

were recovered. The archaeological remains were deposited on the edge of an ancient pool of the dune line. Radiocarbon age of 5,700 RCYBP (Table 14.2) places the human occupation within the Hypsithermal (= Climatic Optimum) range. In concordance, palaeobotanical analyses indicate that the site was occupied under dryness conditions during a warm event (Bonomo et al. 2008a).

The main resources exploited in Alfar were coastal cobbles (93%) reduced by bipolar technique and marine otariids (Otaridae; MNI = 7; MNE = 175). Other marine (*Amiantis purpurata*, *M. mactroides*, *Spheniscus* sp., Cetacea) and continental *taxa* (*L. guanicoe*, *Ozotoceros bezoarticus*, *Ctenomys* sp., Rehidae, etc.) were recorded (Bonomo and Leon 2010). As in the surface dune sites, the most abundant lithic artifacts are flakes (92%), followed by bipolar cores (7%) and scarce unifacial flake tools, hammers, and anvils (1%). The abundance of otariid skeletal parts in association with a coastal lithic technology shows the relevance of this site to understand the lithic surface contexts from the dune line sector with low bone preservation and also to evaluate the role played by sea mammals in the subsistence of past hunter-gatherers.

Moving inland in the dune barrier, a progressive increase in the use of lithic resources transported from the Tandilia Mountain Range is noted. In contrast to Alfar site and the 16 workshops located in the dune line, two surface sites (Arenas Verdes 1 and El Moro 1) placed in the interior of the dune barrier are dominated by inland raw materials (71 and 66%, respectively), mainly quartzite from Tandilia (Table 14.1). This prevalence of raw material from distant locations indicates that alternative activities, apart from toolmaking with local rocks, were carried out.

Very few coastal sites were interpreted as multiple activities. In general, grinding stones and pottery are scarce in the dune line record. However, La Ballenera (MLP – Museo de La Plata collection) and Cristiano Muerto (MLP) museum collections with abundant inland raw materials as well as a few mortars, mills, hand stones, and pottery have been recorded. These assemblages were located in the internal dune zone consolidated by herbaceous vegetation (see similar observations in Politis 1984:310). Mortars and mills are heavy tools with long use life, little transportability, and frequently reused by subsequent occupations of the same site (Adams 1999; Wright 1994). The predominance of distant raw materials and the presence of artifacts related to domestic tasks in the interior semifixed and fixed dunes suggest more generalized activities at these places than in sites located in the moving dune zone. Taking into account the above information and the earlier ages of pottery in the Pampean region (i.e., 3,000 RCYBP; Politis et al. 2001), such contexts could be classified as Late Holocene residential camps.

The Plains Record

The archaeological record of the plains nearby the coast contrast with the dune evidence. Twelve archaeological sites and three Museum collections have been included in the study of this area for the purpose of this chapter. Nutria Mansa 1 (NM1), Claromecó 1 (CL1), and Quequén Salado 1 (QS1) sites (Fig. 14.4) have been analyzed in greater detail due to their stratigraphic position and to the preservation of faunal remains that permit to establish their absolute chronologies. The main results of these three sites are summarized below.

NM1 stratigraphic site (Bonomo 2004) is located on the left margin of the homonymous stream (General Alvarado District) and in a 3.5-km straight line distance from the present coastline. Numerous bone specimens, lithic materials, mineral pigments, and coastal cobbles without anthropic modification have been found in a total excavated area of 23 m^2. Three AMS radiocarbon dates yielded ages between 2,700 and 3,100 RCYBP (Table 14.2).

Diverse lithic materials of different origins were utilized in the site (n = 1,603; 5 of them include rocks of undetermined origin). However, the inland raw materials (89%; mainly Tandilia quartzite) are predominant over the coastal cobbles (11%; Table 14.3). The most abundant artifacts are flakes (70%), followed by tools (27%) and cores (3%; and mostly bipolar cores). Scrapers, side-scrapers, drills, knives, and other unifacial flake tools were recovered. Also, bola stones, hand stones, mills, hammers, and anvils were recorded, showing a significant typological variability. The general tendencies of the lithic assemblage indicate that the raw material reduction took place in the site mainly oriented to flake production for making retouched tools.

The best represented species is *L. guanicoe* (*guanaco*; MNI = 60) out of the total faunal specimens quantified (n = 142,732). A wide range of skeletal parts is represented. However, the appendicular bones (MNE = 1,093) are more frequent than the axial skeleton (MNE = 135). In addition, faunal remains corresponding to an open sea fish and several mammals taxa (n = 26), including two teeth of *Carcharodon carcharias* (MNE = 2; white shark) and otariid bones (MNE = 3) have been recovered. The root tips of these shark teeth present an artificial transversal trench fitted to tie a thread. Moreover, the edge serrations are strongly eroded, suggesting that they have been also used as tools (Cione and Bonomo 2003).

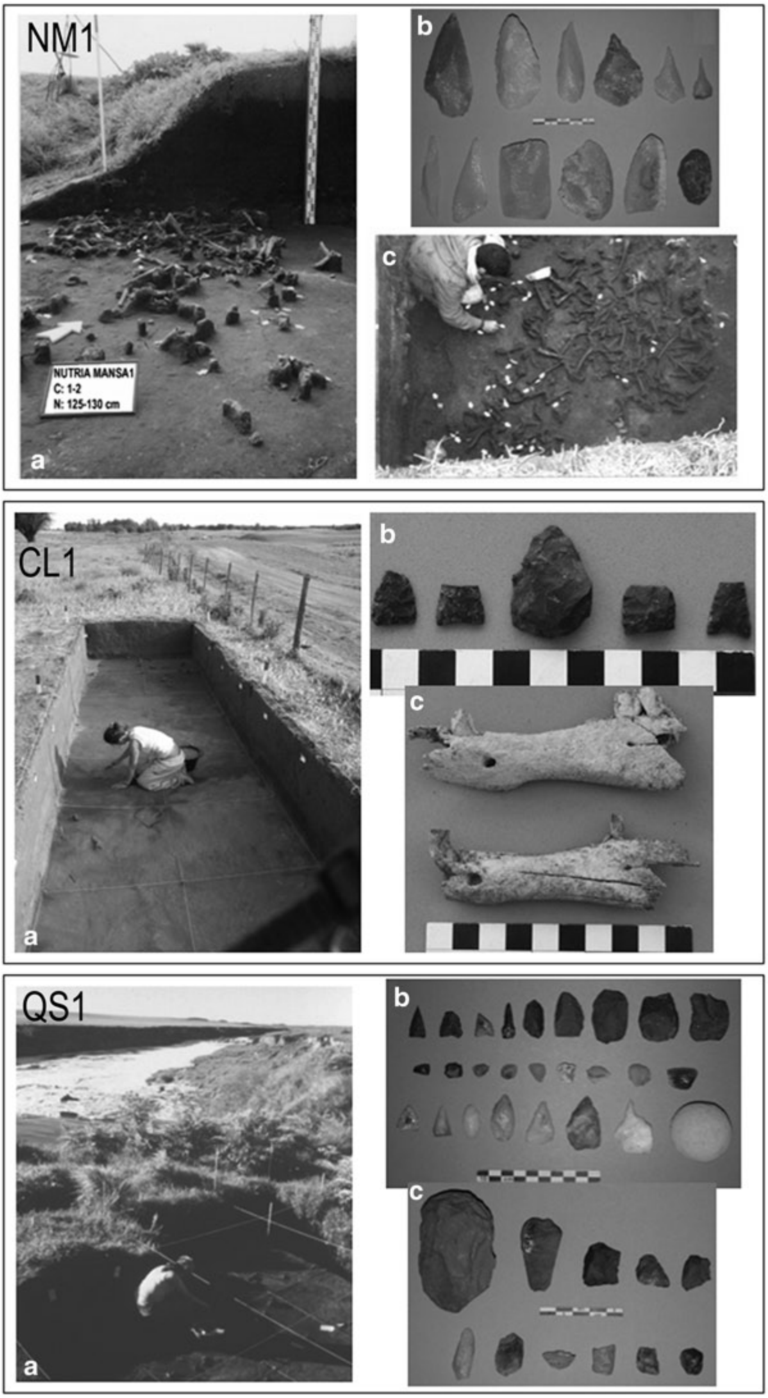

Fig. 14.4 Archaeological sites of the plains behind the coast. Nutria Mansa 1 (NM1): (**a**) excavation general view, (**b**) quartzite diverse type flake tools, and (**c**) guanaco bone concentration. Claromecó 1 (CL1): (**a**) excavation view; (**b**) projectile points and preforms of coastal cobbles, and (**c**) guanaco mandibles. Quequén Salado 1 (QS1): (**a**) excavation view, (**b**) flake tools, and (**c**) cores of inland and coastal raw materials

Table 14.3 Lithic artifacts from the archaeological sites of plains near the coast

	Tools		Cores		Flakes		
Site	C	I	C	I	C	I	Total
PLP	0	0	0	0	2	80	82
LE1	1	13	9	0	38	363	424
NM1	43	381	35	13	102	1,024	1,598
NM1sup	4	30	10	2	23	54	123
NM2sup	4	121	57	6	46	633	867
ALB	0	5	0	1	6	50	62
LLB	1	1	5	1	59	39	106
QG1	1	9	0	3	8	55	76
QG2	1	2	1	0	28	64	96
CL1	12	1	38	0	336	13	400
QS1	17	35	5	6	289	520	872
Total	84	598	160	32	937	2,895	4,706

PLP Playa Las Palomas site; *LE1* La Estafeta 1 site; *NM1* Nutria Mansa 1 site; *NM1sup* Nutria Mansa 1 surface site; *NM2sup* Nutria Mansa 2 surface site; *ALB* Arroyo La Ballenera site; *LLB* Laguna La Ballenera site; *QG1* Quequén Grande 1 site; *QG2* Quequén Grande 2 site; *CL1* Claromecó 1 site; *QS1* Quequén Salado 1 site; *C* coastal lithic raw materials; *I* inland raw materials

Hunter-gatherer groups that occupied this site processed *guanaco* carcasses for obtaining meat, fat, hide, and marrow. Skeletal parts diversity might be explained as most *guanacos* have been hunted in the site nearby and selection and transport of anatomical units have not been necessary. The results of the lithic technotypological analysis indicate that several artifact manufacturing activities, including core reduction to tool maintenance, have been conducted in the site. All these evidences suggest the accomplishment of a great variety of tasks or multiple activities in this riverine environment during the beginnings of the Late Holocene.

CL1 archaeological site (Bonomo et al. 2008b) is located on the left margin of the Claromecó stream (Tres Arroyos District) and 3 km away from the Atlantic coast. A total surface of 21 m^2 has been excavated in two field seasons carried out in 2004 and 2005. The archaeological material recovered include 423 lithic artifacts (23 of them include raw materials of undetermined origin), 2 mineral pigments, 87 pottery sherds, 4,494 quantified faunal remains, 6 unmodified coastal cobbles, and 2 fragments of petrified wood. The site chronology indicates an age of 800 RCYBP for the human occupation (Table 14.2).

Faunal analysis indicates the presence of *guanaco*, Pampean deer (*O. bezoarticus*), *vizcacha* rodent (*Lagostomus* sp.), *tuco-tuco* (*Ctenomys* sp.), armadillo (*Chaetophractus villosus*) dermal plates, *ñandú* (*R. americana*) bones and eggshells, and a marine gastropod (*Zidona* sp.). The *guanaco* predominance (MNI = 5; MNE = 66), the presence of bone helical fracture debris, and thermally altered eggshells are important features of the site. The lithic technomorphological study exhibits a clear prevalence of coastal raw materials (96%) in comparison to inland rocks (4%; Table 14.3). The best represented categories are flakes (88%), followed by bipolar cores (9%) and tools (3%), which include four small triangular projectile points.

CL1 is a Late Holocene site located adjacent to the coast, whose lithic material sources are located in the coast and in Tandilia Mountain Range. A remarkable aspect on lithic technology is the high proportion of coastal cobbles knapped by bipolar technique and the lower frequency of inland rocks. These characteristics differentiate this assemblage from the majority of the other Pampean sites from the plains and the mountain ranges. However, the faunal exploitation in CL1 is mainly of continental origin.

QS1 (Madrid et al. 2002) is situated on the left margin of the homonymous river (Tres Arroyos District) and 11 km inland from the coastline. A total surface of 25 m^2 have been excavated and 4,559 lithic artifacts, 15 pottery sherds, over 3,800 faunal remains, 204 mineral pigment fragments, and 2 unmodified coastal cobbles have been recovered. Four AMS radiometric dates situate the chronology of the human occupations toward the end of the Late Holocene, between 1,000 and 320 RCYBP (Table 14.2).

The preliminary analysis of faunal remains (Rodríguez Loredo 2001) indicates that *L. guanicoe* (MNI = 6) is the dominant species. In addition to guanaco, other taxa have been identified: Artyodactila indet., *O. bezoarticus*, Carnivore indet., Dasipodidae indet., Rodentia indet., *Cavia* sp., and Birds indet. The lithic sample analyzed ($n = 943$; it include 71 items of undetermined origin) shows that artifacts manufactured on inland raw materials are the most abundant (64%), although coastal materials are also present in high frequency (36%). Flakes (93%) are predominant in relation to tools (6%) and cores (1%; Table 14.3). The most common knapped tool types are side-scrapers, scrapers, nondifferentiated flake fragments with retouched edges, and small triangular projectile points (Bonomo 2004).

As NM1 and CL1, QS1 presents an archaeological assemblage that shares specific coastal and inland characteristics. Like in near all Pampean sites (Alfar and La Olla 1 Early-Middle Holocene sites are exceptions), the exploitation of continental mammals predominates. Although in low frequencies, marine resources such as mollusk shells, white shark teeth, and seal bones have been also recovered (NM1 and CL1). Technologically, the use of inland rocks from Tandilia is important in sites located near the cobble supplying area like in QS1 and also in NM1. The coastal resources were utilized in a differential way. On the one hand, the elevated percentage of coastal raw materials reduced by the bipolar technique is clear in CL1 and QS1, and it is greater than NM1, which is located in a similar environment behind the line of dunes (though at different distances). These contexts have lithic products with similar characteristics to those generated by coastal technologies implemented in the workshops located in the dune line. On the other hand, the marine fauna, such as otariids, is recorded in a low frequency in NM1 and was either not exploited or not transported to the sites in CL1 and QS1.

To sum up, and considering all the assemblages recorded in the plains behind the coast (12 sites and 3 collections), their archaeological records show differences to the dune evidence for several reasons. In general, in those adjacent plains there are large lithic assemblages where the retouched tools (14%) are more frequent than cores (4%). In addition, edge retouched tools display an important diversity, and most of the sites are mainly composed by inland rocks (88%) and by a minor proportion of coastal cobbles (12%), showing preference on quartzite at regional level. Nevertheless, there are some contexts (CL1 and LLB) with a predominance of cobbles (Table 14.3), which could represent a more intense coastal rock supply in settlements that had little amounts of quartzite ready for use (see similar topics in Hofman 1991).

The small sample of grinding tools recovered in the dunes ($n = 16$) contrasts with the high frequency ($n = 137$) found in Nutria Mansa, La Ballenera, and Claromecó streams located in the plains near the coast. In the latter, 465 pottery sherds have been recorded. Furthermore, 16 large quartzite cores (5.9 kg maximum weight) with an important potential for reduction have been found in the plains and were absent in the dune line. These large quartzite cores have been arranged in places where this rock was not naturally available, providing the sites with anthropic raw material deposits for future use (see discussion in Martínez and Mackie 2003–2004). This diversity of artifacts, added to the high proportion of transported raw materials (from distances between 100 and 160 km), suggests that the majority of these sites have been multiple activity sites and potentially residential camps.

Discussion

As it can be observed from the contexts where faunal remains have been preserved, *guanaco* is the predominant resource in Late Holocene sites (NM1, CL1 and QS1). In contrast to the low frequency or absence of marine fauna in those sites, in Middle Holocene Alfar site seals are more important than *guanaco*. This faunal data match the isotopic studies of human bones found in the area. Analysis of $\delta^{13}C_{col}$ were carried out in Late Holocene human skeletons from Laguna Tres Reyes 1 and El Guanaco inland sites (105 and 13 km away from the modern littoral, respectively), and from the Túmulo de Malacara coastal site of the study area (Flegenheimer et al. 2002; Politis and Barrientos 1999). They suggest a similar diet in both environments based primarily on products of continental origin with an occasional contribution of marine food.

Recent systematic stable isotopic analysis (Politis et al. 2009) has been performed on collagen and apatite fractions from 31 human skeletons from Arroyo Seco 2 (AS2) and 2 skeletons from Monte Hermoso 1 (MH1) earlier sites. AS2 (7,900–4,400 RCYBP) is located 50 km away from modern littoral and MH1 (7,900 and 6,500 RCYBP) is on the Atlantic coast, close to La Olla 1 site. The information comes from 29 $\delta^{13}C_{col}$, 22 $\delta^{13}C_{ap}$, and 12 $\delta^{15}N$ values. Results show that the diet of most of the individuals was based on terrestrial herbivores, which in turn consumed type C3 plants. In contrast, three individuals (one from AS2 and two from MH1) incorporated large amounts of marine food in the diet (Politis et al. 2009). Overall, this isotopic information probably suggests a more important consumption of marine fauna in Early-Mid Holocene than in Late Holocene times.

Although there is a lack of chronological control for an important number of sites in the study area, especially for surface contexts, coastal spaces were available for human populations only after the Middle Holocene transgression (6,000 RCYBP).

Potential older coastal sites (Late Pleistocene and Early Holocene) could have been covered and eroded during this global event. Therefore, some archaeological tendencies could be outlined for the Middle-Late Holocene period.

Along this chapter, we briefly characterize the archaeological record found on the moving dune zone and internal semifixed and fixed dunes of the coast, and the plains. It has been our aim to demonstrate that the differences between the accumulated materials through time in different environments indicate recurrent forms of interaction between human populations and certain sectors of the landscape. According to the topographic location of sites, variations in rock use, as well as in the amount and diversity of discarded artifacts, can be recognized. These spatial tendencies in the archaeological record of this study area indicate the development of variable activities that can be outlined as in the model presented in Fig. 14.5.

As it has been illustrated, few archaeological sites associated with the tasks developed in base camps have been detected in the dune line. This aspect of the settlement system is of vital importance because it shows a close relationship between the Pampean Atlantic coast and the inland. It indicates that the annual circuit of residential movements of hunter-gatherers that produced the coastal sites did not frequently include the littoral dunes. The fact that most contexts found on the dune line are sites of limited activities does not support the hypothesis of populations permanently settled in the coastal environment with a subsistence based on the intensive utilization of marine shellfish. In addition, other arguments contradict this idea, as it is briefly shown.

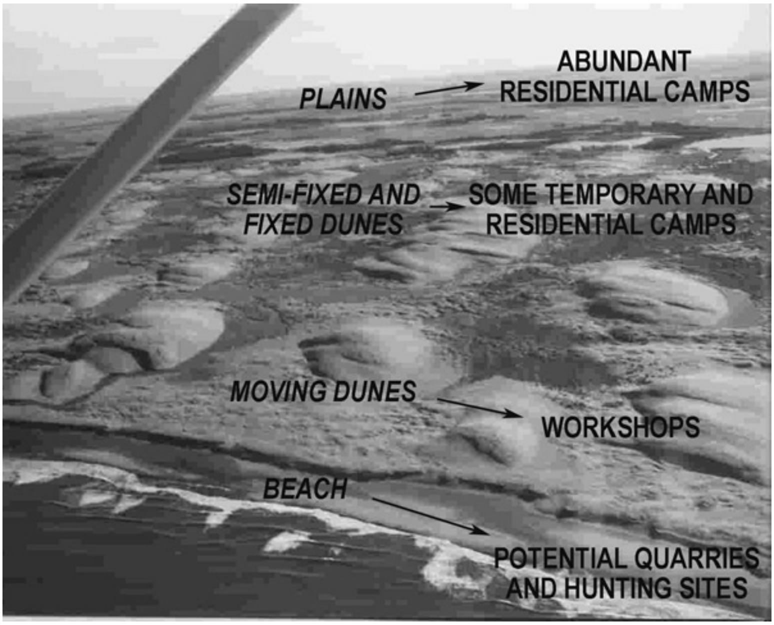

Fig. 14.5 Space use in the Pampean Atlantic coast

The distribution of coastal cobbles and marine shellfish is not limited to the coast. Those elements obtained on the coast are frequently found in low frequencies in inland sites, with chronologies that range from the first occupations of the Pampean region in the Late Pleistocene (ca. 12,000 RCYBP) to post-Hispanic times (>500 cal BP). This shows that coastal products were transported by hunter-gatherers in their inland movements and exchanged around the vast Pampean landscape since the earliest human occupations of the *Pampas* grasslands.

In the case of cobbles, the presence of coastal rocks reduced by bipolar technique in the inland sites indicates a technological continuity between both environments, as it was proposed in a large scale to the *Interserrana* area during the Holocene (Politis 1984; see also Martínez 1999). It also indicates that the coast was included within the lithic supply areas of human groups that inhabited the inland plains in different periods. Rather than differentiating coastal and inland human populations, these facts give evidence of the use of the different Pampean environments by the same cultural groups.

The case of mollusks needs a more detailed discussion. A synthesis of the Pampean archaeological records with mollusks has been provided elsewhere (Bonomo and Aguirre 2009), and it shows that more than 1,200 marine molluskan remains (beads, artifacts, fragments, and complete shells with no human modifications) of 19 taxa have been recovered from 37 sites. A great majority of the sites containing mollusks are located in the plains near the Atlantic coast, although in several cases they extend over 200 km from the coastline. Among the recognized taxa in the Pampean sites, those of the *Adelomelon* genera and Volutidae family are the most frequent.

The marine shells recovered in the Pampean sites appear in very low quantities, and shell mounds that imply an intensive human gathering of shellfish have not been detected on the Pampean coast. This is an important difference with the Atlantic coastal sites of Southern Brazil, Uruguay, and Patagonia where, as it is mentioned, there were large quantities of mollusks collected with feeding purposes forming artificial mounds. Most Pampean sites have no more than ten molluskan remains. The sites exhibiting greatest abundance of mollusks are AS2 (Politis 1984) and Chenque I (Berón 2004), where their shells were transformed in more than 1,100 beads and were associated with human skeletons in funerary contexts.

Most taxa also occur in the Pampean Pleistocene and Holocene marine deposits and live today in the area within a bathymetric range of 4 mts down to more than 200 mts. Only a few taxa represented by scarce specimens live in the intertidal zone (e.g., *Olivancillaria*, *Mesodesma*), and other shallow taxa common in the littoral at present (*Donax*, *Brachidontes*, *Mactra*) are absent in the archaeological sites. Consequently, the majority of the mollusks of the Pampean sites may have been collected dead, as empty shells, along the contemporary beach or on the marine fossil deposits. As it can see in Table 14.4, the habitat of most recorded species is not in the tidal zone, but in deep waters in depths superior to 9 mts.

On the Pampean coast, there is no evidence of systematic selection of edible species, such as surf and yellow clams or mussels, readily available from the beaches and exploited in other South American Atlantic sectors (see above).

Table 14.4 Main bivalve and gastropod taxa represented in the archaeological sites of the Pampean region

	Depth (m)	Chronological range
Gastropoda		
Drupa sp.	<20	Late Holocene
Zidona dufresnei	15–100	Late Holocene
Adelomelon beckii	10–75	–
Adelomelon brasiliana	18–70	Late Pleistocene–Late Holocene
Adelomelon ancilla	10–350	Middle Holocene
Adelomelon sp.	<10	Late Holocene
Volutidae indet.	10–350	Middle–Late Holocene
Olivancillaria sp.	4–30	–
Bivalvia		
Arca bisulcata	15–40	–
Glycymeris longior	10–20	–
Mytilus sp.	4–80	–
Pecten sp.	20–130	Middle Holocene
Mesodesma sp.	0–20	–
Amiantis purpurata	15–20	Middle–Late Holocene
Amiantis sp.	>15	Early–Middle Holocene
Bivalvia indet.	–	Late Holocene
Mollusca indet.	–	Early–Late Holocene

For 21 Pampean sites, the gastropods and bivalves were most likely utilized, according to the large dimensions, hardness, color, and shape of their shells for making ornaments (beads for necklaces or bracelets), containers, and possible tools (drillers and retouched artifacts). Many shells were used to manufacture numerous beads that are linked to human burial and have red pigments adhered and have been recorded at long distances from the coast. Therefore, a symbolic value of these elements cannot be ruled out. This idea is in accordance to expectations derived from ethnographic information from Patagonian hunter-gatherers, where mollusks were used in clothes linked with healing ceremonies and in ritual contexts as funerary goods (du Nort 1599 cited in Embón 1949; Vignati 1930).

An inverse situation appears in bordering zones to the coast of the study area, as the Uruguayan and Northern Patagonia Atlantic coast where bivalves dominate the assemblages, and their meat consumption was established. In both sectors, sites with great numbers of nutritional species that are readily accessible from the beach have been recovered. The shell middens are constituted by surf clams on the Uruguayan coast (Castiñeira et al. 2010) and by yellow clams and mussels in Northern Patagonia (Bórmida 1964; Sanguinetti de Bórmida 1999). Along the study area, the scarcity of typical hard shores like in Patagonia determines less availability or absence of typical taxa with high nutritional value (*Mytilus*, *Aulacomya*, and *Patinigera*). In addition, the microtidal regime of the study area (1–2 mts) in comparison with the Patagonian coast (2.5–10 m) implies much lower productivity in the oceanic waters of the Pampean region. This situation could have been disadvantageous to allow the exploitation of mollusks. In summary, biological and archaeological data indicate that marine mollusks did not have a clear relation with the subsistence of the Pampean hunter-gatherers (see Bonomo and Aguirre 2009 for a complete discussion).

Conclusion

In conclusion, the evidence discussed implies that the human groups that occupied the Pampean coast might not have had a strategy strongly oriented to the exploitation of marine mollusks for feeding purposes, although a sporadic consumption cannot be completely excluded. Besides, their shells were usually linked with nonutilitarian activities and possibly had a symbolic value. Taking into account a supraregional scale, this situation is a singular aspect of the Pampean coast in comparison with other areas of the South American Atlantic coast such as Southern Brazil, Uruguay, and some sectors of Patagonia, where shellfish had an important role in the economy.

The information developed in this chapter shows that the Pampean coast, as in the case of Uruguayan littoral, was used by the same inland populations. The Pampean groups included the Atlantic coast within their annual movements around the landscape. Nevertheless, they did not frequently set up residential camps in the dune line. They mainly placed their campsites in the plains in close proximity to the dunes such as NM1, QS1, and Claromecó archaeological sites. These sites show a hunter-gatherer economy focused mainly on guanaco and on the use of quartzite, which are associated both with artifacts of coastal cobbles, and occasionally with marine fauna. From these domestic spaces located in the inner plains near the dunes, coastal sources of raw material were exploited. Specific tasks using bipolar reduction of local cobbles for making tools were developed on the dune workshops. These workshop sites do not support the idea of coastal societies adapted to the exploitation of maritime resources. They represent a small part of the settlement system of the Middle-Late Holocene hunter-gatherers who also occupied the Pampean plains.

The scarce number of otariid bones recovered in the plains next to the coast does not indicate an intense sealing from this environment. In addition, this possibly suggest that these marine mammals' processing was limited to the seacoast or to places near the colonies of seals. The otariids predominance in Alfar distinguishes this site from those placed on the plains, and also from those adjacent to the coast where basically terrestrial mammals were exploited. The interesting information of Alfar site, among with stable isotopic studies, shows a more intensive consumption of marine foods before Late Holocene. This expands the discussion of the subsistence of the pre-Hispanic hunter-gatherers when they were settled on the Pampean coast.

Finally, although the model proposed is explanatory of the Middle and Late Holocene occupations, it is important to take into account that the Late Pleistocene-Early Holocene coastal sites would be subrepresented, since they could have been destroyed during the Holocene marine transgressions. Even though the potential archaeological materials deposited on the coast between 12,000 and 6,000 years RCYBP could have disappeared, as it is mentioned, the use of coastal cobbles and marine mollusks has been recorded in this early period sites in the mountain ranges and plains. Therefore, this shows that the Atlantic coast was included within the environments utilized by hunter-gatherers from the beginnings of the human occupation of the Pampean region.

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Chapter 15
Coastal Resources and the Early Holocene Las Vegas Adaptation of Ecuador

Karen E. Stothert

Introduction

This essay focuses on the archaeological evidence used to interpret the preceramic Las Vegas culture of the Santa Elena Peninsula of southwest Ecuador. The Las Vegas people are probably the best-studied Early Holocene occupants of South America, and their case has special importance because they developed subsistence systems focused on both wild resources and domesticated plants in a coastal locale in the neotropics. Their choices enabled economic, social, and ideological innovations that facilitated the emergence of more complex cultures.

My colleagues and I have modeled the Las Vegas adaptation, including the emergence of food production, using evolutionary theory, particularly Human Behavioral Ecology and Optimal Foraging theory (Kennett and Winterhalder 2006; Piperno and Pearsall 1998; Zeder et al. 2006). This thinking focuses on human beings as rational decision makers in small-scale subsistence systems, the apparent site for selection, and an appropriate locus for research on dietary choices and technological innovation. Like other Americans, the Vegas people developed more energy efficient subsistence activities, although this process was probably halting, episodic, and subject to both environmental and social contingencies.

It is not known precisely when the first people arrived in coastal Ecuador, or what their origin was. While they might have been big game hunters who diffused into northwestern South America along terrestrial routes, it is equally likely that they were boat people who dispersed down the Pacific coast armed with skills for extracting food from the sea and littoral habitats. New finds in North and South America have invigorated the idea that the earliest settlers, equipped with seagoing crafts, traveled along coastal routes (Erlandson 2002; Jones et al. 2002).

It is sure, however, that hunters and gatherers with diverse adaptations lived along the Pacific littoral of South America in the Terminal Pleistocene (Dillehay

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et al. 2004; Roosevelt et al. 2002), and at some locations marine resource were exploited intensely (Keefer et al. 1998; Llagostera 1979; Richardson 1992; Sandweiss et al. 1989, 1998, 1999). Among these were the Las Vegas people, who were attracted by both aquatic and terrestrial resources in what was once a well-endowed littoral ecotone in the lowland neotropics (Fig. 15.1). They adapted successfully to the changing environments in the Late Pleistocene and Early Holocene periods, between 10,840 and 6,600 RCYBP.[1]

The Santa Elena Coast

Today's Ecuador is a small country (270,000 km^2) characterized by a large number of compressed terrestrial zones with impressive variations in altitude and rainfall from region to region (Fig. 15.2). The tropical lowlands of the coastal

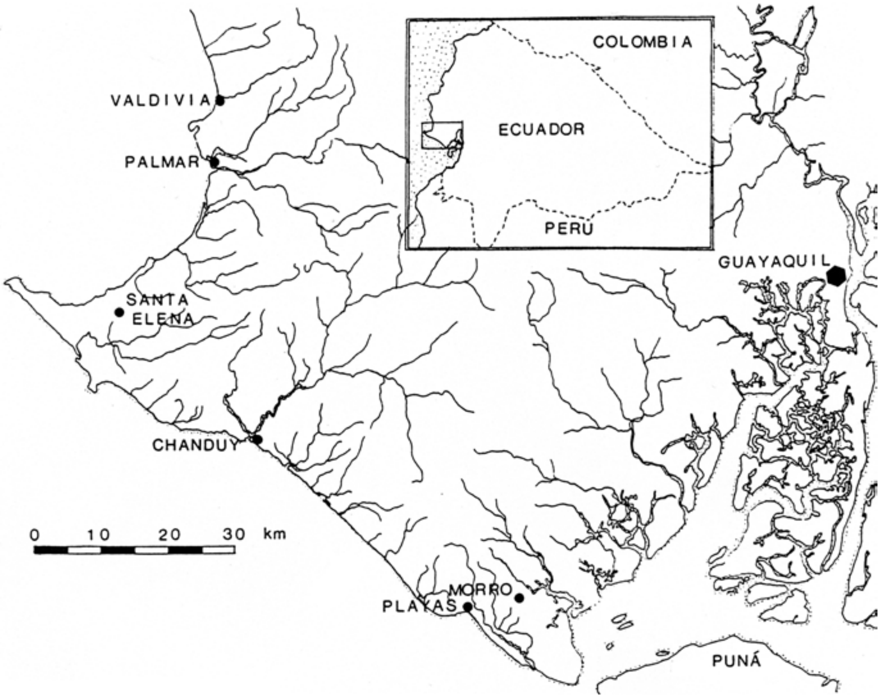

Fig. 15.1 Location of several modern towns and seasonal rivers of the Province of Santa Elena, also showing the city of Guayaquil on the mangrove estuary of the great Guayas river system. If narrowly defined, the Santa Elena Peninsula is the area west of a line between Palmar and Chanduy, the same region where all the known Las Vegas archaeological sites are found

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[1] All dates are cited in uncalibrated radiocarbon years BP (RCYBP). Geological periods are Terminal Pleistocene (11,000–10,000 RCYBP), Early Holocene (10,000–7,000 RCYBP), and Middle Holocene (7,000–3,000 RCYBP).

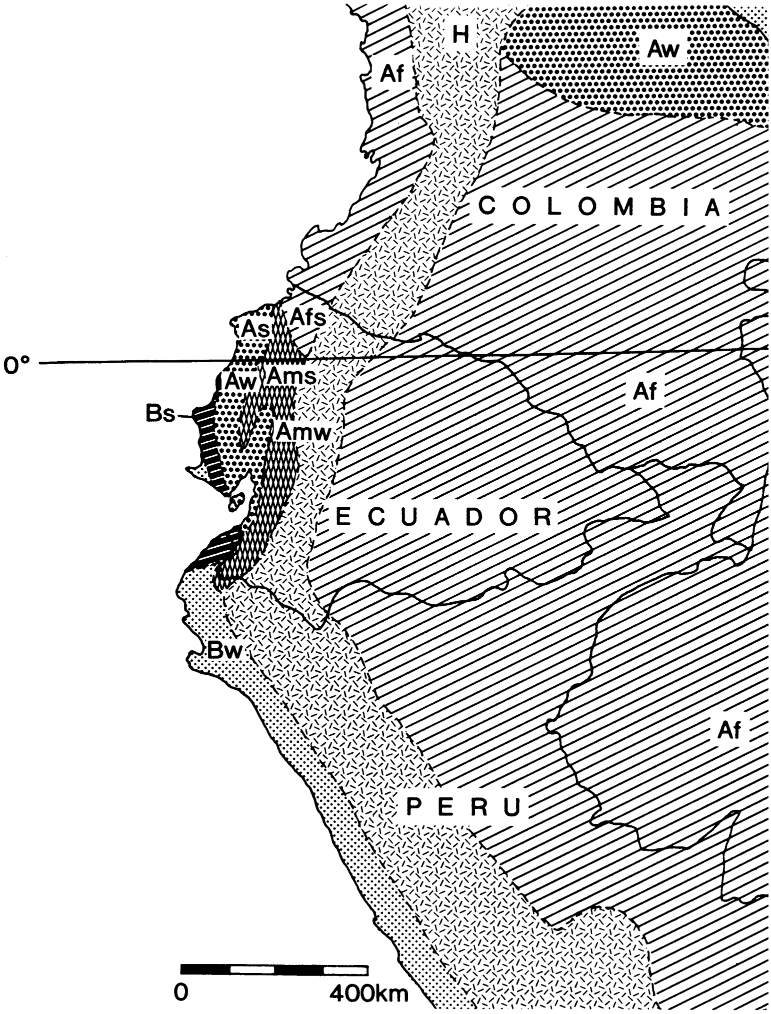

Fig. 15.2 Northwestern South America showing the exceptional compression of distinct environmental zones in coastal Ecuador (after Ferdon 1950; Trewartha 1966:Fig. 1.4). *Af* tropical wet; *Afs* tropical wet with precipitation distributed seasonally; *As* tropical wet-and-dry; *Aw* tropical wet-and-dry with an emphatic dry season; *Ams* tropical wet with two yearly precipitation maxima; *Amw* tropical wet with a strong dry season; *Bs* semiarid; *Bw* arid or desert; *H* undifferentiated highlands. The Santa Elena Peninsula (narrowly defined) is classified today as *Bw*

zone include the environmentally diverse slopes of the Andes, a seasonally wet coastal plain dominated by the great Guayas river system, and the Pacific littoral, which today is semiarid in the south but characterized by seasonally dry and very wet tropical forest in the north.

This environmentally complex coastal region is 700 km long and has a maximum width of only 200 km. Adequate rainfall and good soils predominate in most of this environmental mosaic, but the agricultural potential of the Santa Elena Peninsula is limited by low precipitation.

The Santa Elena region (now the new Province of Santa Elena) is a tropical ecotone characterized by an important interface with the sea, resulting in a mosaic of microenvironments and impressive biological complexity. The Ecuadorian coast contrasts with that of neighboring Peru because the former is bathed by warm equatorial currents, while the cold Humboldt current dominates along the latter. Today, the shallow coastal waters of Ecuador are rich in pelagic fish, economic crustaceans, and mollusks, and this marine environment is only slightly less rich than that of Peru in terms of carbon, phytoplankton, and zooplankton. The marine resources of Ecuador, together with the range of species available in mangrove swamps,[2] estuarine habitats, salt marshes, and other coastal wetlands, were attractive to humans throughout the aboriginal period, not only for their abundance and diversity but also because high biomass was accessible throughout the year. Although coastal morphology and the localized contribution of nutrients from river systems cause irregularity in the distribution of marine resources, the same faunal species are available in differing proportions along the entire coast. In the past, the aquatic ecosystem of Santa Elena involved, at least temporally, both freshwater and marine components.

The Santa Elena Peninsula is sometimes called the "abnormal appendage" of Ecuador because of it relative aridity (Wolf 1975 [1892]:188). Today, the vegetation includes dry tropical forest, thorn scrub, savanna formations, and areas of anthropogenic desert (Lindao and Stothert 1994; Valverde et al. 1979), but throughout history the semiarid coast of Santa Elena supported village farmers, and in fact until the middle of the twentieth century the inhabitants of the region gardened seasonally, raised cattle, and fished. More recently, commercial fishing has devastated local marine resources, and the mangroves, seasonally inundated estuaries and wetlands of the western Peninsula have disappeared due to human interventions.

All known Las Vegas archaeological sites are located in the Santa Elena district where remains are easily identified in the denuded landscape (Fig. 15.3). It seems likely that Early Holocene hunters and gatherers also exploited the moister valleys north of the peninsula and the extensive lowlands of the Guayas Basin – but their habitation sites are unknown today.

Late Pleistocene Environmental Conditions

Any discussion of the Las Vegas adaptation depends upon an understanding of paleoenvironments and the effects of change on terrestrial and marine resources.

Only tiny fragments of chert artifacts and shells were recovered from pre-Las Vegas archaeological deposits dating to the Terminal Pleistocene, and the contemporaneity of megafauna and human beings has not been supported by evidence in coastal Ecuador (Stothert 1983). The discovery of a few stone projectile points with no archaeological context is scant evidence that the Santa Elena Peninsula was occupied by Paleoindian hunters.

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[2] Mangroves are extremely productive biotic zones characterized by economically useful plants, and inhabited by myriad vertebrate and invertebrate creatures. The mangrove is a critical breeding ground for hundreds of marine and wetland species.

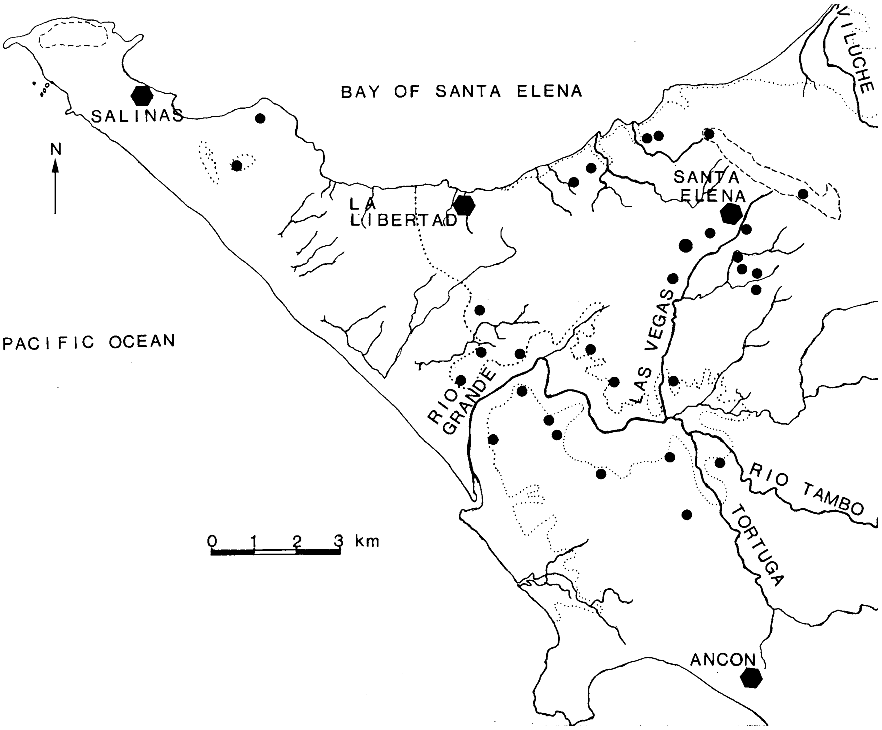

Fig. 15.3 The western portion of the Santa Elena Peninsula showing the distribution of Las Vegas preceramic sites, the modern drainage pattern, the modern 10-m contour (*dotted line*), modern towns (*hexagons*), Las Vegas Site 80 (*large dot* near the town of Santa Elena), and 30 other Las Vegas camp sites (*small dots*)

Late Pleistocene paleontological finds are, however, abundant on the Santa Elena Peninsula: the remains recovered include mastodons, horse, camelids, giant ground sloths, saber-toothed tigers, deer, and smaller mammals, reptiles, and birds (Edmund 1965; Hoffstetter 1952). The environment was characterized by open grasslands with gallery vegetation along the river courses, and rainfall apparently maintained a high water table, standing pools of water, and vegetation along the drainage courses, but it was insufficient to support forests between the rivers (Lemon and Churcher 1961).

In general, the Late Pleistocene in tropical America was characterized by dry, cool climates and vegetation and faunal communities that differed substantially from those seen today (Piperno and Pearsall 1998, Chap. 2). The first human inhabitants of the neotropics would have adapted to seasonally dry tropical forests, savannas, and thorn scrub formations, which were very widespread in Central America and South America (Fig. 15.4), and to fluctuating environmental conditions and changing resource availability. These seasonally dry environments have drawn considerable attention recently because they are the regions where we find (1) the wild ancestors of many plants that eventually were domesticated in America and (2) archaeological evidence that Early Holocene peoples were cultivating and modifying the genetic makeup of these plants (Piperno 2006a; Piperno and Pearsall 1998).

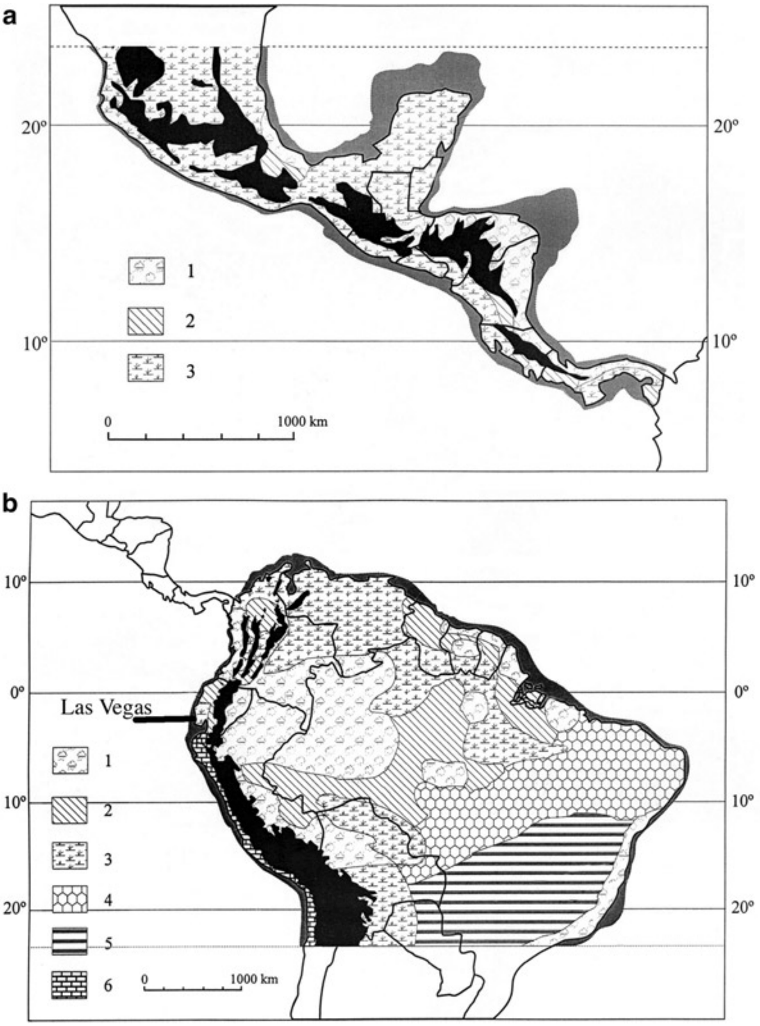

Fig. 15.4 Reconstructed vegetation of lowland tropical Central America (**a**) and South America (**b**) between 20,000 and circa 10,500 RCYBP (Piperno 2006a:Fig. 7.4; Piperno and Pearsall 1998). (1) Moist forest; (2) dry forest; (3) thorn woodland, low scrub, savanna vegetation; (4) dry and open, few trees; (5) open forest and semievergreen forest; (6) desert/cactus scrub. The Santa Elena Peninsula may have had terrestrial vegetation classified as (3)

The Early Holocene Paleoenvironment

Because there is no paleoecological evidence from the Santa Elena Peninsula that would permit a fine-grained environmental reconstruction, our understanding of conditions in the Early Holocene is based on evidence from archaeological sites and on models derived from proxy data. Evidence indicates that Amerindians in the neotropics at the very beginning of the Holocene manipulated terrestrial environments by burning, clearing native vegetation, and tending plants (Athens and Ward 1999; Piperno and Pearsall 1998; Stahl 1996:113–114).

In Santa Elena, people developed a very broad spectrum foraging strategy focused on plants and animals of both the terrestrial and mangrove/marine environments. During the Early Las Vegas period, they would have been challenged by "gradual and oscillating climatic amelioration" after which there were "greater seasonal extremes in temperature and moisture" that resulted in substantial changes in the communities of plants and animals: "[I]n this scenario, local richness and evenness of any biota would be in a state of constant spatial and temporal flux as each component acted and reacted according to its own ecological needs depending upon changing circumstances" (Stahl 1996:110). It is not known if the ENSO (El Niño/Southern Oscillation) phenomenon contributed to the instability of conditions in the Early Holocene. The Las Vegas midden deposits are too compressed to allow the documentation of climate processes and minor oscillations, but it is widely believed that these processes created long- and short-term environmental variations throughout the Early and Middle Holocene (Piperno and Pearsall 1998:90–107).

It is argued here that these conditions favored, on the one hand, the cultivation of certain wild (and later domesticated) plants and, on the other, the continued harvesting of the reliable, and dense biomass of the coastal marine and freshwater ecosystems. The following three discussions summarize our current understanding of past environments based on archaeological remains from the Las Vegas type site (Stothert et al. 2003:25–33):

1. Evidence from archaeological midden indicates that the same aquatic resources present today were also available to the Las Vegas people (Table 15.1). Apparently, the changes in Early and Middle Holocene ocean currents and water temperatures in the Pacific, which dramatically altered the distribution of marine faunal species further south in Peru, did not affect the marine biotope of Santa Elena.

   Worldwide changes in sea level, which determine the shape of coastlines and the distribution and extent of littoral resources, are probably the factors that most drastically transfigured the peninsula. Research shows that marine transgression from the end of the Pleistocene until about 4,000 years ago was marked by reversals and changes in tempo, so the Las Vegas people were confronted with dynamic conditions along the littoral. Regrettably, the relationship between the sea and the land at particular geographical locations at various dates in the past cannot be reconstructed with surety.

   Nevertheless, Fig. 15.5 represents an attempt to model the ancient Santa Elena coastline using information about change in sea level (Bird 1993; Fairbridge 1960, 1961, 1962) and bathymetric soundings from the modern sea floor off the peninsula (INOCAR 1980 [1989]). This modeling assumes that only sea level was changing, ignoring for the moment both tectonic uplift and other kinds of geomorphological change.

   If mean sea level about 10,000 years ago was depressed 30 m below its modern level, then an additional 600 km^2 of land might have been exposed, and

Table 15.1 Composite list of animal species identified in both Early and Late Las Vegas faunal assemblages excavated from Site 80[a]

Family or species	Common name, Spanish	Common name, English	Habitat
Fish			
Carcharhinidae	Tiburón	Sharks	Off and in shore
Mustelus sp.	Tollo, cazón de leche	Requiem shark	–
Dasyatidae	Raya	Stingrays	In shore
Ariidae	Bagre	Sea catfish	Estuaries & in shore
Bagre sp.	Bagre	Sea catfish	Estuaries & in shore
Centropomus sp.	Robalo	Snook, robalo	Off shore
Serranidae	Guato, cherna	Sea basses, groupers	Estuaries & in shore
Batrachoides sp.	Bruja	Toadfish	Rocks
Scombridae	Atún, bonito, sierra	Tunas,mackerels	Off and in shore
Caranx sp.	Jurel, caballa	Jack, yellow caranx	Estuaries & in shore
Chaetodipterus sp.	Leonora, chavela	Spadefish	Rocks
Mugil sp.	Liza	Mullet	Estuaries & in shore
Trachinotus sp.	Pámpano	Pompano	Beach
Lutjanus sp.	Pargo	Snapper	Estuaries & in shore
Diapterus sp.	Mojarra, palometa	Mojarra	Beach
Orthopristis sp.	Teniente, presidente	Grunt, pigfish	–
Isacia sp.	–	Grunt	–
Micropogonias sp.	Corvina, roncador	Croaker	In shore
Odontoscion sp.	–	Drum, croaker	–
Scianidae	Corvina, chogorro	Drum, croaker	Estuaries & in shore
Conodon sp.	Limona	Drum, Barret grunt	Beach
Paralonchurus sp.	Rayado, ratón	Drum, croaker	Beach
Sciaena sp.	Corvina, roncador	Drum	–
Sphaeroides sp.	Tamborín, tambulero	Swellfish, puffer	Beach
Cynoscion sp.	Corvina	Weakfish	In shore
Amphibians			
Ranidae	Rana	Frog	Cosmopolitan
Bufonidae	Sapo	Toad	Cosmopolitan
Anuran	Rana, sapo	Toads, frogs	Cosmopolitan

Reptiles			
Cheloniidae	Tortuga	Sea turtles	Sea
Emydidae	Tortuga	Box & water turtles	–
Dicrodon sp.	Lagarto	Lizard	Thorn-scrub
Boa sp.	Boa	Boa constrictor	Cosmopolitan
Drymarchon sp.	Culebra	Indigo snake	Cosmopolitan
Birds			
Psittacidae	Loro	Parrots	Cosmopolitan
Mammals			
Didelphus sp.	Zarigueya/zorro	Opossum	Cosmopolitan
Sylvilagus sp.	Conejo	Rabbit	Cosmopolitan
Mustela sp.	Chucuri	Weasel	Cosmopolitan
Dusicyon sp. (now *Lycalopex* sp.)	Lobo de selva, zorro	Desert fox	Cosmopolitan
Mazama sp.	Chivicabra, mazama	Brocket deer	Cosmop/mangrove
Odocoileus virginianus	Venado	White-tailed deer	Cosmopolitan
Tayassu sp.	Saíno, javelina	Peccary	Cosmop/thorn scrub
Cricetinae	Ratas, ratón de campo	Rats and mice	
Sigmond sp.	Rata (–)	Cotton rat	–
Proechimys sp.	Rata (–)	Spiny rat	–
Other rodents	Roedores	Rodents	–
Tamandua t.	Oso mielero, tamandua	Anteater	Forested & shrubland habitats
Sciuriade	Ardilla	Squirrel	Cosmopolitan
Canidae	Perro, lobo	Dog/wolf	Cosmopolitan
Felis sp.	Tigrillo (–)	Cat	–
Marine mammal	Mamífero marino	Marine mammal	Sea/beach
Crustaceans			
Decapods	Cangrejo	crab	Rocks & mangroves

(continued)

Table 15.1 (continued)

Family or species	Common name, Spanish	Common name, English	Habitat
Mollusks			
Anadara tuberculosa	Concha prieta	Black arc	Abundant in mangrove
Anadara grandis	Pata de burro	Mangrove cockle	Sand banks/low tide line
Astraea buschii	Colón	–	Rocks in tidal zone
Cerithidea pulchra	Churo, jeringaolorra	–	Mangrove/high tide line
Chione subimbricata	Concha	Clam	Bays & swamps
Chiton plates		Chiton	Rocks
Fissurella sp.	Conchalagua	Keyhole limpet	Rocks in tidal zone
Hexaplex regius	Churo zambo	Royal murex	Tidal zone
Lyropecten subnodosus	Concha de abanico	Scallop	Shallow and deep waters
Argopecten circularis	Almeja pinganilla	Speckled or calico scallop	Shallow and deep waters
Malea ringens	Churo	Grinning tun	Sand banks & rocks in tidal zone
Melongena patula	Caracol	Pacific crown conch	
Modiolus capax	Mejillón	Capax horse mussel	Shallow and deep waters
Natica sp[b]	Caracol	Moon snail	–
Ostrea columbiensis	Ostion	Oyster	Deep waters
Pinna rugosa (or *Atrina maura*)	–	Pen shell (clam)	Abundant in mangrove Sand banks & bays
Pinctada mazatlanica	Concha de perla	Pearl oyster	Shallow waters
Pteria sterna	Concha de perla	pearl oyster	Shallow waters and tidal zone
Pitar catharius	Concha	Clam	
Protothaca ecuatoriana	Concha	Clam	Deep sea
Tagelus dombeii	Michulla	Razor clam	Intertidal
Thais kiosquiformes	Churo	Mangrove snail, dog winkle	Intertidal, mangrove
			Intertidal, mangrove
Trachycardium sp.	Concha		
Turbo saxosus	Guerere soñador	Cockle	Shallow & deep waters
Strophocheilus sp.	Caracol de monte	Stone turban	Rocks in tidal zone
		Tree snail	Trees and bushes

[a] Data from Byrd 1976, Chase 1988, Stothert 1988, Wing 1988; see also Cobo and Massey 1969, Patzelt 1978, Keen 1971

[b] Identification now rejected: identified as freshwater snails, *Pomacea* sp

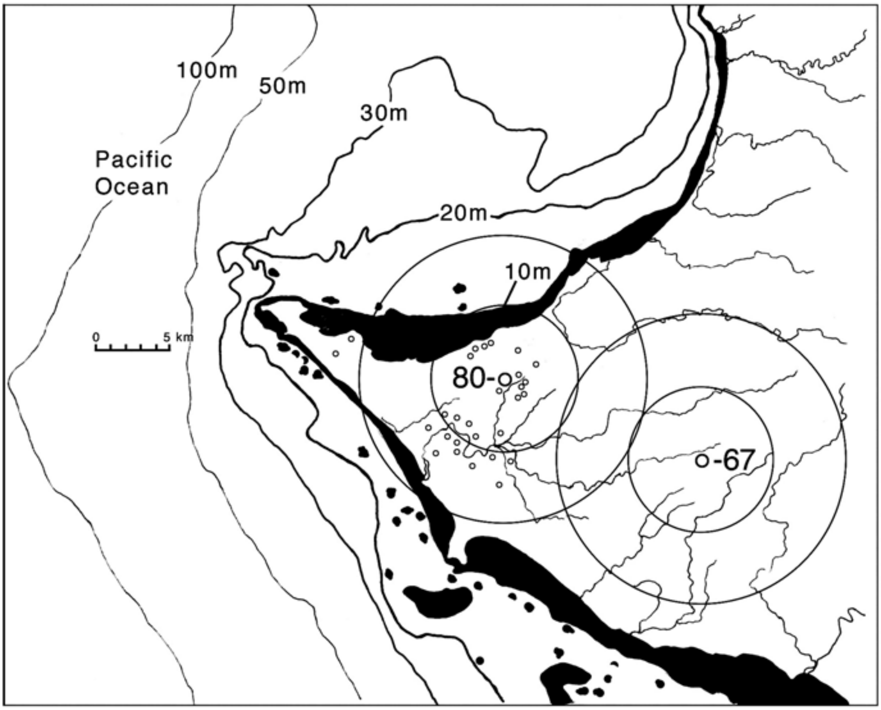

Fig. 15.5 The changing coastline of the Santa Elena Peninsula is inferred from bathymetric readings of the modern sea floor. When sea level was depressed 30 m, the paleocoastline may have approximated the 30 m isobath, and the continental shelf between that contour and the present coast may have been dry land. The area between the 10 m isobath and the present shore is marked in *black* and models the coastline at 7,000 RCYBP. Small Las Vegas camps are indicated by *small circles*, and two large camps/cemeteries, Sites 80 and 67, are shown with their respective 10 and 20 km catchment areas

the peninsula would have had a totally different coastline from what we see today (Stothert et al. 2003:Table 2). Of course, I am unsure that the coastline drawn in Fig. 15.5 is anything like the ancient one, since the topography of both the sea and the land has been continuously subject to constructive and destructive forces, including erosion, infilling, persistent tectonic uplift, and catastrophic geological distortion due to earthquakes.[3]

Changes in historical sea level would have seriously affected the distribution of resources along the Santa Elena littoral, as would have tectonic movements (which today continue to change the relationship between the land and the sea in

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[3] Speculative reconstructions of the geological history have suggested that the Early Holocene Rio Grande formerly (date unspecified) debouched near Salinas (Fig. 15.3), possibly creating continuous mangrove formations between its present mouth and Salinas (Ferdon 1981; Sheppard 1932, 1937; Stothert 1988:Fig. 13.1).

northwestern South America). In the earliest Holocene, the Las Vegas type site (Site 80) might have been located as much as 13 km from the beach, and depending upon local topography, the exposed areas of continental shelf might have been characterized by estuaries, vast wetlands, lagoons, and/or mangrove swamps.

By 8,000 RCYBP, the oscillating sea level might have approached the 20 m isobath, in which case Site 80 could have been about 12 km from the north shore of the peninsula, and the people may have enjoyed some 360 km^2 of land, and perhaps estuaries and mangrove formations, which are today submerged on the continental shelf. By 7,000 years ago, the journey from Site 80 to the beach may have been only 5.5 km, and the extent of the mangroves might have been reduced again, although compared to today, about 63 km^2 of additional continental shelf might have been exposed. Depending upon local topography, the exposed areas could have been characterized by wetlands, lagoons, and mangrove swamps crossed by rivers (like the Rio Grande) in various stages of development.

During the Early Las Vegas phase, short-term oscillations in sea level of relatively great amplitude might have taxed the Las Vegas people by destroying traditional resources, but at the same time other resources were created, presenting an opportunity to adopt new subsistence strategies. Later in the Holocene (between 7,000 and 3,000 RCYBP), these fluctuations were less severe.

The most important implication of this modeling of environmental conditions in the Early Holocene littoral of Ecuador is that as the sea level rose and fluctuated, the people of Santa Elena would have witnessed the repeated creation and destruction of mangrove swamps, as well as the alteration of river courses, water tables, salt marshes and other wetlands, lagoons, and estuaries (Bird 1993; Oyuela-Caycedo and Rodriguez Ramírez 1995).

A deep sea core from off the coast of Ecuador, which reflects conditions on the continent, provides evidence that mangrove formations reached their maximum development between 12,000 and 7,000 years ago (Heusser and Shackleton 1994:223). In fact, mangrove clams (*Anadara tuberculosa*) dominated the molluscan assemblages of the Early Las Vegas Period but were less well represented in Late Las Vegas assemblages after 8,000 RCYBP (Stothert et al. 2003:Table 4). These numbers may track a long-term decline in the extent of mangrove formations on the peninsula, or some sociocultural change.

Even without specifying precisely when and where physiographic changes took place, it is clear that plant and animal communities living along beaches, rocky points, and in bays, mangroves, and estuaries would have been affected by both sea-level fluctuations and by the tectonic uplift that has characterized this coast. In the terrestrial zone, changes in water table, in river gradients, and sedimentation rates can be inferred. The long-term settlement of some sites in western Santa Elena may reflect the formation and persistence of productive embayments, estuaries, and mangroves during the period of dramatic marine emergence (Bird 1993:15). Cultural changes in the archaeological record of the Late Las Vegas and Early Valdivia periods may reflect human responses to the instability of highly productive estuarine resources, particularly mangrove swamps (for similar argument, see Oyuela-Cacedo and Rodriguez 1995).

2. Second, I argue that the vertebrate faunal remains recovered from Las Vega sites on the Santa Elena Peninsula support the idea that conditions on the land were always subhumid (Table 15.1). The problem with the highly compressed archaeological midden (Fig. 15.6) is that we are currently unable to generate evidence that might suggest seasonal or other short- or long-term fluctuations in local environmental conditions.

   Assemblages of terrestrial vertebrate animals that accumulated for over 3,000 years in Las Vegas midden deposits show only species that are found today in the subhumid and arid environments of southwestern Ecuador. Reanalysis of the Las Vegas fauna, now in progress, may reveal that wetlands (coastal marshes and freshwater ponds) were more important for Vegas foragers than previously thought.[4]

   Despite a potential for radical environmental change (caused by shifts in global climate or Pacific currents), species characteristic of moist tropical forests are missing from the Vegas fauna, and the marine resources of the past are similar to those of the present (although mangrove formations are locally extinct). We conclude that the Vegas people probably enjoyed somewhat moister conditions, but these may have fluctuated seasonally and cyclically.

Fig. 15.6 The north wall of Excavation K-9 in Site 80 shows the highly compressed Las Vegas midden with a low density of shells

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[4] Re-analysis of a sample of Las Vegas fauna by Markus Tellkamp has revealed a number of new bird species that indicate the presence of wetlands and mangrove formations (Stothert and Tellkamp 2006). Similarly, a new analysis of the Las Vegas molluscan assemblage reveals a significant number of apple snails (Pomacea) throughout the midden, but particularly in Early Las Vegas levels (Kathleen Clark, personal communication 2008): these snails are common in freshwater

The remains of fish and shellfish that accumulated in the Vegas midden indicate species that are still present today, although several types of mollusks that are only abundant in mangrove swamps are less frequent in the later Las Vegas assemblages.

3. Third, the occurrence of abundant grass and shrub phytoliths in the Vegas soil is evidence that the ancient environment was seasonally dry. In Vegas times, the western part of the peninsula probably was characterized by seasonally dry tropical forest, perhaps mixed with thorn scrub and wooded savanna (Piperno and Pearsall 1998: Chaps. 2 and 4, Fig. 4.1a, b). Of course, the grasses represented may have dominated only the disturbed areas immediately around the habitation sites.

   Phytoliths and starch grains from domesticated plants constitute evidence that the Las Vegas people began to manipulate economically important species between 9,000 and 10,000 RCYBP, and they support the inference of seasonal rains that enabled gardening in alluvial soils, while the absence of phytoliths from palm trees (*Heliconia*) and bamboo (*Bambusa* sp.) indicates that these useful tropical plants were not present in the immediate environment because of inadequate rainfall and/or a prolonged dry season. Furthermore, pollen and charcoal recovered in the midden at Site 80 do not contradict the hypothesis that dry tropical forest and savanna characterized the western peninsula.

Las Vegas Site 80, Midden and Material Culture

Although 32 Las Vegas sites are known on the Santa Elena Peninsula (Figs. 15.3 and 15.5), the reconstruction of this preceramic adaptation is based principally upon evidence from the Las Vegas type site, Site 80 (CT M5 A3-80; formerly OGSE-80; located 2°13′S, 80°52′W), which is characterized by deep midden that accumulated for almost 4,000 years (Stothert 1985, 1988, 1992; Stothert et al. 2003). Today, the site is located about 3 km from the Bay of Santa Elena.

The chronological framework for interpreting Las Vegas evidence is supported by 28 acceptable radiocarbon dates, mostly from Site 80 (Table 15.2). These inspire confidence because they form a coherent series, agree well with independent stratigraphic interpretations in Site 80, and the assays were made at different laboratories using shell, charcoal, human bone, and by directly dating microfossil samples using AMS techniques.

Three radiocarbon dates associated with sparse cultural materials in the deepest levels of Site 80 are the only evidence of a pre-Las Vegas occupation between 10,800 and 10,000 RCYBP (Stothert 1988:618–619).

The subsequent Las Vegas occupation lasted from about 10,000 to 6,600 RCYBP. In the deepest portion of the midden at Site 80, a discontinuous shell layer observed in the profile at about 100 cm below datum was chosen as a stratigraphic marker: this

Table 15.2 Thirty-two radiocarbon dates and calibrated ranges from Las Vegas cultural contexts (Stothert et al. 2003:26, Table 1)

	Site number	Measured radiocarbon age BP	Material assayed	Conventional radiocarbon age (RCYBP)	95% Probability dendrocalibrated age range in calendar years BP (2-sigma)[a]
Rejected dates	80	15,850 ± 400	C	15,850 ± 400	20,160–17,750
	80	12,130 ± 70	P[b]	12,130 ± 70	circa cal 15,260–13,830
Pre-Las Vegas	80	10,840 ± 410	C	10,840 ± 410	circa cal 13,820–11,350
	80	10,300 ± 240	C	10,300 ± 240	12,950–11,210
	80	10,100 ± 130	S	10,510 ± 130	circa cal 12,310–10,850
Early Las Vegas	80	9,800 ± 100	S	10,210 ± 100	circa cal 11,620–10,640
	80	9,740 ± 60	P[b]	9,740 ± 60	circa cal 11,220–10,890
	80	9,550 ± 120	S	9,960 ± 120	circa cal 11,310–10,300
	201	9,460 ± 100	S	9,870 ± 100	circa cal 11,150–10,290
	80	9,080 ± 60	P[b]	9,080 ± 60	circa cal 10,370–10,170
	80	8,920 ± 120 [9330 ± 120]	S	9,330 ± 120	circa cal 10,540–9,560
	80	8,810 ± 395	C	8,810 ± 400	circa cal 11,090–8,990
	80	8,600 ± 200	S	9,010 ± 200	10,290–8,980
	78	8,600 ± 100	S	9,010 ± 100	circa cal 9,930–9,080
	80	8,250 ± 120	HB	8,350 ± 120	9,540–9,020
	80	8,170 ± 70	S	8,580 ± 70	circa cal 9,410–8,890
	38B	8,100 ± 130	S	8,510 ± 130	circa cal 9,590–8,770

(continued)

Table 15.2 (continued)

	Site number	Measured radiocarbon age BP	Material assayed	Conventional radiocarbon age (RCYBP)	95% Probability dendrocalibrated age range in calendar years BP (2-sigma)[a]
Late Las Vegas	80	7,960 ± 60	P[b]	7,960 ± 60	9,010–8,610
	67	7,480 ± 70	S	7,890 ± 70	8,460–8,180
	66	7,390 ± 60	S	7,800 ± 70	8,380–8,120
	202	7,780 ± 90	S	8,190 ± 90	8,940–8,430
	80	7,710 ± 240	HB	7,810 ± 240	9,290–8,160
	80	7,600 ± 100	S	8,010 ± 100	8,700–8,290
	80	7,440 ± 100	S	7,850 ± 100	8,500–8,110
	38A	7,250 ± 150	S	7,660 ± 150	8,400–7,810
	80	7,170 ± 60	P[b]	7,170 ± 60	8,110–7,860
	80	7,150 ± 70	S	7,560 ± 70	8,160–7,870
	203	6,900 ± 80	S	7,310 ± 80	7,930–7,610
	80	6,750 ± 150	HB	6,850 ± 150	7,960–7,440
	80	6,600 ± 150	HB	6,700 ± 150	7,820–7,310
Post-Las Vegas	213	5,830 ± 80	S	6,240 ± 80	6,860–6,490
	80	5,780 ± 60	P[b]	5,780 ± 60	6,710–6,430

Dated material includes phytoliths (P), shell (S), human bone (HB), and charcoal (C). Beta Analytic provided the Beta/Pretoria calibrations (Stuiver and van der Plicht 1998; Stuiver et al. 1998; Talma and Vogel 1993)

[a] In the case of each date that has multiple ranges, caused by the highly variable correlation between radiocarbon years and calendar years, the set of ranges has been collapsed into a single range [circa Cal xxxx–yyyy] for purposes of this discussion

[b] AMS date

has been used to divide the preceramic occupation into an Early Las Vegas phase (10,000–8,000 RCYBP) and a Late Las Vegas phase (8,000–6,600 RCYBP).

The Las Vegas lithic tool assemblage (Stothert 1988) features flakes struck expediently from technologically simple cores of locally available chert, and a series of shapely quartzite cobbles that functioned as hammerstones, as well as diverse, minimally modified cobble tools, edge-ground cobble tools, large quartzite flake tools, an array of naturally flat stones, one apparent grinding stone with neatly shaped edges, and a single polished stone axe deposited in a burial. A very few shaped bone objects were recovered (1988:94–96), and the only shell artifacts were carefully finished scoops or dishes made from portions of grinning tun shells (*Malea ringens*), assorted small ornaments of mother-of-pearl, and perforated conch shells that might have been hafted as picks or digging tools (1988:96–98). Red and yellow ocher as well as white chalk and black wood charcoal bits are abundant in excavated midden, and red ocher was preserved on the interiors of shell dishes, on human bones in burials, and on the surfaces of cobble tools that might have served as pestles.

The Las Vegas material culture seems poor because most artifacts were likely made of perishable materials available in dry tropical forests. No textiles, baskets, or other containers manufactured from wood, skin, or bark were recovered from the midden. Archaeologists working in drier environments in coastal Peru have documented a wide variety of perishable objects from contemporary sites, and an array of artifacts manufactured from organic materials are known from excavations in the waterlogged Windover necropolis in Florida, dated between 8,000 and 7,000 RCYBP (Doran 2002). By 7,000 RCYBP, other hunting and gathering inhabitants of Florida used technically sophisticated log canoes, some of which have been recovered from aquatic sediments (Wheeler et al. 2003).

It seems likely that cotton was domesticated in the Las Vegas period in the region around the Gulf of Guayaquil where the wild ancestor is endemic. Macrobotanical evidence of cotton occurs in dry coastal Peru before 7,000 RCYBP, and in coastal Ecuador by 5,500 RCYBP in Valdivia contexts, although the domesticated status of those seeds and fibers has not been verified (Damp and Pearsall 1994; Pearsall 2003:224–225; Piperno and Pearsall 1998:147–152). It seems likely that the Vegas adaptation to the sea was facilitated by spinning cotton fiber for the manufacture of fishing gear. Bottle gourds, an early cultivated plant at Site 80, have been used as net floats in the Americas for thousands of years and also might have been used by Vegas fishermen.

Settlement Strategy and Economic Activities

Vegas people may have resided at Site 80 either continuously or reoccupied it repeatedly from the terminal Pleistocene until about 6,600 RCYBP. Small sites, consisting of shallow deposits of midden dated to both the Early and Late Las Vegas periods, suggest that the preceramic people also occupied short-term campsites near the western tip of the peninsula (Figs. 15.3 and 15.5) while they exploited marine and land resources (Stothert 1988:225–236). This kind of settlement hierarchy is consistent with a logistical strategy involving reduced mobility (perhaps a degree of sedentism at Site 80) and temporal use of smaller camps. If the Vegas people ever created large shell mounds, those sites are now lost on the submerged continental shelf.

Recently a second Vegas base camp, Site 67/66, has been identified 15 km east of Site 80 (Fig. 15.5). Most of the midden accumulated at the beginning of the Late Last Vegas phase (two radiocarbon dates fall around 7,800 RCYBP) and the burials in the midden are very similar to those of Site 80 (see below). The seasonality of occupation at Sites 67 and Site 80 has not been determined. Although Site 67 is located today more than 15 km from any coast, its residents consumed fish and mangrove clams, in addition to deer and cultivated plants.

It is not known if the people who inhabited Site 67/66 were the same as those who lived at Site 80, or if two distinct (but related) groups existed. The marine and mangrove resources consumed at Site 67 might have been received from neighbors living at Site 80 or acquired independently by walking 15 km north or south from Site 67. One wonders if similar Late Las Vegas base camps were located at 15 km intervals all along the coastlines of southwest Ecuador, giving small groups access to littoral resources, open habitats, patches of seasonally moist alluvia for gardening, and forest for hunting and collecting. The complex mosaic of microenvironments would foster such an adaptation.

The two known large Vegas base camps are characterized by deep midden, hearths, and pits, and evidence that people performed some storage activities, although it is not known whether these features contained wild or cultivated foods. At Site 80, an apparent wall trench, only 2 m in diameter, is evidence of a small circular shelter, similar to the earliest houses of the subsequent Valdivia culture. Since a mature woman was buried under the threshold of the Vegas structure, it might also be interpreted as a mortuary structure.

The study of 200 human skeletons recovered from Late Las Vegas graves in Site 80 has resulted in an important conclusion: Late Las Vegas people maintained very good health (Ubelaker 1980; Ubelaker and Newson 2002). While they consumed some cultivated plants, Vegas people did not suffer the deleterious effects, such as tooth decay and anemia, which afflict food producers who depend on starchy foods. Also, Site 80 is one of the largest early cemeteries in the New World, and the mortuary ceremonialism reconstructed from the complex burial pattern has been interpreted as evidence for developing social complexity. Data are inadequate to address the question of population growth, but it seems likely that the thriving community of Late Las Vegas people was the result of demographic increase over the previous 2,000 years.

The burials at site 80 are focused around the top of a low hill where deep midden had accumulated. The graves and their contents suggest a complex funerary program involving the repeated burial and reburial of bones, a process accompanied by a series of ritual acts, such as the application of red ocher to the bones, the offering of symbolic objects, and probably the consumption of food and drink. Ceremonies may have functioned to propitiate ancestors and to provide opportunities for the creation of social networks and the construction of patterns of dependence and leadership.

Faunal Remains from Site 80 are now being restudied, but earlier investigators identified 25 taxa of marine fish, 4 amphibians, 5 reptiles, 1 bird, 16 mammals (mostly terrestrial), 1 crustacean, and 15 mollusks (Table 15.1). As Vegas collectors moved short distances through local terrestrial and aquatic environments, they would have found diverse plant and animal communities. Capture techniques may be modeled, but no specialized equipment has been recovered from Vegas sites.

Our study of faunal remains suggests that the Las Vegas people, living in an ecotone with little seasonal variation in the availability of marine resources, exploited a wide variety of species and enjoyed a constant supply of animal protein. Based on the analysis of small samples, we speculate that in the Late Las Vegas period people acquired half of their food from marine and estuarine environments, while the other half came from the terrestrial zone.

A comparison of the faunal assemblages from below and above the stratigraphic marker in Site 80 showed a subtle evolution of exploitation patterns from the Early to the Late Las Vegas Phase (Stothert 1985:620; 1988:193–195). The earlier people concentrated on land animals, principally deer, while the later people were slightly more involved in fishing. This is a basis for suggesting an intensification of fishing.

The small sample of marine vertebrate remains studied more than 25 years ago indicates that 35% of the fish taken are found commonly in waters close to shore and in estuaries; 25% were likely captured along beaches, 10% among rocks, 15% inshore, another 10% in both near and offshore waters, but only 5% were likely to have been sought in deep waters. This evidence is generalized and does not distinguish between the two Las Vegas phases. The percentages should not be taken to imply the intensity of prey taken from each microenvironment. Clearly, Vegas people fished mostly in near shore locations.

Returning to the molluscan sample, we see that about 22% of the species in the mollusk list were collected in the mangrove zone (including the mangrove fringes in the tidal zone), 43% in shallow water habitats, including within the tidal zone, on sand banks, among rocks in the tidal zone, and in shallow waters, 9% in the bay, on sandbanks and in swamps, but only 26% were sought in shallow and deep waters. This molluscan assemblage indicates the variety of habitats exploited by Vegas people, but it reflects neither the amount of food collected from each zone nor change through time.

Based on a calculation of the Minimum Number of Individuals represented in samples of molluscan remains from Site 80, it has been shown that in Early Las Vegas contexts, rock-living species made up only 0.8–1.5% of the MNI of the species counted (Stothert et al. 2003:Table 4), whereas these species made up 5.3–8.6% of the MNI in the late phase. Mangrove clam shells, which constituted 81–87% of the Early Las Vegas molluscan assemblages, declined to only 57–70% in the Late Las Vegas ones. The distance to rocky points may have decreased, with marine transgression, and the extent of the mangroves also may have decreased.

The reduction in mangroves may be reflected in the increased use of marine fish in the Late Las Vegas period and the decline in the number of both mangrove clams and bird species (Stothert and Tellkamp 2006; Tellkamp 2005). Other factors may have encouraged the increased emphasis on fish, such as improved technologies that made fishing more energetically efficient, a reduction in available biomass (protein) from terrestrial sources, or the desire to produce, for social purposes, surpluses of dried, salted, or smoked fish.

Evidence also suggests that animals from both aquatic and terrestrial environments were used as symbols in the ideological system of the Late Vegas people (Stothert 1988). Offerings of teeth of the "desert fox" (*Lycalopex* sp., formerly called *Dusicyon sechurae*) were associated with human burials at Site 80 (Wing 1988): these canids may have been evoked as psychopomps or messengers from the spirit world. Also, shells of the species *Anadara tuberculosa* were used to construct a bed for the burial of an infant, and large gastropods and a variety of bivalve species were found in a pit together with human bones in the center of the Las Vegas cemetery (Stothert 1988:150, and Fig. 6.22). Other mortuary offerings manufactured from shell include ornaments of nacreous shells, dish-like artifacts made from the grinning tun, *Malea ringens*, that served to protect the joints of the dead (Fig. 15.7), a container

Fig. 15.7 Feature 10 (Site 80) is a Late Las Vegas phase grave containing the skeleton of a woman (age 35–45 at death) buried with her head to the north and facing east. Her right shoulder joint is protected by a portion of worked shell (*Malea ringens*) in the form of a shallow dish. A similar artifact lies nearby, and a utilized cobble tool was also associated with the body

of the same shell with ground red ocher, two carefully perforated immature valves of *Malea ringens* that are functional whistles but might have been employed as containers for snuff or for lime used in rituals involving the consumption of some narcotic; a conch trumpet (*Melongena patula*), and possible digging tools fashioned from valves of *Melongena patula*. Shell is a useful raw material that accumulated great symbolic significance in later Precolumbian cultures: shell is a hard substance, often brilliant in color, associated with spirituality, immortality, water, life, and fertility. People's relationship to coastal resources was not purely economic.

Plant Remains

Today, the seasonally dry tropical forest and savannas formations of southwest Ecuador have a variety of useful and edible plants (Lindao and Stothert 1994; Valverde et al. 1979), many of which would have been available to Vegas people, but the poor preservation of plant macrofossils has frustrated the reconstruction of the vegetal aspects of Las Vegas subsistence.

Wild fruits and nuts would have been harvested from trees, a variety of annual plants would have satisfied a range of needs, and roots and tubers, which famously store starch for the dry season, would have attracted the attention of Vegas people. Foraging for wild resources, however, may not have been as energetically efficient as cultivation, especially as populations increased and mobility decreased. At many locations in the tropical forests and savannas of Central and South America, Early Holocene peoples began to cultivate plants and (intentionally or not) to domesticate them. Women especially would have been interested in reducing their mobility and increasing their per capita productivity (Surovell 2000).

In their comprehensive model of the origin of cultivation in the tropics, Piperno and Pearsall (1998, Chaps. 1, 2, and 4; see also Piperno 1989, 2006a, b) argue that broad-spectrum collecting developed as people found more energetically efficient adjustments to the changing resource patterns of the Late Pleistocene and early post-Pleistocene periods. In particular, because people operated in an ecosystem poor in starchy wild plants, they would have found it desirable to inject more calories into their diet. Contrary to popular belief, in tropical forested biomes plant cultivation is a more energetically efficient subsistence activity than wild-plant collecting. Evidence from several regions, including southwest Ecuador, supports the idea that plant cultivation was a low-cost subsistence strategy innovated in seasonally dry tropical forest areas. Not surprisingly, horticulture developed in Central and South America before 9,000 RCYBP, during a period when there was much more environmental instability than was experienced by people later in the Middle Holocene (Piperno 1994:638).

The study of plant microfossils at Site 80 shows a progressive development in the use of plants from Early to Late Vegas times (Piperno 2006a; Piperno and Pearsall 1998; Stothert et al. 2003). Early Vegas farmers cultivated bottle gourd (*Lagenaria siceraria*) as early as 9,000 RCYBP, and phytoliths from this species continued in later archaeological levels. Bottle gourds, which are always cultivated in America, may have been grown for their seeds, or because their fruits were used as net floats, containers, or rattles. Phytoliths from the seeds of *Calathea allouia*, a plant called lerén, which is today cultivated for its starchy root in northern South America, also appear in a 9,000 RCYBP context and become common in later levels. Edge-ground cobbles and small grinding stones may have been used to process this root food. Distinctive maize (*Zea mays*) microfossils appeared only in Late Las Vegas samples: a primitive maize variety was present in the latest midden level deposited at Site 80, but it was not a staple food (Piperno et al. 2001). Maize seeds, originally from West Mexico, were widespread among preceramic peoples in Central America and northwestern South America by 7,000 RCYBP. The cultivation and storage of maize and other seeds crops would have been favored in Santa Elena because of its long dry season. We suspect that Late Vegas people also cultivated beans, cotton, peanuts, and other tropical root crops because these are present in contemporary archaeological contexts in neighboring regions.

An analysis of the size of modern *Cucurbita* (squash) phytoliths has provided a way to distinguish domesticated forms from wild squashes, and furthermore, the size of ancient squash fruits and seeds can be estimated from archaeological phytoliths (Piperno et al. 2000; Piperno and Stothert 2003). Phytoliths ubiquitous in the Site 80 midden demonstrate that before 10,000 RCYBP only wild *Cucurbita* was present, but by 9,080 RCYBP squashes had fruits and seeds larger than those of any known wild species: the fruits likely were 12-cm long. These phytoliths closely conform to those of both semidomesticated *C. ecuadorensis* or to *C. moschata*, thought to have been domesticated in lowland, northwest South America. This is an evidence for an independent emergence of plant food production and domestication in lowland South America as early or earlier than anywhere in America. The microfossil sample dated to 7,170 RCYBP contained both maize phytoliths and an assemblage of squash phytoliths with a mean size that overlaps that of modern *C. moschata*: these fruits likely measured about 16 cm. Different species of squash with oil- and protein-rich seeds resulted from parallel domestication processes in lowland South America and Mexico in the Early Holocene.

Ongoing studies of diagnostic starch grains preserved on ancient stone tools and human teeth have provided additional evidence of the use of root corps and maize by Late Las Vegas people (Stothert et al. 2003).

The Las Vegas case demonstrates that as early as 9,000 RCYBP both seed plants (including squashes and bottle gourd) and a root crop (*lerén*) were cultivated in local gardens and supports the idea that food production was innovated at many locations and over wide regions in America, and not in just a few centers.

Marine Resources and Early Agriculture

In summary, the Early Holocene people of the Santa Elena Peninsula developed a pattern of broad-spectrum collecting, focused on both terrestrial and marine resources that fed them well and apparently buffered the local community against instability and fluctuations in the environment. Logistical collecting and relatively sedentary settlement may have been favored because of the economic benefits of exploiting both predictable terrestrial and marine/estuarine resources. During the long Early Holocene, the Las Vegas people became progressively more committed to feeding themselves with garden products while exploiting the rich aquatic resources of ancient Santa Elena. Their innovative farming and fishing strategies proved to be successful adjustments to a dynamic, complex tropical, coastal ecosystem. Late-phase Las Vegas people who practiced both intensified fishing and an evolved form of gardening, with more productive domesticated species, also undertook some social changes, including the development of elaborate communal burial activities. Their mixed strategy apparently gave rise to the adaptation of the subsequent Valdivia people in the ceramic period, and it continued to be the basis of life during the entire aboriginal period in what is now the coast of Ecuador.

It is an aphorism that "water is life," and ecologists know that aquatic environments are highly productive, which leads me to argue that the long-lived Vegas way of life was enabled by resources harvested from both major ecosystems that interface on the peninsula: aquatic resources (whose virtues cannot be praised too highly) enabled sedentary life and underwrote experiments in plant cultivation, while the development of small-scale farming meant that people could maintain their residence by the sea and enjoy a balanced diet.

Archaeological evidence from Vegas sites testifies to the importance of coastal resources in the successful Las Vegas cultural trajectory. It shows how a broad-spectrum foraging way of life was transformed as people developed two strong economic foci that enabled them to weather the fluctuations of the Early Holocene climate and environments: neither the aquatic nor the terrestrial ecosystem was likely to have been stable, but people constructed their subsistence practices to increase the efficiency of economic activities in both the terrestrial and aquatic environments. Over time, the natural and social environment changed, but Vegas people maintained stability in the sense that they continued to eat well and in their late phase undertook more costly cultural activities.

It seems likely that Vegas people had short-term optimization strategies that motored change: they sought to maximize the return on the labor by modifying their behavior in response to perceived conditions. Change may be viewed as an adjustment to environmental alterations or to population growth. It is likely that short-term changes in the climate and biogeography of the Santa Elena Peninsula were factors that shaped the Las Vegas adaptation, and long-term demographic growth may have been another selective pressure. In order to model change successfully paleoenvironmental studies of the peninsula are required, and only the discovery of more Early Las Vegas sites will generate information about demographic change.

By Late Las Vegas times, the people of Santa Elena enjoyed very good health, an evidence that they successfully exploited the resources of the coastal zone, and had responded well to the loss of mangroves and to the vagaries of climate that affected terrestrial resources (positively and negatively). Their strength lay in the continuous creation of adjusted fishing and farming patterns.

An intriguing issue in the study of the Las Vegas adaptation is modeling plant cultivation in the Early Holocene. The Vegas case contributes an important corpus of data to the study of the origin of horticulture in the neotropics and supports the notion that cultivation originated as foragers, familiar with a wide variety of species within their complex tropical ecotone, experimented with cultivation. Their early experiments with horticulture and domestication were enabled by their access to predictable aquatic resources whose natural fluctuations were in part independent of the changing patterns of rainfall, which affected the plant and animal communities of the terrestrial zone.

Las Vegas men and women could have chosen to reallocate their labor for a variety of reasons not directly related to the loss of mangrove or climate instability. Other incentives to change may have included the perception of increasing efficiency of fishing as technology developed for harvesting the large available inshore biomass. Local community growth may have stimulated social change and the desire to increase the production of food surpluses. Plants figure widely into human exchange activities, as do salted, dried, and smoked fish and shellfish. People invest labor to build alliances, engage in reciprocity, and undertake regional and extraregional exchange.

Late Las Vegas people, compared to their ancestors, consumed more fish, trapped fewer small animals, hunted large animals, and cultivated improved squash, root crops (like lerén and perhaps manioc), and eventually maize. Perhaps Late Vegas Period men hunted deer as before, but also parties of kinsmen developed ways of fishing together, improving the productivity of their lines and nets. Women may have gardened in the bottom land along the Las Vegas River, an activity viewed as more productive than foraging in the bush. If Las Vegas women were normally responsible for collecting plants and small animals, and if they were also the farmers, then their growing specialization in cultivation in the Late Las Vegas phase may explain the decrease in the utilization of small animals in that period (Bruhns and Stothert 1999).

Burial ceremonialism in the Late Las Vegas period indicates that people invested more time and effort in community social activities. One imagines that groups of families developed integrative mechanisms, including the mortuary rituals inferred from the Vegas graves, which might have helped them to share food on a regular or irregular basis, and perhaps to field larger work groups and defend the resources of their territory. Ceremonial gatherings imply both the consumption of special foods and the giving of food as gifts (Hastorf 1998). Growing food and producing quantities of fish to share is another way that people insure themselves against resource fluctuation. Food sharing is a strategy for minimizing risk (Piperno and Pearsall 1998; Rossen 1991). The intensification of both fishing and farming may have underwritten the development of ceremonial activities, alliance building, and reciprocal exchange. Spreading one's social net more widely is a strategy that accounts for the strong pattern of interconnectedness observable among ancient Amerindians.

The Late Las Vegas way of life can be seen as a preadaptation for the development of fully agricultural, village life in coastal Ecuador. By 5,000 years ago, peoples who cultivated a full range of useful domesticated plants were ubiquitous in the neotropics, but many living along the littoral continued to fish, as they do today in Santa Elena. By the end of the aboriginal period, dense populations with complex cultures inhabited the littoral of Ecuador: their way of life combined fishing, shellfish harvesting, seafaring and trading with agriculture, forest product extraction, mining, and craft production. Farming and fishing together make up a strategy well suited to regions where agriculture may be risky.

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Chapter 16
Initial Investigations into the Exploitation of Coastal Resources in North Africa During the Late Pleistocene at Grotte Des Contrebandiers, Morocco

Teresa E. Steele and Esteban Álvarez-Fernández

Introduction

While there has long been an interest in Holocene coastal adaptations globally (see other papers in this volume and Erlandson 2001), only more recently has attention focused on marine resource exploitation during the more ancient times of the Middle Paleolithic (MP) and Middle Stone Age (MSA) of Europe and Africa (~250,000–50,000 years ago). The ancestors of all living humans originated in Africa sometime at the beginning, during, or at the end of the MSA, and therefore, investigations into the full variation of human adaptations during this time provide critical data on how changing diets and environments are linked to modern human origins. McBrearty and Brooks (2000) include "shellfishing" starting at 140,000 years ago (140 kya) and "fishing" at 110 kya in their list of behavioral innovations of the MSA (their Fig. 13:530) and as part of a general increase in diet breadth (their Table 3:492) that is indicative of fully modern human behavior. The earliest evidence of shellfishing has since been revised to at least 164 kya (Marean et al. 2007). In addition, Parkington (2003; see also Crawford et al. 1999) has proposed that the nutrients provided by shellfish were integral to building effective modern human brains during the MSA and, therefore, to modern human origins. Others see the exploitation of marine resources as typical of coastal living, and that real indicators of changing behavior, evidenced by further increased diet breadth and increased human population densities, come only after the end of the MSA (Klein et al. 2004). Because studies into coastal adaptations allow us to investigate the relationship between subsistence, technology, human population size and density, and the environment, these studies are uniquely positioned to inform on modern

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human origins, and therefore, it is important that future studies focus on marine resource exploitation during these ancient times.

Late Pleistocene human coastal adaptations are best documented from the shores of South Africa. Analyses of similarly aged assemblages from elsewhere, including North Africa, will benefit by following the research framework established for these sites. The South African results also provide expectations that can be tested elsewhere to assess the robustness of these patterns and to investigate the full range of MSA and MP variation. Therefore, we begin by reviewing what has been learned about coastal adaptations during the South African MSA and the subsequent Later Stone Age (LSA; made by fully modern humans), and we compare these results to what is known about Neanderthal coastal adaptations from European Mediterranean environments during the MP. This establishes a framework for investigating the North African record for Late Pleistocene coastal adaptations. After reviewing the limited amount of information available for North Africa, we discuss some preliminary results from our initial analysis of the mollusks from the Grotte des Contrebandiers (Smuggler's Cave), Morocco. The deposits at the site span the Mousterian, Aterian, and Iberomaurusian. The Mousterian is thought to be equivalent to the Mousterian or MP of Europe, yet this North African version was made by early *H. sapiens* (anatomically modern humans), not Neanderthals (Hublin 1993; 2001). The Aterian is a unique variant of the MP that is most easily characterized by the presence of tanged pieces (stemmed pieces or pedunculates) and bifacially worked foliates, which spanned from the Atlantic coast of Morocco to just west of the Nile Valley (Camps 1974; Canton-Thompson 1946; Ferring 1975). Until recently, the absolute antiquity of the Aterian has been uncertain, but studies indicate that it existed in Morocco between 60 and 110 kya (Barton et al. 2009; see also Bouzouggar et al. 2007; Mercier et al. 2007); ongoing studies are working to refine the chronology. The Iberomaurusian is an Epipaleolithic industry (made by fully modern humans) characterized by high frequencies of nongeometric backed bladelets, which spanned from ~18 to 11 kya across northwestern Africa (Lubell 2001; Barton et al. 2005; Bouzouggar et al. 2008; Camps 1974; Olszewski et al. in review). Together, this sequence provides an opportunity to explore how marine resource use changed through time in this coastal setting.

Southern Africa

The coast of South Africa contains innumerable shell middens, the majority of which were accumulated by LSA hunter-gatherers and pastoralists during the Holocene. A few exceptional LSA sites date to the Terminal Pleistocene, and researchers have identified nine coastal shell middens that were accumulated by MSA people (for a complete listing of sites and their references, see Klein 2009:Table 6.12). The comparison of MSA to LSA samples has revealed a wealth of information about ancient human subsistence and paleoenvironments. The oldest evidence of regular mollusk exploitation derives from part of the MSA sequence at

Pinnacle Point and dates to approximately 164 kya (Marean et al. 2007). The remainder of the MSA samples accumulated sometime between ~140 and ~45 kya, although the chronology needs to be refined for many of them.

The South African MSA coastal samples derived from two distinct marine ecoregions, whose marine and terrestrial environments are heavily influenced by the local ocean currents (Spalding et al. 2007; Branch et al. 1981, 1994; Bustamante and Branch 1996). First is the Namaqua ecoregion on the west coast, which is part of the Benguela marine province. The ecology of this region is controlled by the Benguela current's cold water drifting northward along southern Africa's west coast. Offshore upwellings are produced when the earth's rotation and southeast winds moves the surface water offshore. The cold, upwelling water is rich in nutrients, fueling a very productive marine food chain. Although species diversity is lower than elsewhere in South Africa along these rocky shores, the biomass is significantly higher due to the abundance of nutrients (Bustamante and Branch 1996). Because the cold water provides little moisture to the adjacent land, the region has long, warm, dry summers and limited terrestrial resources. The second ecoregion is the Agulhas Bank along the south coast, which is part of the Agulhas marine province, named after the Agulhas current that flows along the South African coast from the northeast to the southwest, bringing warm Indian Ocean waters into this region. In the Agulhas region, the continental shelf widens, making the current swing away from the south coast, allowing the coastal waters to become slightly cooler and permitting near-shore countercurrents of cooler water. This allows for an area of mixing of Benguela taxa and of those from further northeast in the Natal ecoregion, where species diversity is high because the Agulhas current brings Indo-Pacific species into the area (Bustamante and Branch 1996). The land along the Agulhas current enjoys a higher rainfall than on the west coast and, therefore, has a richer terrestrial environment.

The largest and best-documented MSA samples come from Hoedjies Punt 3 (Parkington 2003) and Ysterfontein 1 (Avery et al. 2008) on the west coast and Blombos Cave (Henshilwood et al. 2001), Klasies River (Voigt 1982), and Pinnacle Point (Marean et al. 2007) on the south coast. Mussels (west: black mussels [*Choromytilus meridionalis*] and south: brown mussels [*Perna perna*]) typically dominate these MSA samples, and limpets provide most of the balance. On the west coast, these are granite (*Cymbula granatina*), granular (*Scutellastra granularis*), and Argenville's limpets (*S. argenvillei*). Granite and Argenville's limpets are also found on the south coast, along with goat's eye limpets (*C. oculus*). The opercula from alikreukel or turban shells (*Turbo sarmaticus*) are also common in south coast assemblages. These taxa overwhelmingly dominate MSA mollusk assemblages. By contrast, LSA middens contain a higher diversity of species, and many species are represented by higher proportions, and taxa such as dogwhelks (*Burnupena* and *Nucella*) and white mussels (*Donax serra*) are occasionally dominant (Parkington 2003; Avery et al. 2008; Buchanan et al. 1978). In addition, along the west coast, MSA assemblages contain relatively more granite and Argenville's limpets than granular limpets, even though the latter are more numerous and occur higher on today's rocky shores (Buchanan 1988; personal observation). If this were true in the past as well, then granite limpets would have been more visible and accessible to MSA foragers, and MSA people must have passed over granular limpets in favor of the larger granite and Argenville's limpets.

Beginning in the 1970s, researchers working in South Africa developed an interest in learning more about how within species variation in mollusk size could provide information about ancient human ecology (Klein 1979; Parkington 1976). It is now well documented that median limpet and turbo size is significantly larger in MSA samples than in LSA samples, and the pattern holds across a diversity of time periods and environments (Parkington 2003; Steele and Klein 2008; 2005/06). Limpets grow slowly and continuously and can be captured with little technology or risk, and in many instances humans tend to take the largest mollusks first (Bigalke 1973; Branch 1975; Hockey and Bosman 1986; Lasiak 1991, 1992). Under heavy predation, the consistent capture of the largest mollusks can drive down the median size of the mollusk population (Branch 1975; Hockey and Bosman 1986; Hockey et al. 1988; Mannino and Thomas 2001). Therefore, the pattern of the smaller limpet and turban size during the LSA is interpreted to indicate that the LSA people were more heavily harvesting these taxa than their MSA predecessors, likely because LSA people were living at higher population densities.

The large mammal component of these sites also provides an indicator of the utilization of coastal resources, most notably the abundant presence of Cape fur seals (*Arctocephalus pusillus*) in the MSA middens of Klasies River (Klein 1976), Blombos Cave (Henshilwood et al. 2001), and Ysterfontein 1 (Avery et al. 2008), a species that is still common along South African coasts today. Cut marks are found on a few of these bones, indicating that humans played a primary role in accumulating many of them. Occasionally, ancient people exploited dolphins and whales, presumably scavenging off of beached or washed up carcasses. Dolphin bones have been found in a number of MSA samples, and the presence of *Coronula* barnacles (such as in Diepkloof Rock Shelter, Pinnacle Point, and Ysterfontein 1), which specifically grow on whales, indicates the use of whale flesh. In addition to large mammals, marine birds, such as penguins (*Spheniscus demersus*), cormorants (*Phalacrocorax* sp.), and gannets (*Morus* sp.), are common in coastal MSA and LSA sites (Avery 1987, 1990). LSA sites contain more birds overall, and a higher proportion of them are flying birds, relative to penguins (Steele and Klein 2009). In addition to more marine birds, LSA middens also contain abundant large fish bones and some rock lobsters (*Jasus lalandii*), both of which are nearly absent in MSA middens. Overall, the marine component of MSA diets was much less diverse than in LSA diets (Parkington 2003; Klein et al. 2004; Steele and Klein 2008).

The presence and relative abundance of marine resources has been quite useful for reconstructing the environment surrounding an archaeological site, allowing researchers to consider the distance to the ocean, the configuration of a nearby shore, and ocean temperatures. Humans rarely transport large quantities of marine shellfish more than 10 km from the collection site, and typically they accumulate shell middens much closer to the sea (for example Buchanan 1988). Therefore, the presence of a shell midden indicates that the ocean was nearby while people were utilizing the site. By combining knowledge of these transport decisions, changes in sea levels during the Late Pleistocene glacial cycles, and offshore bathymetry, we can reconstruct the distance from the site to the ocean at different sea levels and, therefore, if the deposits likely accumulated during a glacial or interglacial. This information has also been used to constrain the age of the deposits, such as at Ysterfontein 1 (Avery et al. 2008) and Pinnacle Point (Marean et al. 2007). Along the south coast of South Africa, the decline in sea levels as the world entered in to the Last Glacial is documented by the decline of coastal species in the Klasies River sequence as the shore moved further and further from the site, and the Last Glacial Maximum is signaled at Nelson Bay Cave (on the south coast) by the presence of black mussel, a cold-water preferring species characteristic of the west coast (Klein 1972). Similar patterns with other taxa have been seen within the MSA mollusks at Klasies River (Voigt 1982) and Blombos Cave (Henshilwood et al. 2001). Throughout the Ysterfontein1 sequence, the ratio of limpets to black mussels varies, likely due to changes in the nature of the nearby rocky coastline and the distance from the site to the collecting area. LSA people tended to carry mussels further from the shore because mussels have higher flesh weight relative to shell weight. An increase in mussel abundance may signal either a receding coastline or a change in the geomorphogy of the local shoreline. In addition, white mussel abundance is highest at the base of the Ysterfontein sequence, suggesting the presence or increased exploitation of a nearby sandy beach. Even small sea-level changes could significantly affect the relative numbers of limpets and mussels locally (Jerardino 1997).

MSA shell middens in South Africa have provided the largest samples of marine resource exploitation during the Late Pleistocene. The work accomplished here provides guidelines to structure future research methods and questions in other regions of the world.

Southern Europe

Closer to the North African shores of interest, researchers have recognized since at least the 1920s that southern European coastal caves contain evidence of shellfish exploitation (Stiner 1994). However, at least the MP mollusk assemblages from these caves did not receive detailed systematic and taphonomic attention until Stiner's (1994) work at Moscerini Cave, found in Latium on the west coast of Italy. The base of the sequence contains abundant surf-polished or beach-worn shells and was likely part of the local beach during the high seas of MIS 5e. In the human accumulated samples, indicated as such by their close association with stone artifacts, rare surf polish, and frequent burning, the most abundant mollusks in the sequence are Mediterranean mussels (*Mytilus* sp.), which prefer rocky shores, and marine clams (*Callista* and *Glycymeris*), which reside in silt or sand. Topshells or turbins (*O. turbinatus*) and cockles (*Cerastoderma* and *Acanthocardia*) are present in low but consistent numbers, while limpets (*P. caerulea* and *P. ferruginea*) are quite rare. Quite interestingly, a few of the *Callista chione* specimens showed evidence of having been continuously retouched unifacially along one edge, appearing like small scraper tools (as reviewed in Stiner 1994:187–188). It is rare to see the working of shell as a raw material in either the MP or MSA. Through the sequence, the relative abundance of rocky-substrate versus sandy-sediment dwelling species varies likely reflecting changes in sea level that influenced the relative abundance of rocky versus sandy shore locally. While Moscerini shows abundant evidence of Neanderthals consuming mollusks, Stiner (1994) reports that overall all the density of shell in the site appeared to be low; the deposits are not a dense shell midden like those seen in local Mesolithic sites from the Holocene. This gives the impression that Neanderthals were foraging for these resources less intensively than later people, a difference similar to that seen when comparing the MSA and LSA assemblages. Unfortunately, too few limpets are preserved from the MP sample to see if they are larger than the subsequent samples. However, the analyses of *P. caerulea* from the Upper Paleolithic sequence of Riparo Mochi, Liguria, Italy does show a decline in size over the last 30 kya of the Late Pleistocene, potentially reflecting increasing exploitation of this resource (Stiner 1999; Stiner et al. 2000).

Other marine resources are notably sparse in the Moscerini assemblage, as well as the other MP samples from Italy (Stiner 1994). Fish and birds of all kinds are extremely rare. Monk seal (*Monachus monachus*) is present in very low numbers in the MP, although one carpal from Sant' Agostino exhibited a cut mark, an evidence of a human role in bringing the seal into the cave. However, the other site to provide seal bones, Moscerini, preserved them in a layer with a heavy carnivore influence and, therefore, does not inform on MP subsistence.

The coastal caves of Gibraltar (Devil's Tower, Gorham's Cave and Vanguard Cave) also provide evidence of MP people exploiting marine resources, primarily mollusks (*Mytilus* and *P. vulgata*), but also marine mammals, such as monk seals and dolphins (some with cut marks; Stringer et al. 2008; Barton 2000). These authors argue that both the MP and subsequent Upper Paleolithic people had similar focused, seasonal marine resource exploitation strategies. However, the samples sizes that they present are too small to reach such broad conclusions (Klein and Steele 2008). Elsewhere along the Mediterranean coasts, a few additional late Acheulean and MP samples reflecting coastal resource exploitation have been identified, such as Lazaret and Ramandils, France (Cleyet-Merle and Madelaine 1995) and Ras el-Kelb, Lebanon (Reece 1998), but either the samples are small or they have not been excavated or analyzed in detail. More detailed work has been conducted on MP samples from Portugal, such as at Figueira Brava (Bicho and Haws 2008) and Ibn Amar Cave (Bicho 2004), and Spain, at Cueva Perneras and Cueva de los Aviones (Montes Bernárdez 1988, 1989) and el Complejo del Humo (Vera-Peláez et al. 2004). These samples consistently demonstrate that mussels (*Mytilus*), limpets (*Patella*), and topshells (*Osilinus*) were the most commonly utilized mollusks. Seals occur in very small numbers in a few sites, and fish and bird remains are very rare in the MP; all these taxa are more abundant in the UP, including seals and cetaceans being represented in art and their bones being formed into ornaments (Cleyet-Merle and Madelaine 1995; Corchón and Álvarez-Fernández 2008, 2010; Corchón et al. 2008). Much work remains for future analyses of MP coastal adaptations.

Northern Africa

Previous Research

The most detailed analyses of mollusk exploitation in North Africa was provided by R. Neuville (in Ruhlmann 1951) for Dar es-Soltan 1, Morocco, today about 260 m inland from and 8 m above the ocean (Fig. 16.1, Table 16.1). He provides species lists for three main levels, the Neolithic, the Aterian, and sterile beach deposits at the base. Ruhlmann refers to the Neolithic level as a kitchen midden (*kjoekkenmoedding*; see also his Fig. 1.4), implying a higher density of mollusk remains in this level. However, this level may in fact contain elements of both Neolithic and Iberomaurusian. Rulhmann (1951:22) refers to it as having an "industrie néolithique de tradition ibéro-maurusienne," and just below it was a layer that contained a few geometrics in a more typical Mousterian context. Ruhlmann concludes that the Aterian mollusks were human food refuse because they are associated with other faunal remains. Unfortunately, while the most abundant species are indicated, the nature of the list makes it difficult to determine detailed relative abundances or densities. The Neolithic people exploited a slightly higher diversity of taxa (17–13 in the Aterian), but a more detailed analysis is necessary to interpret these results. The typical taxa found elsewhere are present during both times: mussels, limpets, and topshells (Table 16.2).

Numerous other caves dot the coastline between Rabat and Casablanca south of Dar es-Soltan, but only brief species lists have been provided for a few of them. Moving south from Dar el-Soltan 1 (where there is also Dar es-Soltan 2), marine mollusks were originally identified from the Aterian layers from El Harhoura 2 (Debénath and Sbihi-Alaoui 1979). The cave is currently situated 300 m from the shore and 10 m above sea level (Nespoulet et al. 2008). El Harhoura 1, situated in the same cliff line as El Harhoura 2, was described as having only rare shells (Debénath and Sbihi-Alaoui 1979), and Aouraghe (2004) provides a list (Table 16.2) that includes mussels and limpets and a few additional species. El Mnasra is located further south, 500 m from the shore, and 14 m above sea level (Nespoulet et al. 2008). New excavations at this site are supplying a rich mollusk

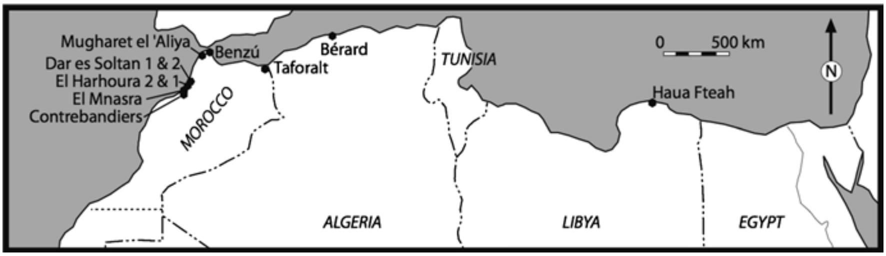

Fig. 16.1 Location of the North African sites mentioned in the text. Map is modified from Klein (2009:469)

Table 16.1 North African sites discussed in the text, along with their associated industries and chronologies, and the references that provide information about their faunal remains, particularly the mollusk remains. The dates provided here reflect the most reliable ones available, but much of the work to resolve the chronology for the Aterian and Mousterian is ongoing and more secure results should be available soon. See Fig. 16.1 for the location of the sites

Site	Lithic industry	Faunal descriptions
Dar es-Soltan 1 Morocco	Neolithic (OSL: 7.6±0.5)[1] Iberomaurusian? Aterian (OSL: 60–115 kya)[1] Aterian/Mousterian (OSL: <125–115 kya)[1]	Ruhlmann (1951)
El Harhoura 1 (Zouhrah Cave) Morocco	Neolithic Aterian	Debénath and Sbihi-Alaoui (1979); Aouraghe (2004)
El Harhoura 2 Morocco	Neolithic (6–7 kya)[2] Iberomaurusian Aterian	Debénath and Sbihi-Alaoui (1979); Nespoulet et al. (2008); Campmas et al. (2008)
El Mnasra Morocco	Neolithic (5,450–4,400 RCYBP)[3] Aterian	Nespoulet et al. (2008), personal observation
Grotte des Contrebandiers (Smugglers' Cave, Témara) Morocco	Neolithic Iberomaurusian Aterian Mousterian	Roche and Texier (1976); Bouzouggar et al. (2002); Souville (1973); personal observation
Haua Fteah (Great Cave) Libya	Historic Neolithic (4.7–7 kya)[4] Libyco-Capsian (7–10 kya)[4] Iberomaurusian (10–15/18 kya)[4] Dabban (15/18 to >40.5 kya)[4] Mousterian (>40.5 kya)[4] "Pre-Aurignacian"	Hey (1967); Higgs (1967); McBurney (1967); Klein and Scott (1986)

Kebibat (near Rabat)		Souville (1973)
Morocco		
Presqu'ile du Canal, Rocher Plat (near Bérard, west of Algiers)	Aterian	Roubet (1969)
Algeria		
Mugharet el 'Aliya (one of the Caves of Hercules)	Neolithic Aterian (ESR: 35–60 kya)[5]	Howe (1967); Howe and Movius (1947); Arambourg (1967); Briggs (1967)
Morocco		

Dates from:

[1] Barton et al. (2009)

[2] As in Campmas et al. (2008)

[3] Nespoulet et al. (2008)

[4] Klein and Scott (1986)

[5] Wrinn and Rink (2003)

Table 16.2 List of the species present for the sites where the data are available. Taxonomic nomenclature has changed since many of these lists were made, and previous published names are provided in brackets. Current names are from the CLEMAM database

		Atlantic	Atlantic	Atlantic	Mediterranean	Mediterranean	Mediterranean	Mediterranean
Species	Common name	Contrebandiers	El Harhoura 1	Dar es-Soltan 1	Kebibat	Algerian coast	Haua Fteah	Vanguard
Bivalves								
Mytilus edulis	Blue mussel		X	X				
Mytilus galloprovincialis	Mediterranean mussel	X						X
Perna perna [*Mytilus afer*]	Brown mussel			X				
Pecten sp.	Scallop		X					
Cerastoderma sp. [*Cardium* sp.]	Cockle		X					
Acanthocardia tuberculata	Tuberculate cockle							X
Donax sp.	White/sand mussel, bean clam			X				
Callista [*Venus*] *chione*	Smooth clam							X
Tapes decussatus	Carpet clam			X				
Unio sp.	Freshwater mussel		X					
Limpets								
Patella caerulea	Rayed Mediterranean limpet	X		X			X	X
Patella ferruginea	Ribbed Mediterranean limpet					X		
Patella intermedia [*depressa*]	Black-footed limpet	X	X	X				

Patella nigra [*safiana*]	Safian limpet				X			
Patella rustica [*lusitanica*]	Rustic limpet			X				
Patella ulyssiponensis [*aspera*, *tarentina*]	China limpet	X						
Patella vulgata	Common/European limpet			X				X
Siphonaria sp.	False limpet		X					
Others								
Osilinus lineatus [*Trochocochlea crassus*]	Atlantic marine snail/topshell	X		X				
Osilinus [*Monodonta*/*Trochus*] *turbinatus*	Med. marine snail/topshell/turbin						X	
Littorina obtusata	Smooth/flat periwinkle				X			
Strombus sp.	Conch		X					
Zonaria pyrum [*Cypraea pirum*]	Pear cowry			X				
Stramonita [*Thais*/*Purpura*] *haemastoma*	Oyster drill/rock shell				X			
Cymbium olla [*Yetus papillatus*]	Olla/algarve volute				X			
Nassarius corniculus [*Amycla corniculum*]	Horn nassa				X			
Nassarius reticulatus [*Nassa reticulata*]	Netted nassa/dog whelk			X				
Balanus sp.	Barnacles							X
Helix sp.	Garden snail		X			X		
Stenogyra sp.	Terrestrial snail					X		
Carcinus sp.	Crabs		X					

sample that will provide valuable data in the near future (personal observation). Finally, previous excavations at Contrebandiers, located 220 m from the sea and 14 m above sea level, yielded abundant limpets in the Aterian (Roche and Texier 1976). Bouzouggar's (1997) subsequent work at the site added to the sample and provided a species list of mussels, limpets, and topshells (Bouzouggar et al. 2002:241; Table 2). New work at the site is providing a large mollusk sample, which will be analyzed in detail; preliminary results are discussed below.

Outside of this region of Morocco, the cave of Mugharet el 'Aliya, Tangiers, perched 18 m almost directly above the ocean (Howe 1967), has potentially provided a great marine mollusk sequence; however, little is known about it. Briggs (1967) mentions that marine mollusks are present, but does not provide a species list. Even worse, Briggs submitted a sample of mollusks to a specialist but states that "nothing of value for our purposes came of this however" (p. 187). The specialist felt that the species present had such a wide distribution in time and space that there would not be enough variation to correlate with the climatic phases of the Pleistocene. The shells were not even considered to have been useful for reconstructing ancient human subsistence. One interesting find did appear in the Aterian sample at Mugharet el 'Aliya: Mediterranean monk seal (Arambourg 1967). To the best of our knowledge, this species has not yet been identified in any other North African Aterian or Mousterian assemblage. Unfortunately, the Mugharet el 'Aliya sample has been moved on a number of occasions, and by the time of P. Wrinn's zooarchaeological analyses, the pieces had been lost (Wrinn 2001; personal communication).

Outside of Morocco, the largest samples of marine mollusks from the longest and most complete cultural sequence come from Haua Fteah, Cyrenaica, Libya. The cave is an enormous cavern currently situated 800 m from the shore and 60 m above modern mean sea level. However, while stable isotopes in the limpets and topshells were analyzed for environmental reconstructions by Emiliani and colleagues (in McBurney 1967), the samples were not investigated from a subsistence perspective. A full species list is not provided, but McBurney (1967:59) states that the shells were "collected from dense masses of food debris forming in many cases virtual 'kitchen middens'." The high density of shells strongly indicated to McBurney that they were the result of human food refuse. However, he does not discuss them stratigraphically, so it is difficult to know if the shell sample is continuous. Emiliani was able to sample throughout most of the sequence, although shells were less abundant during the Mousterian and Dabban periods, perhaps indicating that the sea had moved far from the cave during this glacial time (Klein and Scott 1986). Emiliani and colleagues (in McBurney 1967) were able to use oxygen-isotope ratios of winter and summer growth periods of the shells to reconstruct winter and summer ocean temperature extremes. These reconstructions mirror those created from pollen and other terrestrial sources. New work at this site should provide more details on marine resource exploitation in the future.

A few additional Late Pleistocene localities with apparent mollusks as human food refuse have been identified along the Moroccan and Algerian coasts, such as the Kebibat (Souville 1973) and Bérard (Roubet 1969) sites and the Benzú Rockshelter (Ramos et al. 2008; Cantillo et al. 2010), but little more is known about their mollusk remains.

In the faunal analyses for these sites, there is little mention of the exploitation of birds and fish (see also Steele in press). Like mollusks, these taxa have not yet received the attention that they deserve. Species lists for birds and fish are occasionally provided, but with only a few exceptions, a more detailed analysis has rarely been attempted. One problem may be that many of these assemblages are from excavations that are now many decades old, and systematic screening, especially with fine mesh to collect small fish bones, may not have been typical. However, in the Neolithic deposits for many of these assemblages, these taxa are described as being present (fish at ‘Aliya: Arambourg 1967) or quite abundant (birds at Haua Fteah: MacDonald 1997), so they were recognized and collected in some instances. When species identifications are provided, the Mousterian and Aterian birds come from a variety of species, and while they were potentially consumed as food, they do not appear to reflect a consistent subsistence pattern. In addition, the species do not provide a particular signal of ancient humans focusing on aquatic resources.

Similar to the South African and Mediterranean samples, the initial species lists discussed above and presented in Table 16.2 indicate that mussels and limpets are the most common and consistent components of the North African shell middens, and topshells also appear frequently. Unfortunately, the mollusks have not been quantified, so it is not possible to see if species diversity is higher in more recent time periods, as is seen when comparing the MSA to LSA. Also, similar to other Mediterranean MP sites, birds and fish are rarely taken, and the occasional bones do not reflect regular human subsistence strategies. At first, it is surprising that there are not more monk seals in the assemblages, as MSA people seemed to be quite successful in consuming pinnipeds. However, monk seals belong to the Family Phocidae and fur seals to the family Otariidae, reflecting distinct evolutionary histories and resulting behaviors. Monk seals are highly endangered today, so it is difficult to reconstruct their past ecology and behavior, but they appear to be solitary on land, not participating in gregarious hauling-outs and rookeries like the Cape fur seal. This and other aspects of their behavior may have made them more difficult to capture or given fewer scavenging opportunities compared to Cape fur seals.

Current Research

As mentioned above, work at many of these sites has recently been renewed, and as a result we will learn much more about coastal adaptations during the Late Pleistocene of North Africa. New excavations at Grotte des Contrebandiers (Smuggler’s Cave) began in 2007 (El Hajraoui et al. in press; Olszewski et al. in review). Previous work at the site by Roche from 1955 to 1957 (1969; 1976), Roche and Texier from 1967 to 1975 (1976), and Bouzouggar in 1994 (1997) revealed a sequence that begins with beach sand sterile material (likely from the high sea stands of MIS 5e), moves into the Moroccan Mousterian, then Aterian, followed by the Iberomaurusian and capped by a thick Neolithic, most of which was removed by early excavators. The recent excavations are revealing at times a dense shell midden that provides a new opportunity to study mollusk exploitation in detail. Although the current work on the mollusk remains is preliminary, the current analysis includes about 30% of the 2007 and 2008 samples, the results have been informative (Table 16.3).

The current mollusk sample consists of both piece-plotted shells and bulk samples sorted out of the material recovered from the screening of each bucket (using 5-mm mesh). Identifications are made to the lowest taxonomic level possible, and for each taxon, the MNI (minimum number of individuals; right or left hinges for bivalves; apices for limpets and snails) and NISP (number of identified specimens minus those used for MNI) are recorded; as these values are mutually exclusive, they can be added together for the overall total NISP (Table 16.3). It is common in archaeomalacological analyses to quantify an assemblage using mass. However, much of the Contrebandiers material is covered in calcium carbonates, so mass cannot be used. Quantifying the assemblage by NISP is problematic because it is highly dependent on degree of fragmentation, which occurs pre- and postdepositionally, during excavation, curation, and analysis. However, MNI counts should remain consistent and will be the basis for most analyses. Once final numbers are

Table 16.3 Preliminary summary table of taxa by broad cultural group from the current excavations at Contrebandiers

	Iberomaurusian		Aterian		Mousterian	
Species	MNI	NISP	MNI	NISP	MNI	NISP
Mytilus	9	12	5	3	0	0
P. perna	12	6	3	1	3	13
Bivalve	34	110	29	204	9	54
P. caerulea	11	0	1	0	2	0
P. ferruginea	2	0	0	0	1	0
P. nigra	1	0	1	0	0	0
P. ulyssiponensis	6	0	1	1	0	0
P. vulgata	41	1	111	0	35	0
Patella	63	90	156	346	47	46
Haliotis	0	1	0	0	0	0
O. lineatus	1	11	7	141	1	8
S. haemastoma	0	12	0	17	0	2
Barnacles	28	0	24	0	11	0
Carcinus	2	0	0	0	0	0
Echinoidea	0	1	0	0	0	4
Other	1	0	3	8	4	1
Miscellaneous fragments	0	44	0	309	0	21
Total	211	288	341	1,030	113	1,149
Grand total						2,132

MNI values are for unique countable features of the shells: apices for limpets, snails, and drills, and hinges for bivalves (and the larger value of rights or lefts was taken as the MNI and the smaller added to NISP). These categories are mutually exclusive, and therefore, these two values can be added together for the total NISP. This table represents approximately 30% of the 2007 and 2008 samples. Industry attributions assigned following El Hajraoui et al. (in press:Table 2) calculated, species with just NISP values will be analyzed as having an MNI of 1 so that they are fully incorporated.

Limpets are the most common taxa throughout the Contrebandiers sequence. Multiple species typical of Atlantic and Mediterranean shores have been identified along the Moroccan coast in the past (Table 16.2). The dominant taxon in the current Contrebandiers sample is *P. vulgata*, but this species was not recognized in the previous analysis, although it was recognized at Dar es-Soltan 1 (Ruhlmann 1951:33) only a few kilometers to the North. The Mediterranean limpet species are difficult to separate, and *P. vulgata* exhibits high variability in its morphology, as do many of the other possible species; local environmental factors may influence their shell morphology and coloration (Mauro et al. 2003). At Contrebandiers, the problem is further complicated by the carbonate deposits adhering to the shells, and uncertain specimens were recorded simply as *Patella* sp. *P. vulgata* lives in the intertidal zone of rocky shores and dominates the areas of open rock and patchy seaweed where wave action is moderate, making them easily accessible to ancient foragers.

At least two types of mussels are apparent in the Contrebandiers assemblages, *Mytilus* and *Perna*. Within *Mytilus*, there may be *M. edulis*, the blue mussel typical of the Atlantic Ocean, or *M. galloprovincialis*, the Mediterranean mussel. However, the genetic distinction, let alone morphological distinction, between these two taxa is often subtle or unclear (Poppe and Goto 1991; Tebble 1966; Gosling 1992), and therefore, we have not attempted to differentiate between the two. *Mytilus* can be found on hard substrates in both the intertidal and subtidal zones and can reach densities of up to 1,000 individuals/m^2; typically intertidal specimens are smaller and subtidal ones are larger (Poppe and Goto 1991). *Perna* lives on rocks below the low tide mark (Poppe and Goto 1991) and, therefore, would have been less accessible.

Osilinus, an additional intertidal rocky shore dweller, completes the complement of common taxa in the Contrebandiers assemblages. *Stramonita* is consistently present. A few fragments of *Haliotis* were present in the Iberomaurusian assemblage. *Haliotis* was also identified from the younger assemblage at Dar es-Soltan 1 (Ruhlmann 1951:33) but has not been recognized in any Aterian or Mousterian assemblages. Crab pincers were also recognized in the Iberomaurusian sample, but not in the older material, despite the robustness of these remains. Crab pincers were also found in the younger material at Haua Fteah, but not in the Late Pleistocene material (Klein and Scott 1986).

Limpet species diversity is higher in the Iberomaurusian sample than in the Aterian or Mousterian at Contrebandiers. Although better preservation may allow for easier identification of these more recent specimens, the limpets, especially the *P. vulgata*, in the Iberomaurusian are significantly smaller than the same species in the older assemblages (Steele, unpublished data). This result conforms to the expectations formulated from analyses of the South African mollusk assemblages. Unfortunately, there is a temporal gap between the youngest Aterian and oldest Iberomaurusian samples, just as there is a hiatus between the youngest MSA and oldest LSA mollusk samples. Fortunately, in a few places in North Africa there are older Upper Paleolithic industries, such as the Dabban at Haua Fteah (McBurney 1967) and possibly at Taforalt, Morocco (Barton et al. 2007), which should help span the chronological sequence so that we can further investigate when these subsistence changes occurred.

To investigate why species composition may change in the Moroccan assemblages, future investigations will use existing offshore bathymetry data to investigate how changing sea levels affected the proximity of the ocean to the caves and the proportions of rocky to sandy shores. Fluctuating species abundances may also reflect fluctuating biogeographic boundaries. The Atlantic coast of Morocco belongs to the Saharan Upwelling ecoregion of the Lusitanian province, while the Mediterranean coast belongs to the Alboran Sea ecoregion of the Mediterranean Sea province (Spalding et al. 2007). Currently, the Lusitanian biogeographic region contains a mix of characteristically Atlantic and Mediterranean taxa. However, due to changing environmental conditions such as changing sea levels, water temperatures, or salinity, more or less Mediterranean species may have been present along the Atlantic shores of Morocco. Future research will investigate these potential fluctuations in species abundances.

Summary

Research into coastal adaptations along North African shores are just beginning to build on early descriptions, and the results are promising. Work is progressing following the approach used in South Africa to investigate MSA subsistence and environments during the Late Pleistocene and how these results compare to LSA adaptations during the Holocene. South African MSA shell middens reflect human consumption of mollusks, primarily mussels and limpets, yield a lower diversity of mollusk species, and the mollusks present are significantly larger than their LSA counterparts, contain a smaller proportion of flying birds than flightless birds, and lack fish and rock lobster remains. Changing relative species abundances also reflect changing sea levels, water temperatures, and proportions of rocky to sandy shores. Initial analyses of the mollusk assemblages from the site of Contrebandiers, Morocco, reveal similar patterns where humans primarily consumed mussels and limpets; Aterian and Mousterian limpets are considerably larger than more recent examples; birds, fish, and crabs are virtually absent from the Late Pleistocene levels. The South African patterns have been interpreted to reflect lower human population densities during the MSA, and the same may be true in the Mousterian and Aterian. These analyses are just beginning, and future work promises to reveal much about Late Pleistocene human adaptations and environments along the North African coast, and in turn, provide useful data about variation in MSA and Mousterian subsistence and behavior and, therefore, about modern human origins.

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Chapter 17
Shellfishing and the Interpretation of Shellfish Sizes in the Middle and Later Stone Ages of South Africa

Judith Sealy and Mariagrazia Galimberti

Introduction

South Africa has a long history of coastal occupation, with numerous sites dating from the Holocene and a sizable number from the Late Pleistocene. Research in progress is now revealing evidence of coastal occupation, and the accumulation of shell middens, as far back as the Middle Pleistocene (Jacobs et al. 2006; Marean et al. 2007). These sites preserve some of the earliest evidence, anywhere in the world, of the behaviour of modern humans, making South Africa an especially fruitful area in which to explore questions about the use of coastal resources and how these changed both through time and across space.

A number of Middle Stone Age sites (c. 250–30 kya) known in South Africa lie along the present-day coastline (Fig. 17.1). Many are in caves, where preservation tends to be better than in the open. Both Middle and Later Stone Age (<30 kya) sites tend to be located along rocky, rather than sandy shores, since rocky substrates support more abundant populations of shellfish. Discarded mollusc shells form the dominant component of most coastal sites and contain a great deal of information about past peoples' behaviour and subsistence practices. As with many other biological residues, however, it can be difficult to tease apart the possible causes of variation in shellfish assemblages. Explanations developed by archaeologists have tended to favour human behaviour as the cause of change, invoking shifts in choice of mollusc species collected and changes in intensity of collection as the likely agents. We argue below that we should pay more attention to possible environmental influences on the patterns documented.

Middle Stone Age shell middens surviving on land today date from relatively warm intervals, when the sea level was close to its present position. There must be

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DOI 10.1007/978-1-4419-8219-3_17,

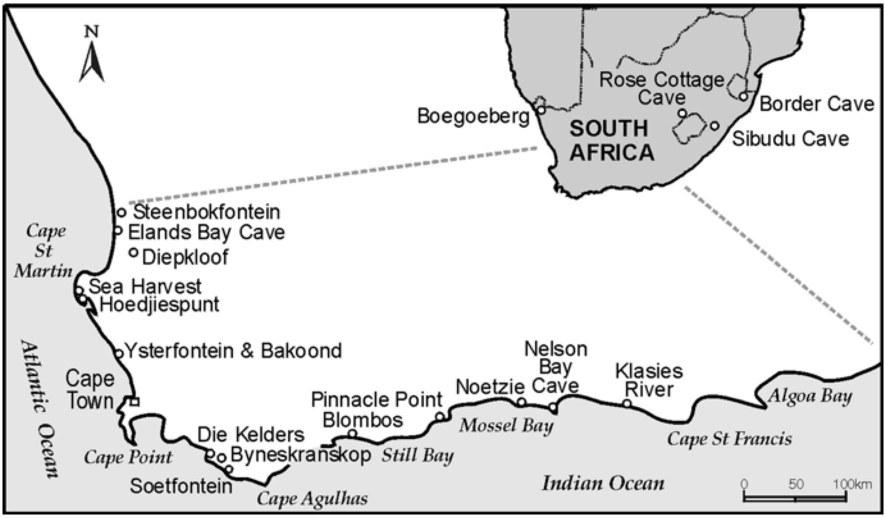

Fig. 17.1 Map of South Africa showing some important Middle and Later Stone Age sites mentioned in the text. Bekbaai and Noordwesbaai are immediately south of Cape St Martin, and north of Sea Harvest

many more middens submerged on the continental shelf, particularly along the shallow sloping south coast of South Africa, where up to 100 km of coastal plain were exposed at the Last Glacial Maximum. The species of shells in MSA middens are the same as those occurring in these areas today. Sites along the south coast, on the edge of the Indian Ocean, contain mostly species that thrive in warm water, while those along the west coast, on the fringes of the Atlantic, are dominated by cold-water-loving species. These patterns have not been entirely consistent over time: around 10 kya, towards the end of the post-glacial sea-level rise, the cold-water-loving black mussel *Choromytilus meridionalis* lived along the south coast, where it was collected for food by the inhabitants of both Nelson Bay Cave and Matjes River Rock Shelter. This species today is found mostly along the west coast, in waters no warmer than 18°C (Clarke and Griffiths 1990). After about 9.5 kya *Choromytilus* disappeared from both sites, replaced by the warm-water brown mussel *Perna perna*, still found in the area today (Klein 1972; Döckel 1998). This shift indicates cooler water temperatures along the south coast in the terminal Pleistocene/early Holocene. *Choromytilus* also occurs in small numbers in the MSA levels of Klasies River and Blombos Cave (Thackeray 1988; Henshilwood et al. 2001).

Shellfish Sizes in the Middle and Later Stone Ages: Food Species

Archaeologists have devoted a good deal of effort to documenting the species of shellfish and measuring the sizes of shells recovered from shell middens. Richard Klein and co-workers have published a number of diagrams such as that shown in Fig. 17.2,

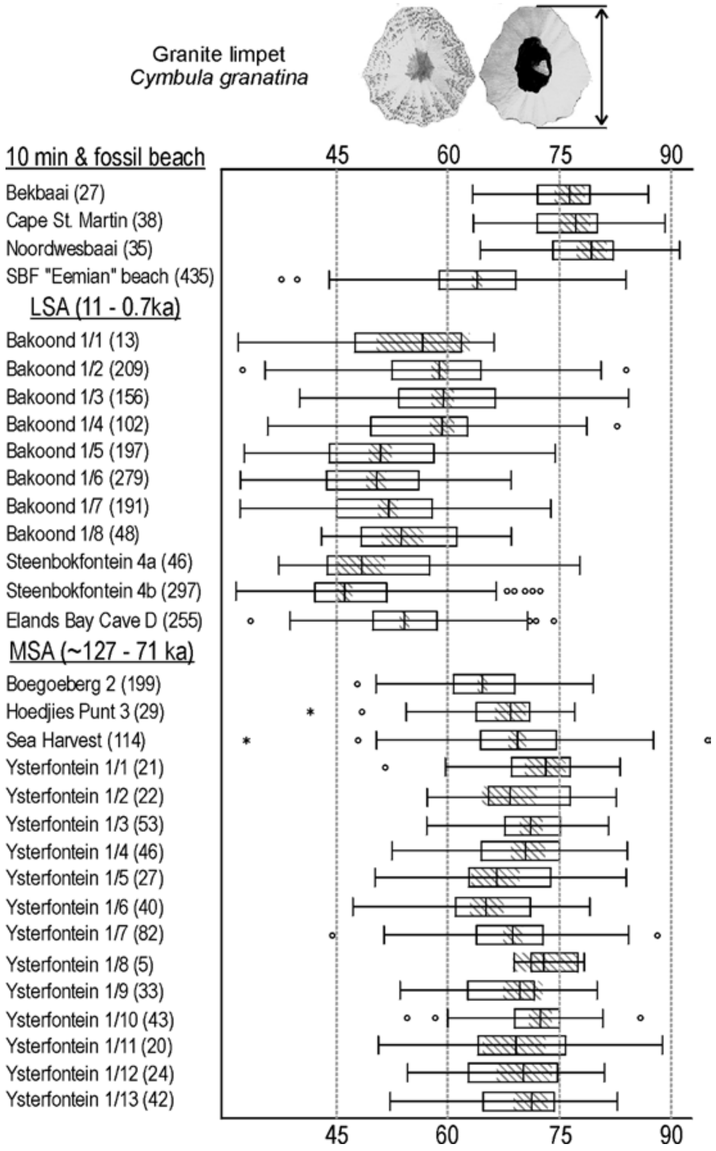

Fig. 17.2 Maximum shell lengths (in mm) of granite limpets from Middle, compared with Later Stone Age sites along the west coast of South Africa (after Klein 2008). Numbers in parentheses indicate sample sizes. The youngest LSA samples are at the *top*, the oldest at the *bottom*. The relative ages of the MSA samples are not known. The *vertical line* near the centre of each box plot shows the median, the *shaded rectangle* indicates the 95% confidence limits of the median, the *open rectangle* encloses the middle half of the data, and the "whiskers" show the range of more or less continuous data. *Stars* and *open circles* indicate outliers. When the 95% confidence limits for two medians do not overlap, the medians differ from one another at or below the 0.05% significance level

which clearly demonstrates significant differences between the sizes of granite limpets (*Cymbula granatina*) from Middle and Later Stone Age sites along the west coast of South Africa. Middle Stone Age shells were substantially larger, and the pattern is about as statistically robust as archaeological data gets. Modern (late twentieth century) specimens, from two areas thought not to be significantly affected by people, are also large. The size contrast between Middle and Later Stone Age limpets is also seen in other species: *Scutellastra granularis* and *S. argenvillei*, for which we have data predominantly from the west coast, and *Cymbula oculus*, from the south coast (Volman 1978; Klein 1998; 2008; Henshilwood et al. 2001; Halkett et al. 2003; Parkington 2003; 2008; Klein et al. 2004; Steele and Klein 2006; Avery et al. 2008).

What about shellfish other than limpets? Along the south coast, one of the most common large gastropods – and an important food species even today – is the turban shell (or alikreukel, *Turbo sarmaticus*), sometimes also called the giant periwinkle. These occur in the lower intertidal and sub-tidal zones of the shoreline, up to a depth of about 8 m. Large individuals measure ~130 mm across (Kilburn and Rippey 1982). Whole *Turbo* are rarely found in archaeological sites, but the lengths of the opercula are a good proxy (McLachlan and Lombard 1981; Yssel 1989). Measurements of opercula from Middle and Later Stone Age sites show a significant decrease in size from MSA to LSA (Fig. 17.3), in the same way as the limpets described above (Voigt 1982; Thackeray 1988; Klein 2008; Henshilwood et al. 2001; Steele and Klein 2006).

The one species for which we have measurements but that does not show this pattern is the black mussel *Choromytilus meridionalis*. Mussel shells usually break up in archaeological sites, but the maximum width of the prismatic band is proportional to the length of the valve (Buchanan 1985), and this band can be measured on fragmentary specimens. The figures for MSA mussels are within the range of LSA assemblages (which themselves vary significantly) (Halkett et al. 2003; Parkington 2003; Avery et al. 2008). Some of the variation in Holocene assemblages has been attributed to changes in water turbidity and sea surface temperature, as well as shifts in collecting practice (Jerardino 1997).

As mentioned above, the most widely published interpretation of the size decrease in LSA, compared with MSA molluscs, is that it resulted from more intensive shellfish collection by larger LSA human populations. As far as we know, hunter-gatherers who lived along the South African coastline collected shellfish, fished and obtained other marine foods from the shore – we have no indication that they used boats, dived or ventured farther into the ocean than the lower intertidal zone, exposed at spring low tides. Limpets, living as they do in the intertidal, are easily accessible to shore-based collectors. Researchers have argued that people would have removed the largest animals first, to the extent that overall size distributions became skewed towards smaller (i.e. younger) animals in later time periods (Halkett et al. 2003; Parkington 2003; 2008; Klein et al. 2004; Steele and Klein 2006; Avery et al. 2008; Klein 2008). The underlying assumption is that shellfish growth rates have remained constant over many tens of thousands of years.

Choromytilus meridionalis also occurs on intertidal rocks, but its range extends lower on the shoreline into the sub-tidal zone. Deeper-water colonies would have

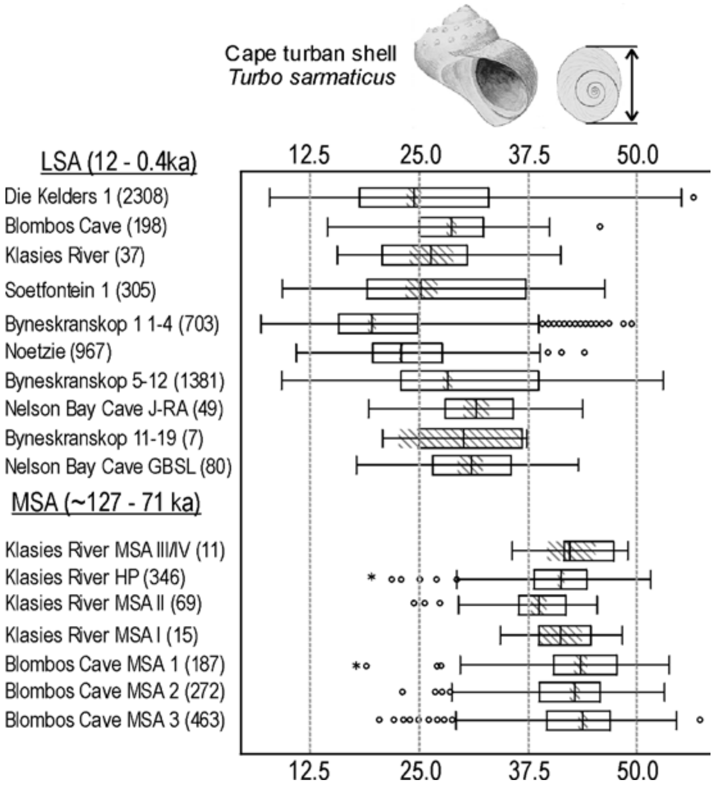

Fig. 17.3 Lengths (maximum diameters) of *Turbo sarmaticus* opercula (in mm) from Middle and Later Stone Age sites (after Klein 2008). See caption to Fig. 17.2 for explanation of box-plot format

provided a stable reservoir from which intertidal populations could be replenished. In addition, *Choromytilus* occurs along the west coast in enormous, very dense mussel beds. Parkington (2003), Klein et al. (2004) and Avery et al. (2008) suggest that we do not see a decrease in the sizes of black mussels in the LSA compared with the MSA because mussel populations would have been less susceptible than limpets to over-exploitation.

If heavy harvesting of shellfish directly impacted size distributions, one might expect to see fluctuations also *within* the Middle and Later Stone Ages, if changes in the numbers of people living along the coast or the importance of shellfish in their diets led to shorter-term variations in intensity of collection. The most detailed evidence comes from the second half of the Holocene, and especially from the west coast of South Africa, around Elands Bay. We have a wealth of information from the long-term research programme in this area led by John Parkington, with contributions from many students and colleagues. In a recent article, Parkington (2008) argues persuasively that spatially patterned variations in the sizes of limpets at the site of Dunefield Midden reflect human impact on shellfish populations over the duration of occupation. He suggests the same mechanism for shifts in limpet sizes and frequencies through the terminal Pleistocene and Holocene sequence at Elands Bay Cave.

Antonieta Jerardino et al. (2008) have recently synthesised several decades' worth of research into archaeological and modern shellfish from dozens of sites in the Elands Bay area. Some of their findings are shown in Figs. 17.4 and 17.5. Figure 17.4 shows that shellfish were a particularly important item of diet between 3 and 2 kya (uncalibrated). The largest number of shell middens dates to this millennium, and these sites are very much bigger (the volumes of deposit are greater) than in earlier or later millennia. This must surely mean that there was significant pressure on shellfish populations. The importance of marine foods – though not, it must be emphasised, specifically shellfish – is also reflected in the δ^{13}C values of bone collagen from human skeletons dating to this same time period.

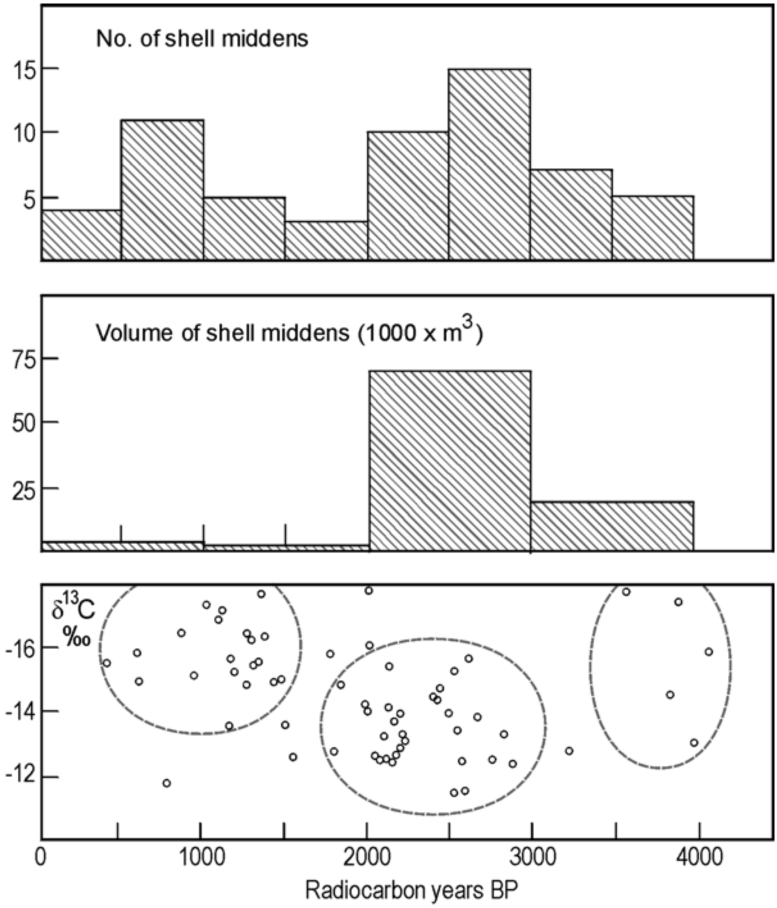

Fig. 17.4 Numbers of sites and volumes of deposit from the Elands Bay area compared with δ^{13}C values of West Coast human skeletons from the past 4,000 years (after Jerardino et al. 2008)

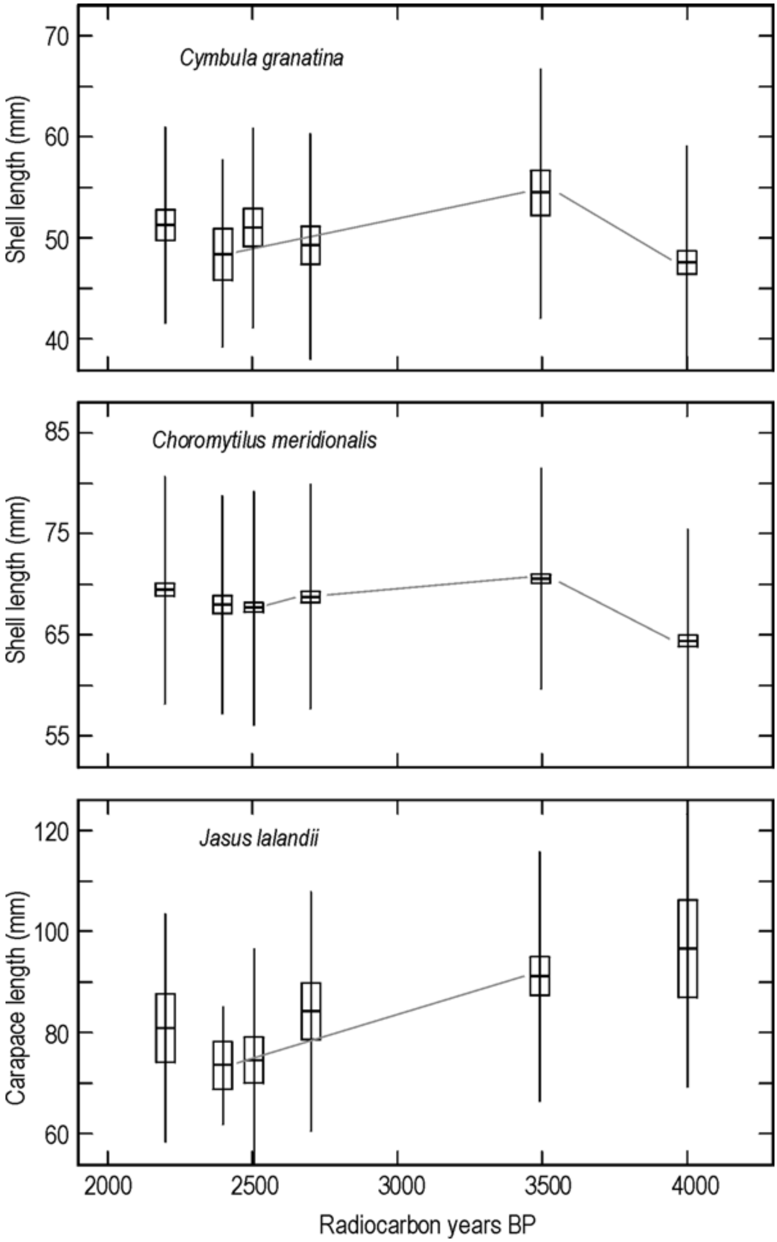

Fig. 17.5 Variations in size of *Cymbula granatina* (granite limpet, $n = 53–409$), *Choromytilus meridionalis* (black mussel, $n = 770–2,360$) and *Jasus lalandii* (rock lobster, $n = 42–237$) at Steenbokfontein Cave during the late Holocene (after Jerardino et al. 2008). Lines linking samples of different ages show differences that are statistically significant at $p < 0.05$

Skeletons from 3 to 2 kya tend to have relatively positive $\delta^{13}C$ values, which in this environment derive from seafood consumption (Sealy and van der Merwe 1988). Given this background, Jerardino et al. go on to examine shellfish sizes between 4 and 2 kya, compared with earlier and later periods. Figure 17.5 shows measurements of *Cymbula granatina* (granite limpet), *Choromytilus meridionalis* (black mussel) and *Jasus lalandii* (rock lobster) excavated from the cave of Steenbokfontein, a few kilometres north of Elands Bay (Jerardino Wiesenborn 1996). Both species of shellfish increase in size between 4 and 3.5 kya and then become smaller between 3.5 and 2.5 kya. At present, there is insufficient data to identify a clear pattern after 2.5 kya. Crayfish, too, decrease in size between 3.5 and 2.5 kya. The authors examine various environmental variables: sea surface temperature (inversely linked to productivity, since upwelling of deep, cold, nutrient-rich water is a major determinant of productivity in this region), turbidity, etc. but conclude that the decline in shellfish sizes is best attributed to intensive harvesting; of any time during the past few thousand years, this is when one would most expect to see this phenomenon.

The decrease in the size of the crayfish, however, requires a different explanation. *Jasus lalandii* are abundant along the west coast, and Elands Bay and environs are a centre of the crayfishing industry today. Very substantial populations of these creatures live in the kelp beds immediately offshore, with some individuals occurring closer inshore, including in deeper rock pools. In earlier times, and even today along parts of the coastline where human access is restricted, crayfish can be caught from rock pools without the need to dive. This type of harvesting would, however, draw on only a tiny fraction of the overall population, and animals that were taken would be replaced by others from the very large pool beyond the range of pre-colonial foragers. Jerardino et al. (2008) point out that it is, therefore, very unlikely that hunter-gatherers "farmed down" the crayfish population.

What, then, might account for the reduction in crayfish size? The authors conclude that there must have been changes in the availability of food or other environmental factors that influenced growth, and thus the sizes of the animals. Whatever the cause might have been, surely we need to explore the likely effect on other marine organisms, including *Choromytilus meridionalis* and *Cymbula granatina*. It would be surprising if these species underwent a parallel reduction in size at precisely the same time for entirely different reasons.

Shellfish Sizes in the Middle and Later Stone Ages: Non-Food Species

We turn now to a species of shellfish that was collected not for food, but as an ornament. *Nassarius kraussianus* (tick shells) are small gastropods, typically 7.5–10 mm long, that live in sheltered environments such as lagoons and estuaries (Kilburn and Rippey 1982). They are too small to have been worth collecting for food, but they are well known from Later Stone Age sites because they were perforated and strung as shell beads (e.g. Goodwin 1938; Schweitzer 1979; Schweitzer and Wilson 1982;

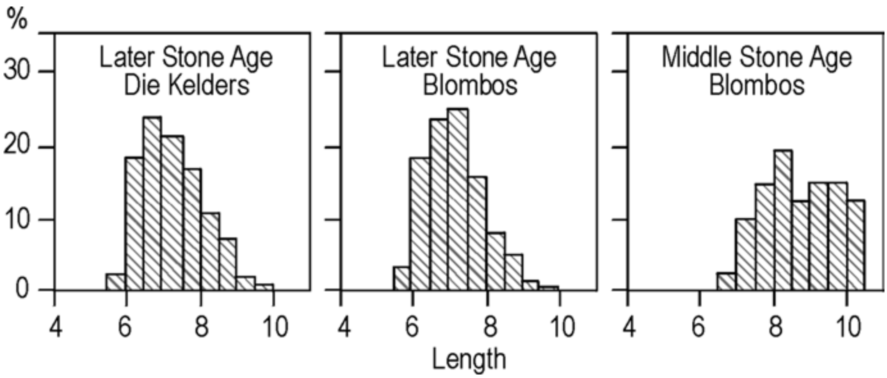

Fig. 17.6 Maximum shell lengths (in mm) of *Nassarius kraussianus* beads from the Middle and Later Stone Age levels of Blombos and Die Kelders (after d'Errico et al. 2005)

Hall and Binneman 1987; Inskeep 1987). Recently, *Nassarius* shell beads have been described from Middle Stone Age levels c. 75 kya at Blombos Cave (d'Errico et al. 2005) and also from Middle Palaeolithic contexts in North Africa and Israel (Vanhaeren et al. 2006; Bouzouggar et al. 2007). Once again, the South African Middle Stone Age specimens are significantly larger than examples from the Later Stone Age levels at the same site (Mann-Whitney $p<0.0001$, d'Errico et al. 2005), and at Die Kelders, approximately 140 km west of Blombos (Fig. 17.6). In absolute terms, the difference is small; from Fig. 17.6, the median value of the LSA samples can be estimated at about seven mm, approximately two mm smaller than the median value for the MSA sample. As a proportion of total length, however, this is substantial. It is extremely improbable that size reduction in *Nassarius* from the Middle to the Later Stone Age can be attributed to increased collection pressure from hunter-gatherers; there simply are not enough shell beads in LSA sites to indicate farming down. In this case, we clearly need to look elsewhere for an explanation.

Environmental Influences on Shellfish Growth

Growth rates of marine molluscs depend on many factors, including temperature, food supply, water turbidity, salinity, topography and population density (McQuaid 1981; Ekaratne and Crisp 1984; McQuaid and Branch 1984; Jerardino 1997; Mannino and Thomas 2002).

The ages of the MSA shellfish assemblages shown in Figs. 17.2 and 17.3 are relevant to this discussion. MSA shell middens on the present coastline are likely to have accumulated at times when the sea level was within a few kilometres of its current position. We lack precise dates for the archaeological assemblages from Boegoeberg 2, Hoedjiespunt 3 and Sea Harvest. Boegoeberg 2 is beyond the range of radiocarbon dating, and the fauna reflect interglacial conditions, so the site may have formed during one of the warmer intervals of the last interglacial (MIS 5e, 5b or 5a) (Klein et al. 1999). Hoedjiespunt 3 is probably the same age as Hoedjiespunt 1, tentatively dated to c. 120–110 kya (Parkington 2003). Sea Harvest is likely to date sometime between 128 and 74 kya (Grine and Klein 1993). The dating of the Ysterfontein site is still in progress, but the evidence thus far indicates a probable age of between 57 and 46 kya, although ca. 115–71 kya is also possible (Klein et al. 2004).

At Blombos Cave, the three MSA levels M3, M2 and M1 date from 98.9 ± 4.5 to 72.7 ± 3.1 kya (Jacobs et al. 2006). At Klasies River, the base of the earliest occupation (the MSA I) dates to c. 120 kya (Deacon and Geleijnse 1988) and the Howiesons Poort (HP) levels to 65–60 kya (Jacobs et al. 2008). The MSA III and IV are not well dated, but the whole Klasies River sequence accumulated between about 120 and perhaps 40–30 kya. Overall, of the MSA shellfish assemblages shown in Figs. 17.2 and 17.3, all those for which we have reasonably precise dates accumulated during times when temperatures were lower than those of the Holocene. Thackeray, in his analysis of shellfish from the MSA at Klasies River, noted that the "presence of *Choromytilus* [*meridionalis* or black mussel] can be used as a basis for suggesting that temperatures during most of the Middle Stone Age represented at Klasies River were cooler than modern conditions off the southern Cape, where *Choromytilus* does not appear at present" (1988:31). The species abundance data is, therefore, consistent with temperatures during the accumulation of MSA shell middens being slightly colder than today, but only slightly (because MSA shellfish assemblages are similar to Holocene ones on both the Atlantic and Indian Ocean shorelines, reflecting colder and warmer-loving species, respectively).

The palaeo-oceanographic literature documents substantial variations in the productivity of the southern oceans over the last glacial/interglacial cycle. Sachs and Anderson (2005) present detailed information from the southern ocean for the period ca. 70–10 kya, documenting marked increases in oceanic productivity coinciding with Antarctic temperature maxima at 58.8, 53, 46 and 38.5 kya. Primary productivity around the South African coastline can certainly be expected to have changed as sea levels and ocean currents shifted. Differences in primary productivity affect the food supply and, hence, are likely to influence size distributions of shellfish populations. Among molluscs in general, small size is typically linked with slow growth (Johnson 1999), and growth is controlled, in part, by food availability (Broom and Mason 1978; Thompson and Nichols 1988). Primary productivity varies around the SA coastline today (Bustamente et al. 1995), and Bosman and Hockey (1988a, b) have shown that increased algal productivity in nutrient-rich situations increases the size of *Patella* (now *Scutellastra*) *granularis*; this is likely to apply also to other shellfish. Quality of diet has been shown to affect the growth rate of *Turbo sarmaticus* (Foster et al. 1999). *Turbo* living in the intertidal consumed a range of macroalgae, but the most important were *Corallina* spp., *Gelidium pristoides* and *Ulva rigida*. In a series of experiments with captive animals, those fed mainly on *Corallina* grew significantly less well than those fed on the other species. Animals that ate *Ulva* only, or a mixture of *Ulva* and *Gelidium*, grew better than those supplied with *Gelidium* alone. Similarly detailed studies have not, unfortunately, been done on other species of molluscs collected by hunter-gatherers, so we cannot yet predict the likely effects of changes in environmental conditions on the different types of shells found in middens. Food availability is only one variable. Temperature is also important: molluscan species have preferred temperature ranges, and many grow during only part of the year when conditions are to their liking (Epstein and Lowenstam 1953; Krantz et al. 1987; Goodwin et al. 2001; Chauvaud et al. 2005; Mannino et al. 2008). Higher temperatures also increase molluscan metabolic rates, so more energy is required for metabolic functioning, possibly at the expense of growth (Broom and Mason 1978). The inter-relationship of all these factors is clearly complex, making them difficult to tease apart (Underwood 1984).

Discussion and Conclusion

The evidence summarised above seems to us sufficiently compelling to warrant re-examination of the assumption that shellfish growth rates have remained constant from the MSA to the LSA. MSA shellfish assemblages available for study today must have accumulated at times when sea level was close to its present position, but most appear to post-date the Last Interglacial, and ocean temperature, food supply and other factors critical for molluscan growth were not necessarily the same as in the Holocene. If MSA shellfish grew faster, then the larger sizes of MSA specimens need not mean that there was less predation pressure by smaller MSA human populations.

The implications of this are far-reaching. If MSA people were not yet cognitively modern and were less efficient at extracting nutrients from their environment, population sizes would have remained relatively small, as argued by Klein (2008, and references therein). This would certainly account for less intensive harvesting of shellfish and other resources. There is, however, a growing body of evidence that MSA people were more advanced (e.g. Deacon 1992; McBrearty and Brooks 2000; Henshilwood et al. 2002; Henshilwood and Marean 2003; d'Errico et al. 2005; Brown et al. 2009). Whatever the case, coastal environments are very productive, and it is difficult to understand why MSA populations living along the coast should have been nutrient-limited. Why did people not simply collect more shellfish? We suspect that the reasons behind the observed variations in shellfish size over the past 100,000 years are more complex and that environmental factors are likely to be involved. A clearer understanding of this would enable us to explore more detailed questions about shellfish exploitation, human population density and possible links to processes of human dispersal and colonisation of new areas (e.g. Mannino and Thomas 2002).

The patterns of change in shellfish size that we seek to explain are, as yet, outlined with only very broad brush-strokes. To sum up, we know that there is a significant decrease from the Middle to the Later Stone Age in the sizes of several species of limpets, of *Turbo sarmaticus* and *Nassarius kraussianus*. There appears not to be a size decrease in *Choromytilus meridionalis*. Over-harvesting as a possible explanation is most plausible for limpets. Today, large (old) limpets form only a very small proportion of the population (Branch 1974a, b; Rebelo 1982 in Parkington 2008), and since limpets are confined to the intertidal zones, entire populations are vulnerable to collection at spring low tides. Human impact is less likely to have caused size reduction in *Turbo sarmaticus*, given that a significant proportion of these animals live in the sub-tidal zone, where they would have been difficult for pre-colonial people to access. Over-exploitation is an *un*likely explanation in the case of *Nassarius kraussianus*, which is not a food species. We should, therefore, also look to environmental factors; if these did indeed play a role, then they are very likely to have affected limpets too. This does not mean that we should abandon consideration of possible over-harvesting – there may well be multiple reasons for the patterns we see. It does mean that we need to explore additional approaches. As already suggested, comparison of long-term size trends in different species of shellfish with varied habitat preferences, feeding requirements, etc. might help disaggregate different contributing factors. Direct investigation of growth patterns of Middle and Later Stone Age shells through the study of growth increments, seasonal variations in oxygen isotope ratios and possibly trace element profiles should enable us to investigate the ages, as well as the sizes of shells, and thus answer these questions more directly.

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Chapter 18
Coastal South Africa and the Coevolution of the Modern Human Lineage and the Coastal Adaptation

Curtis W. Marean

The fossil record indicates that *Homo sapiens* appears sometime around 195–160 ka (White et al. 2003; Clark et al. 2003; McDougall et al. 2005; Smith et al. 2007). Evolutionary genetics (Ingman et al. 2000; Tishkoff et al. 2007; Gonder et al. 2007; Fagundes et al. 2007; Behar et al. 2008) point to the time between 200 and 100 ka as the origin point for the modern human lineage. Modern humans have relatively very low genetic diversity that is best explained by one or more population bottlenecks late in the evolution of the lineage, with estimates for the first bottleneck ranging from 144 ka (103,535–185,642 ka 95%CI) (Fagundes et al. 2007) to 194.3 ± 32.5 ka (Gonder et al. 2007) to 203 ± 12.6 ka (Behar et al. 2008). Fagundes et al. (2007) estimate the effective population of that bottleneck at ~600 (76–1,620 95%CI). A computer simulation by Rogers reported in (Ambrose 1998) suggests that this bottlenecked population was a single contiguous breeding group in one region, since if this population sampled a broad range of populations across Africa the original genetic variation would have been preserved. This bottleneck seems to have occurred during the glacial MIS6 (~195–125 ka), one of the longest coldest stages of the Quaternary (Petit et al. 1999), during which time Africa would have been primarily dry with relatively few isolated refugia. Paleoanthropologists now have a gripping question to address – where did this progenitor population arise, how, and why there?

A related question addresses the timing and circumstances of the origins of cognitive complexity (McBrearty and Brooks 2000; Henshilwood and Marean 2003; Wadley 2003). Paleoanthropologists use various proxies in the archaeological record to try to identify its presence and scope, including artifactual markers of symbolic thought (Henshilwood et al. 2004), and the development of complex technologies (McBrearty and Brooks 2000) that signal the unique ability of humans

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to successively build on prior knowledge over generations (Tomasello 1994, 1999). This “ratchet effect” refers to incremental adjustments to technological procedures already in place. Along with this, modern humans excel at novel “outside-the-box” connections of seemingly unrelated phenomena (Pfenninger 2001; Andreasen 2006). These can result in sharp technological advances with high fitness benefits, and these new creations provide the input to the ratchet effect.

The South African archaeological record provides the richest and oldest evidence for the material cultural complexity that we anticipate will reflect this advanced cognition. It appears during the Middle Stone Age (MSA, dating between 280 and ~35 ka), the technological stage that spans the origins of modern humans. This material cultural complexity has been repeatedly pointed to as a potential indicator of behavioral modernity (McBrearty and Brooks 2000; Henshilwood and Marean 2003; Marean and Assefa 2005). Here, and particularly on the coast, are found early examples of material cultural complexity that predate by some 20,000 years the “Human Revolution” of 50–40 ka. Some researchers once considered this 50–40 ka break in material culture to be worldwide (Mellars 1973; Klein 1998, 2000), but now it is widely accepted that this material cultural complexity occurs much earlier than 50 ka in Africa (McBrearty and Brooks 2000; Henshilwood and Marean 2003; Marean and Assefa 2005). The evidence includes the production of bone tools such as points (Henshilwood et al. 2001a; d’Errico and Henshilwood 2007; Backwell et al. 2008), beads (Henshilwood et al. 2004; d’Errico et al. 2005), large quantities of worked and unworked pigments (Watts 1999, 2002), decorated ochre (Henshilwood et al. 2002; Mackay and Welz 2008), and most recently lithic heat treatment (Brown et al. 2009) in MSA sites. At this stage in research, this burst of complexity appears to occur between 120 and 70 ka, but it is important to note that there is currently only a handful of sites in all of Africa that are directly dated to the prior marine isotope stage 6 (MIS6, ~195–125 ka). Pinnacle Point 13B (PP13B) is one of these. Interestingly, PP13B also provides our earliest evidence (~164 ka) for marine shellfish exploitation, as well as the best dated earliest evidence for the use and modification of pigments (Marean et al. 2007). I think that this lack of evidence for a period of material cultural complexity prior to 120 ka is largely an illusion born of a lack of sites.

Why has the South African coast produced such a rich record of behavioral complexity so early? I will argue below that this record reflects a unique confluence of context and evolutionary events, with marine shellfish collection being a key ingredient. I hypothesize that the progenitor population, the small bottlenecked group detected in the genetic analyses, was on the south coast of South Africa exploiting the rich shellfish beds and geophyte food resources. Together, these food resources presented an ideal nutrition package during the long cold glacial of MIS6. But this also raises an important question – why did hominins wait so long to expand their diet to the sea? I provide a hypothesis to explain this late dietary expansion to sea foods and suggest that this is further evidence that these hominins on the shore of South Africa had evolved a special cognitive system, one that already had in place the working memory and executive functions required to map a mobility system to lunar patterns and tidal rhythms. Modern humans are a terrestrial mammal that, in some cases, has a persistent use of marine resources that develops into a *coastal adaptation* characterized by technological and cultural peculiarities. This coupling of a terrestrial pedigree to focused utilization of sea resources reinforced through embedded cultural knowledge is another uniquely human adaptation among the primates and thus warrants careful consideration as to its origins and impact.

Environmental Context on the South Coast

The Cape Floral Region (CFR, Fig.18.1), a thin strip of land stretching from the east to the west coast, has many special characteristics (Cowling 1992; Goldblatt 1997; Cowling and Lombard 2002; Goldblatt and Manning 2002). This relatively small 90,000 km^2 region has about 9,000 plant species, making its diversity near to that of tropical rainforests with larger area, rainfall, and energy, and it has a very high diversity of endemic floral taxa (69%). The three largest vegetation types are fynbos, renosterveld, and succulent Karoo. Fynbos, the largest of the three, is dominated by mainly low-height, nonsprouting (postfire) shrubs with limited dispersal, few grasses, and few trees. Pinnacle Point is nearly exactly in the middle of the east–west extent of the CFR, and today it is the location of limestone and sandstone fynbos. At Pinnacle Point (average annual rainfall = 375 mm, average annual temperature = 17°C), more rain falls in the summer than winter and it is overall bimodel, and the region is warmed by the Agulhas current (Fig.18.1).

The diversity of geophytes (17% of all species) in the CFR is of special importance to hunter-gatherers – this diversity far exceeds other Mediterranean-climate biomes (Cowling and Proches 2005; Proches et al. 2005). It is widely recognized that geophytes were likely a prominent component in hominin diet (Hatley and Kappelman 1980; Wrangham et al. 1999). Geophytes are a preferred food source generally for the Khoi-San hunter-gatherers of the southern Africa subregion (Tanaka 1969; Lee 1975) and of hunter-gatherers more generally in Africa (Vincent 1984, 1985). Geophyte remains are abundant in Later Stone Age (LSA) archaeological sediments (Parkington 1980, 1981). Geophytes typically have high yields of carbohydrate, temporal predictability, and humans face a relative lack of competitors for their exploitation compared to aboveground fruits, nuts, and seeds. I differ from Parkington who writes "Arguably it was the incentive provided by the poor and seasonal resources of the near coastal landscape juxtaposed to very productive intertidal ecosystems that persuaded people to experiment with and then emphasize the collection of marine foods." (Parkington 2001:330) This superdiversity of bulbs must have been extremely productive for hunter-gatherers, and the seasonality reduced in the bimodel rainfall south coast.

The CFR is distributed in a long thin line along one of the richest coastlines in the world (Branch and Branch 1992; Bustamante and Branch 1996), at the confluence of the Benguella Upwelling and the Agulhas Current (Lutjeharms et al. 2001). This creates a varying oceanic environment from west (cold water, lower diversity,

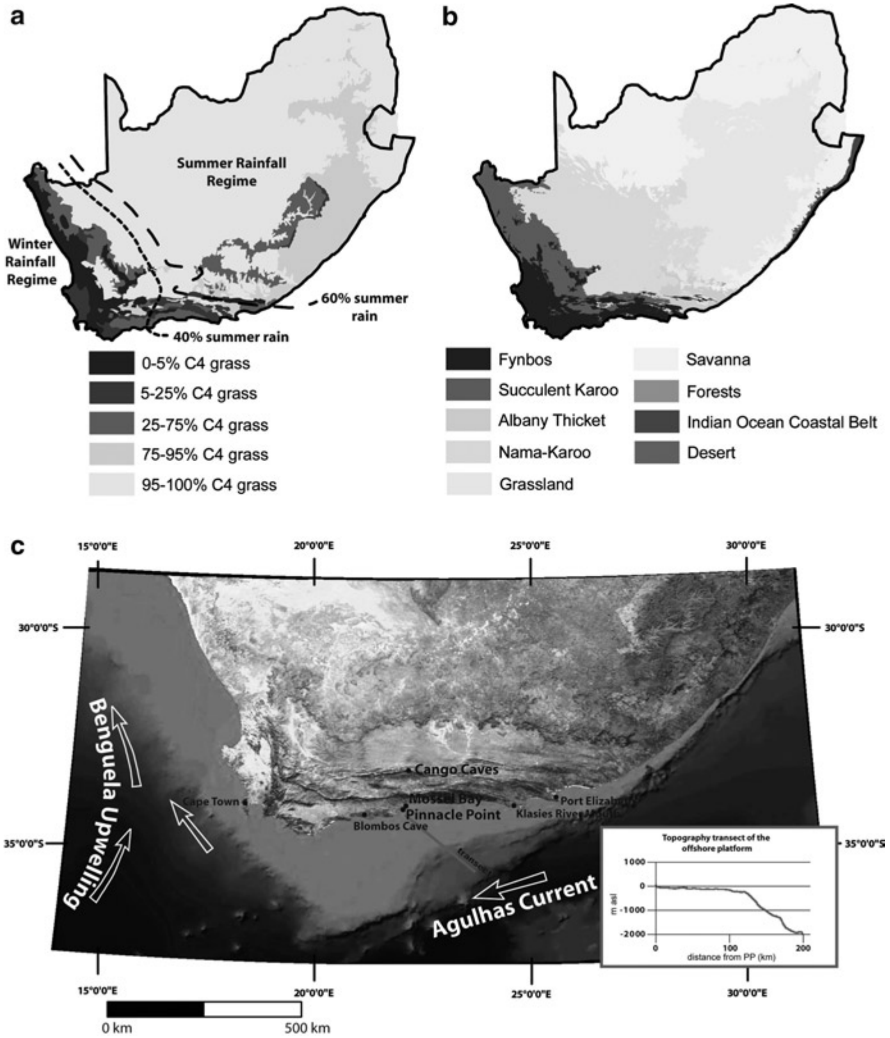

Fig. 18.1 Location of Pinnacle Point and other sites cited in the text in South Africa, the major vegetation zones, distribution of C3 and C4 grasses and configuration of offshore platform. (**a**) Distribution of C4 grasses as a percentage of all grasses (from Vogel 1978) (**b**) distribution of vegetation biomes in South Africa, (**c**) the location of sites mentioned relative to the coast and offshore platform. Base image of South Africa and oceanic topography from NASA World Wind, and the offshore platform transect was generated from the 3D Paleoscape model (Fisher et al. 2010)

greater biomass) to east (warmer water, increasing diversity, lower biomass) but with a mix of cold and warm eddies along the south coast. The result is that the south coast provides a diverse and dense shellfish population on the rocky intertidal zones of the quartzitic sandstones of the Table Mountain Group (TMS) and coastal beach rocks and eolianites, as well as sandy beach species. Once a forager expands their diet to shellfish, the south coast provides an excellent protein source in the form of shellfish. Other protein sources are available as well, including Cape Fur seal, which can be hunted at onshore rookeries, or scavenged from wash-ups (Parkington 1976, 1977; Marean 1986). A diverse rocky shoreline fish population rounds out the marine offerings (van der Elst 2000), and seabirds are available for hunting and as wash-ups (Avery 1987).

The glacial aridity that depresses terrestrial productivity has a more ameliorated impact on shellfish densities and diversity, and in fact biomass increases as ocean temperatures decrease across the south coast (Branch and Branch 1992). Geophytes are well adapted to arid conditions, and the high endemic diversity of this group in the CFR shows clearly that geophytes were always abundant even during the harshest climate cycles (Proches et al. 2005, 2006). So both shellfish and geophytes would have remained a stable source of food through the glacial MIS cycle.

The bi-model rainfall of the south coast, and the relatively less harsh climate compared to the west coast, makes this region relatively lacking in seasonality. This geographic confluence of diverse geophytes, rich shellfish beds, and ameliorated climate provide a unique (for Africa) rich co-association of carbohydrate and protein that even during cold dry conditions of MIS6 would have continued to be productive and predictable, unlike other African floral and faunal biomes from interior locations and further to the west. This produced a singularly rich refugium zone for early modern humans during MIS6 on the south coast. I call this the Cape Floral Region – South Coast Model for the origins of modern humans (Marean 2008).

The gradual slope of the Agulhas bank produced a Pleistocene coastline that regressed and transgressed in association with glacials and interglacials, respectively. We have developed a 3D paleoscape model that generates estimates of the distance and placement of the coastline at 1.5 ka increments through the last 440,000 years (Marean et al. 2007; Fisher et al. 2010). This model shows us that the coastline was at times as far away as 90 km during glacial maxima. A high-resolution speleothem record, dated between 92 and 55 ka (Bar-Matthews et al. 2010), suggests that during colder periods, as the sea level dropped, the south coast received more summer rain and the neocoastline was enveloped in more C4 grassy vegetation. The CFR may have followed the coastline out onto the Agulhas bank.

The Evolution of the Coastal Adaptation

Systematic coastal adaptations are well-known throughout the world where coastal resources are productive (Erlandson 2001). Hunter-gatherers may occasionally exploit coastal and littoral foods to supplement a largely terrestrial diet, and other terrestrial mammals (such as baboons, Hall 1962) do this as well. But there are many ethnographic examples of hunter-gatherer adaptations of varying levels of complexity *focused* on coastal resources, such as the Australian Gidjingali shellfish collectors (Meehan 1982), the Tlingit of the Northwest coast of North America (Moss 1993), and the Chumash of California (Gamble 2008).

In these *coastal adaptations*, hunter-gatherers design mobility systems to intercept the coast for significant portions of the year (or even stay there all year), the people receive a substantial portion of their protein from shellfish and fish, they embed in cultural knowledge and traditions the importance of the lunar scheduling of the tides, and they schedule their activities, and sometimes worldview, around the tidal rhythms of the sea. Some of this complex lunar-tidal cultural knowledge characteristic of people with coastal adaptations has been captured in rare hunter-gatherer ethnography and historical literature (Meehan 1982; Moss 1993; Gamble 2008) but is better known from populations that are now either food producers or embedded in agricultural economies (Cordell 1974; Alves et al. 2005; Nishida et al. 2006a, b). In archaeological contexts, this coastal adaptation is archaeologically manifested by substantial portions of marine animals occurring as food remains in archaeological sites, or even "shell middens," where the sedimentary matrix is substantially or predominantly shell (Erlandson and Moss 2001; Erlandson 2001). Other ways to identify a coastal adaptation include stable isotope analysis of skeletal material (Sealy and Van der Merwe 1987; Sealy and Sillen 1988), but to date such analyses have not been conducted on the rather small South African MSA hominin sample.

The South African archaeological record provides the world's earliest and richest record for the origins and evolution of the coastal adaptation. Until recently, this record was restricted to sites that postdate the MIS5e high sea stand (~123 ka). This is almost certainly due to a series of related phenomena. First, many of the caves and rockshelters in coastal South Africa are below +10 msl, and thus the sediments were subject to being washed out or seriously eroded by the MIS5e high sea stand, which stood at +5–6 msl (Hearty et al. 2007). Second, MIS6 populations were likely quite small, and probably focused their residential core near the coast, which during MIS6 would put their sites out on the coastal platform, and now underwater, on much of the South African coast (Marean et al. 2007; Fisher et al. 2010).

These post-MIS5e MSA sites (Fig.18.2 and 18.3), with rich records of shellfish collection, include Klasies River (Singer and Wymer 1982; Deacon and Geleijnse 1988), on the Tzitizikamma on the east portion of the south coast, and Blombos Cave (Henshilwood et al. 2001b), on the west of the south coast. Die Kelders Cave 1 is a difficult case because identifiable shellfish are not preserved in the MSA deposits, but traces of shellfish have been identified in micromorphology (Goldberg 2000), so it is possible that shellfish were once well represented there. Cape fur seal remains appear regularly but at low levels through the sequence (Marean et al. 2000; Klein and Cruz-Uribe 2000). The Die Kelders Cave 1 dating results so far have produced widely scattered ages (Feathers and Bush 2000; Schwarcz and Rink 2000). For these reasons, I do not discuss it further here. A more recently excavated site, Ysterfontein 2, has several occupations with dense shellfish representation (Halkett et al. 2003; Avery et al. 2008). However, the age of the deposits is unclear, so it is currently impossible to fit the sequence into an analysis of the development of a marine adaptation. Pinnacle Point provides a unique sequence by virtue of its extension into MIS6 at PP13B. PP5–6 is currently under excavation and provides a sequence so far back to ~80 ka and likely older (Brown et al. 2009), but the shellfish have not yet been studied.

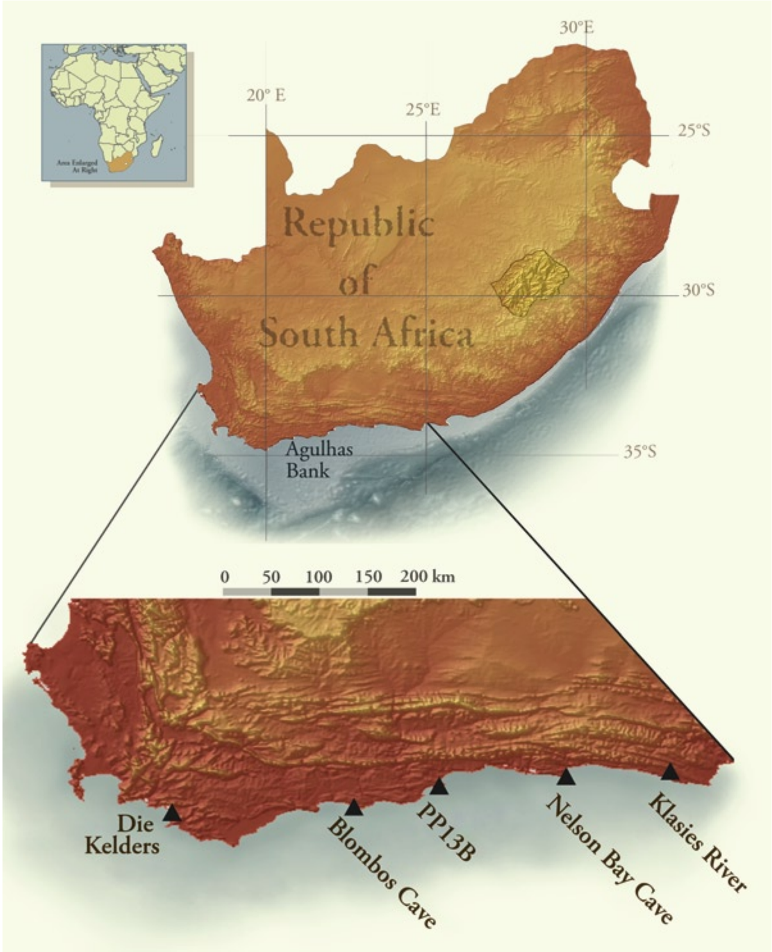

Fig. 18.2 Map of the major sites mentioned in the text

In Tables 18.1 and 18.2, I summarize the record from this set of sites. The shellfish from Blombos Cave have been reported in a preliminary manner (Henshilwood et al. 2001b), while the Klasies River shellfish have received more detailed treatment (Voigt 1973; Thackeray 1988). PP13B have been described in detail (Marean et al. 2007; Jerardino and Marean 2010). Along the left column of each table, I establish several temporal spans that range from ~170 to ~50 ka, which is currently the maximum dated time range of the coastal MSA. Most of the ages in South Africa have been determined by optically stimulated luminescence (OSL), thermoluminescence (TL), and electron spin resonance (ESR). With each of these techniques, the 2-sigma precision is often at 10–30% of the age. In the case of TL and ESR, there is often significant scatter to the published ages from the same layers, while this is not so typical of single-grain OSL. Overall, this means that there

Table 18.1 The appearance of exploitation of rocky shores and both rocky and sandy shores in shellfish collections from four archaeological sites along the south coast of South Africa

Age ka	Blombos Cave	PP13B	PP9	Klasies River
70–50	X	X	X	Rocky/Sandy
90–70	Rocky	X	X	Sandy/Rocky Rocky
120–90	Rocky	Sandy/Rocky Rocky	Rocky	Rocky Rocky
125–120	X	Rocky	X	X
170–160	X	Rocky	X	X

If a site has two distinct occupations within a time interval, then this is indicated by more than one line of text within that time interval. An X indicates that no occupation is known or published during that time interval

Table 18.2 The appearance of different shellfish intertidal collection zones (Cochlear Zone, Lower Balanoid Zone, and Upper Balanoid Zone) in four archaeological sites along the south coast of South Africa

Age ka	Cochlear Zone (very low spring tide)	Lower Balanoid Zone (low spring tide)	Upper Balanoid Zone (low neap tide)
70–50	Klasies	Klasies	Klasies
	Klasies	Klasies	Klasies
90–70	Blombos	Klasies Blombos	Klasies Blombos
	Blombos	Blombos	Klasies Blombos
120–90		Klasies	Klasies
			PP13B PP9
			PP13B PP9
125–120			PP13B
170–160			PP13B

Also indicated in parentheses is the minimum tide needed to safely exploit that zone on the south coast. If a site has two distinct occupations within a time interval, then this is indicated by the site being listed on more than one line of text within that time interval

is quite a bit of room for temporal uncertainty – I try to take this into account. In Table 18.1, I list the major sites across the top and then indicate if the site has an occupation in that temporal span (if not this is indicated by an “X”). If it does have an occupation, I indicate whether the shellfish signal a “rocky shore” exploitation, or a “sandy beach/rocky shore.” In the latter case, this is signaled by high frequencies of the sand mussel *Donax serra*. No sites show an exclusive use of sandy beaches. Rocky shore exploitation is signaled by mussels, various species of limpets, and *Turbo* (locally called alikreukal), and it is common to have an exclusive “rocky shore” signal.

In Table 18.2, I take the same sites and temporal groups and indicate the deepest portion of the intertidal zone that is represented by the shellfish. Over the last several years, I have made systematic observations on the safety of access and exposure of shellfish at Pinnacle Point (a TMS rocky intertidal zone directly exposed to the Indian Ocean) and Tergniet/Rhebok (a gradually sloping planed-off beachrock and eolianite reef in a more protected context within Mossel Bay). These observations show that even at the top of the intertidal zone (Upper Balanoid Zone), where brown mussels dominate, regular safe collection is only possible during low tides. Further into the intertidal zone (Lower Balanoid and Cochlear Zone), this pattern is accentuated, and low spring tide is the only time one can gain safe access. Storms and rough seas further reduce periods of safe access. Thus, the range of shellfish exploited coupled to knowledge of their relative positions in the tidal zone is a potential proxy for how attentive hunter-gatherers are to the tidal rhythms of the sea, and how strictly they may be scheduling their visits to the coast.

While our sample from South Africa includes only a few sites, these few sites sample a wide range of time and provide adequate samples that have been well described. The summarization in Tables 18.1 and 18.2 clearly shows a temporally vectored change in the way these early modern humans exploited the intertidal zone. True shell middens first appear early in MIS5; however, I do want to caution that the lack of true shell middens at earlier periods may partially reflect dissolution of shell, as clearly happened at PP13B in the LC-MSA (Marean et al. 2007). The earliest occupations show an exclusive use of rocky intertidal zones and only the Upper Balanoid zone. This zone can be exploited at low neap tide but is best utilized at low spring tide. The relative lack of Lower Balanoid species is striking and may signal that people are not scheduling their visits during low spring tides or have not yet sufficiently intensified their coastal adaptation to the point that they have pushed into the harder to exploit limpets of the Lower Balanoid zone. This expansion first begins to appear within MIS5, where true shell middens appear at both PP13B and Klasies River. Klasies River shows a first expansion to the Lower Balanoid Zone, and sandy beach exploitation first appears at PP13B. After this, between 90 and 70 ka, there is a clear expansion to the full intertidal zone, all the way to the Cochlear Zone, regular production of shell middens, and use of sandy beaches and rocky shores. Given this apparent progression and intensification in coastal adaptation, I want to address a question that I always hear when I discuss the origins of the coastal adaptation – why did early humans wait so long to exploit the sea and set in motion this development of the coastal adaptation?

The Challenge of Systematic Coastal Foraging

Tropical hunter-gatherers utilize mobility systems that we can divide into an annual home range (the area used by a band within a year) and the daily foraging radius (the area surrounding a residential site that can be exploited in one daily trip) (Binford 1980, 1982; Kelly 1995). The ethnographic record from Africa, and in fact the larger record from tropical to subtropical regions, shows that the use of space around a residential site (camp or home base) is typified by daily foraging trips defined by what a person can walk out and back in one day, generally 8–12 km

(Binford 1980, 1983; Kelly 1995), and this is well illustrated in Khoi San ethnography (Lee 1972; Tanaka 1980; Silberbauer 1981).

This foraging radius is a zone that, over the time of its exploitation, will show depleting foraging returns (McArthur and Pianka 1966; Charnov 1976; Krebs and Davies 1981; Stephens and Krebs 1986; Smith 1991; Krebs et al. 1999). When hunter-gatherers place their residential site directly on the coast, then if they eschew coastal resources they are presented with a foraging radius of roughly 50% the size and potential return of a comparable foraging radius that is further to the interior and does not engulf the coast. This rather self-obvious result predicts that hunter-gatherers should very rarely locate their residential sites at the coast if they do not forage off coastal resources. Keeping in mind that a site on the coast has half the exploitable terrestrial area of a site more than 10 km inland, this means that we would not expect sites to be on the coast until hominins commanded the ability to drive up return rates from coastal resources to equal or surpass the returns for fully terrestrial site locations. How do hominins accomplish this?

The shellfish exploited by early modern humans on the south coast were all intertidal, so tidal variation is crucial to scheduling of coastal visits. Tidal variation occurs at several levels – yearly (the presence and absence of equinox tides), lunar month (spring and neap tides), and lunar day (low and high tides), with the latter two being most significant to a forager, though it has been noted that equinox tides are monitored and targeted by foragers (Meehan 1982; Kyle et al. 1997). Lunar monthly variation has two opposing states classified into spring and neap tides, which are driven by lunar position relative to the sun (Fig.18.4). When the sun and moon align, their gravitational forces are additive and spring tides occur where the low tide is very low and the high tide is very high (tides "spring" back and forth). Spring tides correspond to full and new moons. When the sun and moon are not aligned, their gravitational force is subtractive, resulting in neap tides that hover more tightly around the midtidal (mean sea level) mark.

In areas with gradual vertical decline of the offshore platform, such as the south coast of South Africa, spring lows reveal substantial areas of the intertidal zone, and these are the most productive and safest times to collect intertidal shellfish (Meehan 1982; Lasiak and Dye 1989; Kyle et al. 1997; de Boer et al. 2002). In rocky shores, even foraging during spring lows requires vigilance for waves in the lowest exposed areas (Lower Balanoid and Cochlear zone). A neap tide forager must target a narrow band of productivity that is subject to sudden wave onset. Since most low tides occur during daylight only once per day, there is a very tight temporal band of productive collecting available.

Ethnographic and historical accounts of hunter-gatherers document that shellfish collecting is typically done by women and children (Bigalke 1973; Meehan 1982; Hockey and Alison 1986; Claasen 1991; Moss 1993; Bird et al. 2002; de Boer et al. 2002). Women tend to focus food collection on low-risk and nondangerous foods, and many of these same ethnographic accounts document a strong preference and sometimes exclusive use of low spring-tide shellfish collection. My long-term observations of tidal variation and safety of access around Mossel Bay shows that only spring tides on the south coast present prolonged, safe, and easy access to

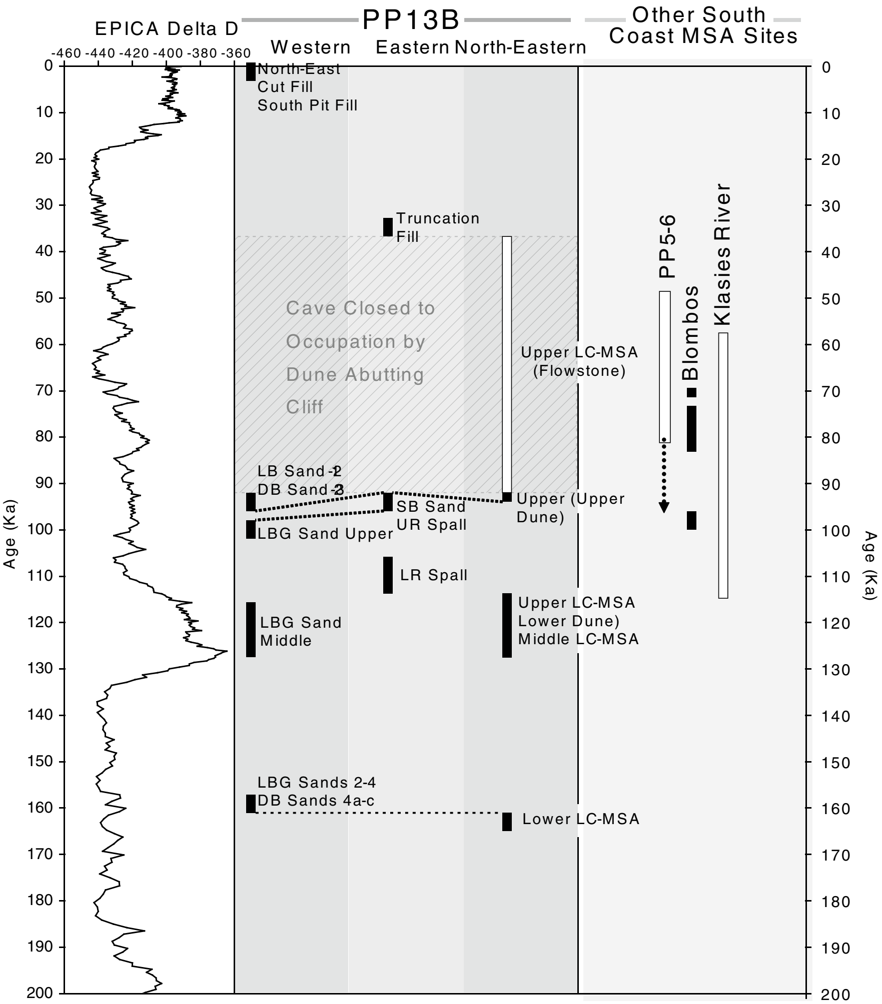

Fig. 18.3 Timescale of the sites where the shellfish characteristics are compared

rocky intertidal taxa, and this is particularly true of the Lower Balanoid zone and below. Figure 18.4 schematizes these observations. This suggests that along the south coast shellfish return rates, and thus the value of a coastal location for a residential site, rises and falls with the moon and tides. The returns of terrestrial resources are seasonally driven and not subject to lunar patterns, so over a lunar month coastal return rates fluctuate by lunar month around seasonally fluctuating terrestrial resources.

Lunar-forced variation in availability and return poses several challenges for a would-be human shellfish collector. Coastal locations inhabited during neap tides will have relatively low return rates, while coastal locations inhabited during spring

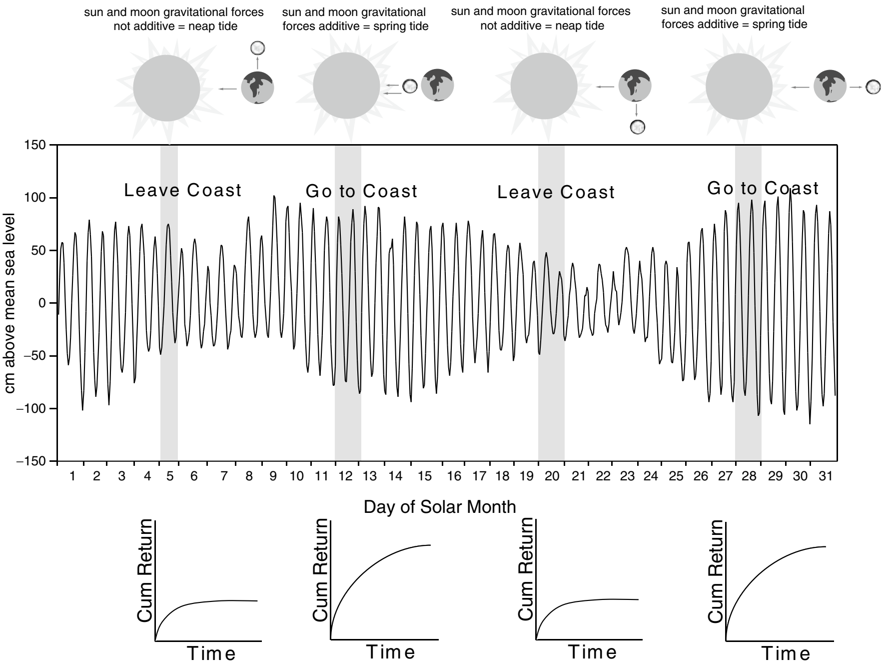

Fig. 18.4 Tidal variation relative to lunar cycle, and estimates of cumulative return rates and movement patterns from it. The tidal variation for January 1998 and its tide gauge data from the Mossel Bay tide gauge supplied by the South African Navy Hydrographic Office

tides will have relatively high return rates. Random use of the coast is highly inefficient, and would be atypical for hunter-gatherers. A human forager should schedule visits to coastal residential sites at times during the lunar month when spring tides are present and then move slightly inland during neaps to broaden the size of the exploitable terrestrial area. The math for calculating spring tides is rather difficult if one relies on solar days. The lunar month is 27.3 solar days; tides advance 25 min per tide, or 50 min per day.

I suggest that this unique lunar forcing of availability and return rates poses a special cognitive challenge to the hominin forager and is doubly difficult, since most of the time the lunar signal occurs at a time when one cannot see the tides (it is nighttime). The complexity of estimating tides is why fisherman and other coastal enthusiasts rely on complex printed tide schedules or programmed watches. If a hominin forager is moving about the landscape, and wants to schedule their visits to the coast so as to intercept the spring tides, they must have a clock of some type, the main candidate being lunar observation.

Once a forager has moved to the coast, and is targeting shellfish, the forager still faces the challenge of hitting the low tide. This may seem as easy as looking down at the water, but this is only true if one has a clear and near view. Tidal conditions are virtually impossible to see if one is not close to the shoreline, and they are very hard to predict due to the 25 min advance of each tide relative to the solar day. The lunatidal interval (the difference between the time that the moon passes the meridian and the high tide) varies by geographic coordinate (at Mossel Bay it is about 3 h and 16 min), so developing a comprehension of the relation between moon and tidal variation requires recurrent observation. The obvious solution is to place one's residential site right at the water's edge, but that may not always be possible or convenient. Meehan (1982) notes that even expert shellfish collectors regularly made errors in timing the low tide, and once they arrived and found that they have missed the low, they abandoned the foraging foray and walked back to camp, which was typically set several kilometers back from shore.

Being an efficient human shellfish collector requires the novel connection of lunar patterns to tidal variation to shellfish return rates and safety of collection, substantial planning abilities, and communication of complex parameters between group members. All of this is a signal that the enhanced working memory and executive functions (Coolidge and Wynn 2009) of the modern human intellect are in place. Only marine and littoral foods vary by the lunar clock, making the recognition of the lunar to tidal link a clear novel connection, and its multigeneration implementation and refinement a potent example of the ratchet effect. I suggest that coastal settlement became energetically efficient when humans developed the cognitive complexity necessary to understand the relationship between lunar stages and spring tides. The complex lunar-based systems for monitoring and communicating lunar time and tidal variation that are well documented ethnographically (Cordell 1974; Alves et al. 2005; Nishida et al. 2006a, b) would develop to embed this knowledge and facilitate its teaching. Once the settlement is within walking distance of the coast (but not immediately adjacent), timing the visit to intercept the low tide required equally difficult timing and planning.

How do other animals that are not cognitively advanced exploit intertidal resources, and schedule their rhythms around tides and lunar schedules? Among sea animals behaviors that schedule to tidal rhythms are almost all certainly genome-based behavior. The rocky shoreline fish of course have the majority of their behavior embedded in the genome, so natural selection has driven their adaptation. Some seabirds, such as oyster catchers (*Haematopus moquini*), utilize rocky intertidal species (in this case, limpets and mussels). Unlike humans, they can avoid swells through flying straight up and almost certainly like fish have a genome-based behavioral adaptation to tidal patterns. It goes without saying that humans lack this genome-based knowledge – if we had this we would not require tide charts, watches, or cultural systems of lunar-tidal knowledge. I know of no terrestrial mammal that, like humans, has an adaptation that joins terrestriality with persistent and focused use of coastal resources. Some, such as baboons, are known to exploit shellfish occasionally and opportunistically, but these are not coastal adaptations as defined above.

This terrestrial lifeway joined to persistent use of marine resources is another uniquely human adaptation, one that occurs late in the human origins story. I think that the systematic and efficient shellfish collection by early modern humans required the evolution of cognitive complexity that made its first appearance roughly coincident to when the modern human lineage first appeared (~200–140 ka). This allowed the novel connection between moon and coastal food, and opened an entirely new niche for humans that had many important benefits.

Conclusions

The south coast of South Africa has an unusual confluence of plant diversity, coastline richness, and moderate climate that I think provided the ideal conditions for a refuge for the bottlenecked modern human lineage during the long cold MIS6. The expansion of this population's diet to shellfish was likely crucial to their survival and provided the ideal conditions for the development of the complexities in behavior expressed in the archaeological record from this region. The earliest evidence for shellfish exploitation comes from this region at ~164 ka, but I suspect that early modern humans were exploiting shellfish out on the now submerged continental shelf before this date. I have proposed that their ability to expand their diet to this new resource was a benefit of the development of the modern human cognition that appeared coincident with the origin of the modern human lineage. A complex cognition characterized by fully modern working memory and executive functions allowed them to link lunar phases to tidal rhythms and, thus, develop an effective way to schedule visits to the coast in a manner that maximized returns from the coastal resources. Once this was done, this set in motion a progressive increase in the complexity of the marine adaptation along with an increasing emphasis on coastal resources that culminated by 90 ka with dense shell midden accumulations with collection at the Lower Balanoid Zone and Cochlear Zone, and the use of both rocky and sandy beach contexts. Throughout this time, there is regular, but rare, use of marine mammals such as Cape fur seal and whales, probably through scavenging. By 70 ka, there is the first rare evidence for fishing (Henshilwood et al. 2001b). Upon entering the Holocene, the full range of coastal prey, short of deep-sea fishing and diving, is common in South African sites (Jerardino et al. 2008).

The expansion of the diet to marine foods must have had major, cascading impacts on human diet, nutrition, technology, and mobility. Omega-3 fatty acids are critical to healthy brain growth and placental development, and while marine foods are not the only source (Langdon 2007), they are the best source and their addition to the diet can have substantial fitness benefits (Broadhurst et al. 2002). Unlike the latter authors (see also (Parkington 2003; Parkington et al. 2009)), I do not think that the addition of marine foods stimulated the development of the modern human cognition. Rather, this dietary expansion was a *consequence of that cognition*. I do agree though that a coastal niche provided excellent incubation conditions for the *material cultural expression* of behavioral complexity and may explain the rather singular material cultural complexity evident in the South African archaeological record during this crucial phase in the origins of modern humans.

Coastal adaptations facilitate larger group size and reduced mobility (Erlandson 2001). These larger group sizes place added selective pressure on more effective mechanisms for mediation of social relationships. The typical economic contract between men and women, where men provide the protein, is challenged by the coastal adaptation, with possible widespread effects on intersex relations. We can possibly expect social structures with greater evenness if protein is supplied by women (Hawkes 1996; Hawkes and Bliege-Bird 2002) but also by women collecting shellfish in relatively unthreatening circumstances with their children. With further fieldwork, high-quality methods, and highly resolved chronology, we may be able to investigate these interesting possibilities with this rich coastal archaeological record.

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Chapter 19
Coastal Foragers on Southern Shores: Marine Resource Use in Northeast Australia since the Late Pleistocene

Sean Ulm

Introduction

The sea is central to the lives of contemporary coastal Aboriginal and Torres Strait Islander people across northeast Australia. Indigenous histories and documentary sources show the sea to be a vital source of subsistence, raw materials, spirituality and connection with other peoples. Coasts, and especially islands, were a focus of occupation, with high population densities linked to low mobility along the length of the Queensland coast. But what are the antecedents of these people–sea relationships? In this review, the archaeological evidence for coastal foraging across northeast Australia from the late Pleistocene is explored and the main themes and challenges in developing an understanding of how coastal resources figured in the lives of ancient Australians are discussed.

Queensland in northeast Australia is taken as the focus of the review (Fig. 19.1). This region has received renewed attention in archaeological debates, with genetic evidence identifying adjacent Papua New Guinea as one of several likely entry points for colonisation of the continent (see review in van Holst Pellekaan 2008). The earliest occupation of northeast Sahul (the combined landmass of Papua New Guinea, Australia and Tasmania) occurred between 40 and 50 RCYBP (David et al. 2007). Given that many of the earliest sites are located far inland, we can assume that people arrived on the northern coast of Sahul some time before 50 RCYBP, most likely between 50 and 60ka BP. Many commentators have noted that the required island-hopping route to Australia prefigures a strong coastal adaptation (Bowdler 1977; Bulbeck 2007). Although coastlines were clearly important in the initial colonisation and subsequent dispersal of people in Australia (Rowland 1996), the role of coastal areas in these early economies is debated (Beaton 1995; Veth et al. 2007).

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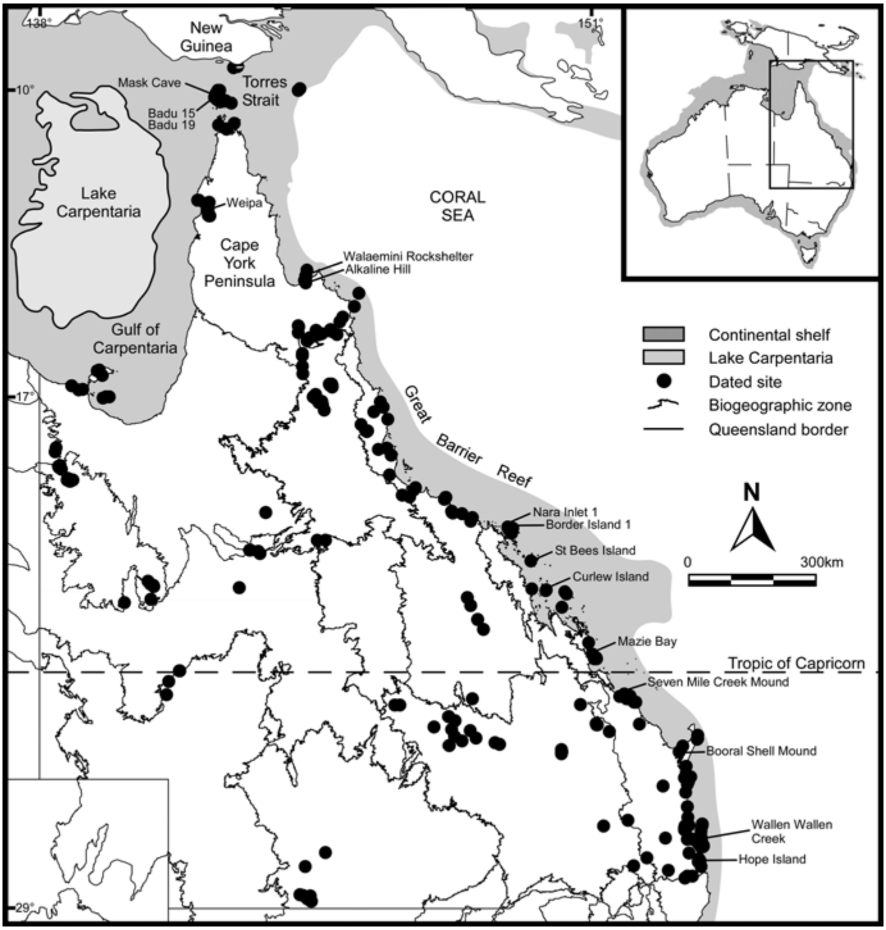

Fig. 19.1 Distribution of dated archaeological sites in northeast Australia (Ulm and Reid 2000). Sites mentioned in the text are named

Over the last 2 decades, general syntheses of regional archaeological patterns have emerged for well-studied parts of northeast Australia, emphasising significant increases in coastal site numbers and use since the mid-Holocene (Fig. 19.2) (e.g. Barham 2000; Barker 2004; McNiven 1999; Ulm 2006; Ulm and Hall 1996; Walters 1989). Many of these studies emphasise the primary role of marine resources in the elaboration of social complexity (e.g. Barker 2004; Walters 1992). However, others have pointed to environmental (Rowland 1999), sampling (Ulm 2004) and preservation factors (Bird 1992; Rowland 1989) that may be responsible for shaping these archaeological patterns. These issues are explored here through a review of the environmental context for human settlement and use of the coasts and consideration of the archaeological evidence for coastal occupation since the late Pleistocene.

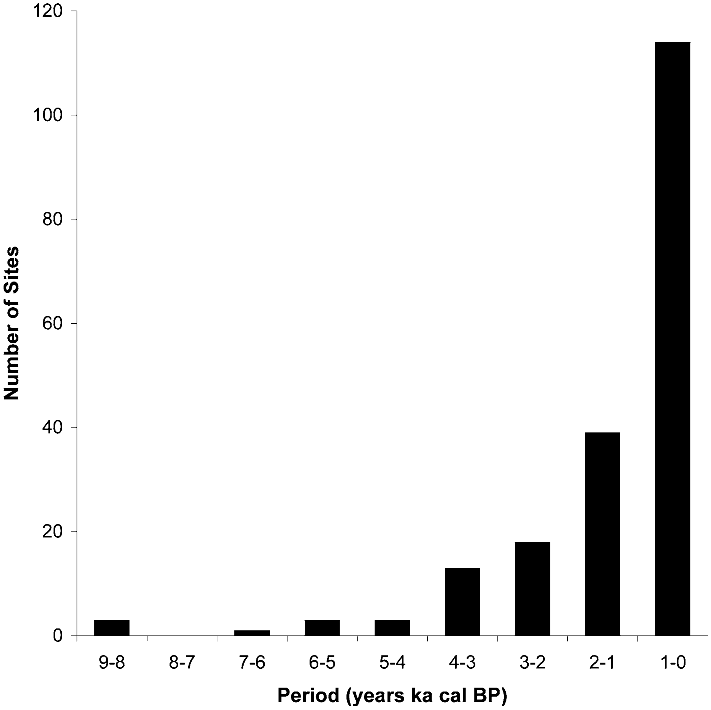

Fig. 19.2 Number of new sites established on the Queensland coast in each millennium (Ulm and Reid 2000)

Environmental Considerations

The Queensland coastline is 13,347 km in length and extends through 19° of latitude. The east coast is dominated by the Great Barrier Reef and the north coast by the shallow Torres Strait separating Australia and New Guinea and the broad Gulf of Carpentaria to the west of Cape York Peninsula. Islands are a prominent feature, with 1955 islands comprising 6,374 km of coastline (Geoscience Australia 2009a, b). Coastlines grade from high-energy sandy beaches anchored to rocky headlands in the south to low-energy depositional coastlines across much of northeast Australia. The length of the coast is punctuated by extensive estuaries and embayments bordered by saltflats and claypans comprising recent sediments (Hopley 1985).

Coastal conditions in northeast Australia were very much different from today for most of the length of human occupation. At the height of the last glacial maximum (21–19ka cal BP) sea levels retreated as much as 123 m, connecting northeast Australia to New Guinea across Torres Strait and enlarging the current landmass by more than one quarter (Fig. 19.1) (Hanebuth et al. 2009). On the east coast the continental shelf is up to 250 km wide and at times of maximum low sea level would have had a limestone ridge comprising ancient coral reefs created during earlier high-sea stands along its seaward margin, terminating in a sea cliff where it intersected the continental rise. Mulvaney and Kamminga (1999:116) among others have suggested that sea caves formed at the base of these limestone cliffs may have provided locales for early human occupation of Australian coastlines. For much of the late Pleistocene the northwest of Queensland (the present-day Gulf of Carpentaria) was part of a broad low-lying savannah corridor linking Australia and New Guinea and dominated by a large freshwater lake (Lake Carpentaria) fed by rivers from both northern Australia and southern Papua New Guinea (Fig. 19.1). Between c.40 and c.12.2ka BP Lake Carpentaria was fully lacustrine, reaching its maximum extent of c.190,000 km^2 around 14ka BP followed by first marine incursion associated with sea-level rise at 12.2ka BP (Reeves et al. 2007). Palaeoenvironmental studies suggest that the exposed coastal plain was vegetated by savannah grasslands and woodlands. Although access to coastal resources by people may have been difficult at periods of maximum sea-level fall, expanded river valleys across the continental shelf would have offered a range of resource zones, some perhaps with no modern correlates.

Shortly before 19ka cal BP, sea levels began to rise with a rapid period of transgression in the terminal Pleistocene (Hanebuth et al. 2009). The great width and low gradient of the continental shelf in northeast Australia meant that sea-level rise shifted the coastline by more than 1,000 km in places such as the Gulf of Carpentaria (Sullivan 1996). As Mulvaney and Kamminga (1999:121) note, this would have created an intertidal zone up to several kilometres wide, dramatically impacting on the structure of coastal resources and during some periods bringing each high tide higher than the last one.

By the early Holocene the coastline would have been close to its present position around much of northeast Australia. Sea levels peaked +1.0 to +1.5 m above current sea levels between c.7,000–7,500 and c.2,000 cal BP, before dropping to approximately modern values (Lewis et al. 2008; Sloss et al. 2007). Recent studies also suggest oscillations around 4,800 and 3,000 cal BP associated with sea-level falls, which impacted on the growth of coral reefs and intertidal shellfish communities (Lewis et al. 2008).

Beaton (1995) distinguished between procumbent and precipitous coastal profiles. Procumbent coastlines dominate northeast Australia and are characterised by low-energy shorelines with gentle slopes. Precipitous coasts comprising steep rocky shores are more common in southern Australia. This is a key distinction in understanding the impacts of marine transgression on coastal foragers. The impact of rising sea levels on precipitous shorelines is primarily in the vertical dimension, where relative stability might be expected in the distribution of resources and the potential for survival of occupation sites. However, procumbent coasts are primarily affected horizontally, with dramatic redistributions of resource zones associated with major landscape reconfigurations, associated with low site preservation rates.

Late Pleistocene/Early Holocene (50–6ka BP)

There is strong evidence that people have used coastal resources since initial colonisation of the continent. Rockshelters in Island Melanesia on the northeast periphery of the expanded continent of Sahul contain sometimes dense assemblages of marine resources dating to the late Pleistocene (e.g. Allen et al. 1989). Late Pleistocene coastal resource use has also been reported from parts of Australia which have always been in close proximity to the sea, particularly in the northwest of the continent (e.g. Morse 1988; O'Connor 1999; Veth et al. 2007). Although the first direct evidence for marine resource use in northeast Australia dates to the early Holocene (see below), one can assume that the coasts of northeast Australia were also used from the earliest period of occupation. Early marine resource use is poorly documented because few coastal sites date to before the mid-Holocene, many others presumably having been inundated by sea-level rise. Beaton (1995) pointed out that the few coastal subsistence remains which survive from the late Pleistocene cannot be construed as coastal economies and in the only major study available, Veth et al. (2007) convincingly argue that marine resources dating to this period were just one component of broad-based economies.

Beaton (1985) suggested that the coastal zone would have been abandoned with sea-level rise and only recolonised in the late Holocene when stable coastal resource communities were established after sea-level stabilisation. The notion of a time-lag between sea-level stabilisation and coastal occupation, related to the slow development of littoral resources, has been persistent in explaining changes in Australian coastal resource use (e.g. Hall and Robins 1984; Lampert and Hughes 1974; McCarthy 1943; Walters 1989, 1992). Palaeoenvironmental data, however, indicate that a variety of marine communities were in place by the end of the marine transgression. Radiocarbon determinations on relict Holocene shellbeds in southern Queensland demonstrate the presence of a variety of molluscan communities by 7,500 BP (e.g. Wood and King 1974). Fringing coral reefs were also present in near-shore areas before the mid-Holocene (Hekel et al. 1979; Woodroffe et al. 2000), suggesting that marine fauna associated with coral communities may have also been present by this time (cf. Barham 2000:284). Cores from coastal areas and the drowned continental shelf also show the persistence of mangrove communities throughout the transgression (Hull 2005). The presence of mud crab (*Scylla serrata*) in early Holocene archaeological deposits also demonstrates the presence of taxa closely associated with mangrove communities (Barker 2004:141). Clearly, elements of biologically diverse coastal environments were in place by the early Holocene, but it is unclear whether resource availability and abundance are analogous to today in the absence of detailed modelling of transgressive events and other changes in marine and shoreline parameters to assess the impact of these events on biological systems (e.g. Jablonski 1980).

Although the effects of environmental change on coastal resources in specific contexts may have significantly influenced coastal occupation, the general applicability of the time-lag model has been overturned by the discovery of sites that demonstrate the use of coastal resources throughout the marine transgression. Yet rising seas clearly impacted on patterns of human occupation. McConvell (1996), using linguistic data, suggested that widespread migrations took place in the early to mid-Holocene related to rising sea levels. Others such as Mulvaney and Kamminga (1999:73), however, “do not believe in widespread evacuations of people when the seas rose”, instead arguing that the “regions that lost much territory quickly were probably least inhabited”. The meagre archaeological evidence does not shed much light on resolving these divergent views.

Wallen Wallen Creek on North Stradbroke Island in southeast Queensland provides one of the few Australian examples of a site that spans the transition from pre-coastal (terrestrial) to coastal (marine) assemblages. Radiocarbon dates place first occupation of the site at 21,800 ± 400 RCYBP (OxA-806), when it would have been located c.40 km inland on the edge of a major river valley. Although the site dates from the late Pleistocene, faunal remains are restricted to the upper deposit, dated to the last c.4,000 years. People initially focused on terrestrial resource exploitation (including wallabies and snakes), but then shifted their focus in the last 2,000 years to coastal resources (fish and shellfish) (Neal and Stock 1986).

Only three other coastal sites in Queensland are known to date to before the mid-Holocene (Table 19.1). Occupation of the Badu 15 rockshelter on Badu Island in Torres Strait dates from 8,053 ± 42 RCYBP (Wk-11947), when the island was still connected to the Australian mainland (David et al. 2004). After isolation, the site appears to have been effectively abandoned from 6,000 RCYBP until continuous occupation recommenced in the last 3,500 years. The site contains only stone artefacts, but its location 3 km from the modern coast does indicate that people were occupying coastal areas in the extreme north of Australia in the early Holocene, although the nature of that occupation is unknown.

The earliest *direct* dates for the use of coastal resources come from the Whitsunday Islands, where oyster (*Saccostrea* sp.) has been dated to 6,700 ± 60 RCYBP (ANU-11381) at Nara Inlet 1 and 6,440 ± 90 RCYBP (Beta-56976) at Border Island 1 (Barker 2004; Lamb and Barker 2001). These remarkable sites are located on rocky continental islands adjacent to deep water and were never far from the coast throughout the final stages of marine transgression. Nara Inlet 1 has a non-basal date on charcoal of 8,150 ± 80 RCYBP (Beta-27835) and a sequence showing continuing use of coastal resources from initial occupation (cf. Sim and Wallis 2008). Like Badu 15, Nara Inlet 1 (and possibly Border Island 1) was on a landform connected to the mainland at the time of first occupation. Rock platform gastropods dominate the shellfish assemblage, especially *Nerita undata*, with increases in discard in the last 2,000 years. Barker (1996, 2004) argues for a trajectory from ephemeral use of coastal resources in the earliest period towards specialised marine economies emphasising turtle and dugong procurement associated with intensive occupation such as that documented ethnographically in northern Australia (McNiven and Bedingfield 2008). Close examination of the data suggests alternative interpretations. Particularly problematic are Barker’s (2004) arguments for an increasing focus on turtle and dugong through time. At Nara Inlet 1, Barker (2004:141) calculates

Table 19.1 Queensland coastal and island sites with median calibrated ages for first occupation greater than 3000 cal BP (Ulm and Reid 2000)

Site	Radiocarbon age (RCYBP)	Median calibrated age (cal BP)	Lab. No.	Material
Wallen Wallen Creek[a]	8,200 ± 90	9,103	OxA-809	Charcoal
Nara Inlet 1	8,150 ± 80	9,022	Beta-27835	Charcoal
Badu 15	8,053 ± 42	8,866	Wk-11947	Charcoal
Border Island 1	6,440 ± 90	6,917	Beta-56976	*Saccostrea* sp.
Walaemini Rockshelter	5,210 ± 80	5,557	ANU-3041b	*Anadara granosa*
New Brisbane Airport	4,830 ± 110	5,497	Beta-33342	Charcoal
Teewah Beach 26	4,780 ± 80	5,457	Beta-25512	Charcoal
Hope Island	4,350 ± 220	4,884	Beta-20799	Charcoal
Mazie Bay	4,274 ± 94	4,733	NZA-456	Charcoal
Badu 19	4,060 ± 50	4,221	OZH-968	*Asaphis violascens*
Seven Mile Creek Mound	3,780 ± 60	3,925	Wk-8327	*A. trapezia*
Alkaline Hill	3,890 ± 70	3,847	ANU-3041a	*A. granosa*
King's Bore Site 97	3,560 ± 100	3,783	Beta-25510	Charcoal
Mourilyan Midden	3,827 ± 172	3,779	Wk-11350	Charcoal
Mask Cave	3,540 ± 50	3,759	OZH-275	Charcoal
Bribie Island 9	3,280 ± 80	3,455	Beta-56566	Charcoal
St Bees Island Rockshelter	3,180 ± 150	3,324	Unknown	Charcoal
Mort Creek Site Complex	3,430 ± 140	3,280	Wk-6986	*A. trapezia*
Eurimbula Site 1	3,020 ± 70	3,137	Wk-3945	Charcoal
Polka Point	3,020 ± 100	3,134	Beta-24540	Charcoal
Freshwater Bay Midden	2,970 ± 80	3,070	Wk-2691	Charcoal
Booral Shell Mound	2,950 ± 60	3,038	Beta-32046	Charcoal
Curlew Island Rockshelter	2,930 ± 120	3,029	Beta-54204	Charcoal

Median calibrated ages were calculated using OxCal 4.0 (Bronk Ramsey 1995)

[a] See text

a turtle meat weight contribution of 3,814.8 kg based on just 6.2 g of turtle bone. As Barker (2004:141) himself notes, the evidence for dugong is even more limited, with only a single tentative identification made. Hiscock (2008:169–170) showed that the Nara Inlet 1 and Border Island 1 assemblages actually demonstrate a trend towards generalised shore-based foraging and away from the targeting of large marine reptiles and mammals, with the highest rates of discard of turtle bone at Border Island before 6,000 years ago. This interpretation is in keeping with patterns of expanding diet breadth documented elsewhere in northeast Australia (see below).

Evidence for the use of marine resources from the early Holocene in Whitsunday Island rockshelters and sites elsewhere in Sahul located near palaeoshorelines and the coincidence of widespread coastal occupation with the final stages of marine transgression provide strong support for continuous use of coastal resources throughout the marine transgression, with people simply following the transgressive coastline (see Hall and Hiscock 1988; McNiven 1991; Rowland 1989).

Mid-Holocene (3–6ka BP)

Coastal archaeological sites older than 3,000 RCYBP are not common on the Queensland coast (Table 19.1). Put another way, there is only one site dating to before 3,000 years ago for every 600 km of coastline. Increasing numbers of coastal sites are known from around 5,500 RCYBP, broadly coincident with sea-level stabilisation. In addition to the Whitsunday Islands sites noted above, elevated rockshelters preserving evidence for marine resource exploitation appear at Princess Charlotte Bay (Walaemini Rockshelter and Alkaline Hill; see Beaton 1985), in Torres Strait (Mask Cave; see McNiven et al. 2006) and on islands off the central Queensland coast (St Bees and Curlew Islands; see Border 1999). At Nara Inlet 1, discard of marine remains diversifies with a major increase in shellfish and crab in addition to fish, and evidence of predation pressure on the rock platform gastropod *N. undata* (Barker 2004). In western Torres Strait, low numbers of fish and turtle bone dating from c.3,800 years ago were recovered from Mask Cave on Pulu, followed by significant increases in the discard of marine material only in the last 2,500 years (McNiven et al. 2006).

Although 15 open sites on the Queensland coast date to this interval, only three have evidence for focused marine resource exploitation pre-dating 3,000 RCYBP. The Hope Island site, with a non-basal age of 4,350 ± 220 RCYBP (Beta-20799), contains abundant shell remains dominated by oyster, although fish bone is apparently absent (Walters et al. 1987). Badu 19 yielded small quantities of shell and fish, turtle and dugong bone from c.4200 years ago with major increases in the last few thousand years matching patterns observed elsewhere in Torres Strait (Crouch et al. 2007). The 4000-year-old dugong remains at Badu 19 represent the earliest evidence for dugong use in northeast Australia.

Some of the earliest evidence for focused use of coastal resources comes from the Seven Mile Creek Mound in central Queensland, built up over a period of 350 years between c.3950 and 3600 cal BP. The 44 m^3 of deposits there represent broad utilisation of intertidal and near-shore resources, including extensive shellfishing, crabbing and fin fishing. Shell remains are dominated by oyster (*Saccostrea glomerata*), with lesser quantities of hairy mussel (*Trichomya hirsutus*), mud ark (*Anadara trapezia*) and scallop (*Pinctada albino sugillata*). Fish remains occur throughout the deposit, representing the major dietary contribution at the site, but they are from very small fish and so suggest an inshore fishery (Ulm and Vale 2006). Although shell mounds are a relatively common feature of the coastal archaeological record of northern Australia (see below), these site types are generally restricted to locations north of the Tropic of Capricorn and are almost exclusively late Holocene in age (Fig. 19.3) (e.g. Bailey 1999; Beaton 1985). The Booral Shell Mound in Great Sandy Strait, dating to 3,000 years ago, is the only other mound excavated on the Queensland coast south of the Tropic of Capricorn (Frankland 1990), although reports indicate that other mounds existed in southeast Queensland but have been destroyed (McNiven 1994). I have argued elsewhere (Ulm 2006) that this early mounding behaviour points to logistical mobility strategies targeting estuarine resources inconsistent with a pattern of widespread residence on the coast. Rather, the use of the site appears to be embedded into regional settlement systems with a subcoastal focus. The act of mounding is of particular interest as it appears to be linked more to social factors defining discard behaviours than resource availability.

The first unequivocal evidence for offshore island occupation is at Mazie Bay on North Keppel Island (Rowland 1985) shortly before 4,500 RCYBP. No earlier evidence for offshore island use has been forthcoming despite nearly 3 decades elapsing since this discovery. As Rowland (2008:102) noted, it seems extraordinary that humans colonised Australia more than 50,000 years ago by crossing large distances of open ocean "but only began to re-cross minimal water barriers in the last 4,000–3,000 years and with regularity only in the last 1,000 years". Sim and Wallis (2008) contended that offshore islands across northern Australia were abandoned around the time they became isolated from the mainland in the early Holocene when sea-level maxima was attained, not to be reoccupied until after 4,200 years ago. There is a hint of mid-Holocene occupation at Badu 15 in Torres Strait (David et al. 2004) and Nara Inlet 1 in the Whitsunday Islands (Barker 2004), but even if these equivocal suggestions of use are proven they indicate only very ephemeral occupation (Sim and Wallis 2008). Sim and Wallis (2008) argued that climatic instability combined with poor watercraft technology precluded colonisation of islands in the intervening period. Amelioration of climate and improvements in watercraft between 4,200 and 2,500 years ago are viewed as the preconditions necessary for permanent island colonisation. However, these patterns must be considered in the context of evidence for more intensive occupation of mainland areas, which, David et al. (2004) point out, provided the origin for "systematic territorial and sea-based expansions across much of northeastern Australia" in the mid-Holocene. Evidence for increasing use of islands after 4,000 years ago appears along the length of the northeast Australian coast, including the remote Percy Islands some 60 km offshore (Border 1999).

At all other open coastal sites in Queensland pre-dating 3,000 BP ($n = 12$) (Table 19.1), faunal remains are either entirely absent, represented in minute quantities or restricted to deposits dating to the last 3000 years. The absence of faunal remains from these early deposits is commonly attributed to ephemeral occupation, taphonomic considerations and/or problematic recovery strategies (Ross and Duffy 2000; Ulm 2002). McNiven (1991) suggested that the survival of fish bone in southeast Queensland deposits may be correlated with the occurrence of shell, as shellfish remains provide a protective matrix, creating chemical properties conducive to bone preservation. This pattern may also reflect the low survival potential and reduced archaeological visibility of low-intensity coastal resource use (Dortch et al. 1984; Mulvaney and Kamminga 1999:174). Does the paucity of marine food remains in these sites mean that coastal resources were not much used prior to 3,000 years ago? Walters (1989, 1992) has consistently argued that marine fishing was only incorporated as a regular feature of subsistence-settlement systems in southeast Queensland after 2,000 RCYBP. However, data now available from the length of the Queensland coast clearly show that fishes were always a key resource (Crouch et al. 2007; McNiven et al. 2006; Ulm 2002; Ulm and Vale 2006).

On the basis of these data, coastal occupation before c.3,000 RCYBP in northeast Australia is often characterised as low density and ephemeral, and linked to low population densities and high levels of mobility (e.g. Barker 1996, 2004; David et al. 2004; McNiven 1999; Ulm 2006). Notwithstanding problems associated with small sample sizes and differential preservation, these data suggest patterns of geographically focused, short-term and discontinuous occupation prior to the late Holocene.

Late Holocene (0–3ka BP)

The majority of known coastal archaeological sites in northeastern Australia date to the last millennium (Fig. 19.2). In many areas a trend towards increased site creation and use around 1000 years ago is reflected in structural changes in the archaeological record. Most significant is the widespread appearance of shellfish remains, as evidenced by the dramatic increase in coastal shell middens, a site type which only appeared in the mid-Holocene (Figs. 19.4 and 19.5). Several other studies have also documented significant subsistence transformations in the late Holocene, reflecting a general broadening of the subsistence base (e.g. Hiscock 2008; Morwood 1987; Walters 1989). Lourandos (1997:161) has described these changes as part of "a more specialised and broad-based coastal emphasis in the economy of the most recent phase" (see also Barker 2004; McNiven 1999; Morwood 1987; Ulm and Hall 1996; Walters 1989). Ulm and Hall (1996) dated these changes to 1,200 RCYBP in southeast Queensland and McNiven (1999) to 900 RCYBP for the adjacent Great Sandy Region. To the north, Barker (1996, 2004) associated increases in diet breadth in the Whitsunday Islands from 600 years ago with the emergence of specialised marine economies akin to those documented in the ethnohistoric record, while Rowland (1982) found that the Keppel Islands were only permanently occupied c.700 years ago.

My work on the central Queensland coast pointed to increasingly localised resource use after 1,500 RCYBP (Ulm 2006). In addition to obvious increases in coastal settlement and use of marine resources (especially fish and shellfish), stone raw material sourcing becomes almost exclusively local. Exchange of edge-ground hatchets manufactured on distinctive raw materials also points to the integration of people into regional social networks in the recent past (Ulm et al. 2005). In this and many other areas, relationships between coast and hinterland areas appear to have

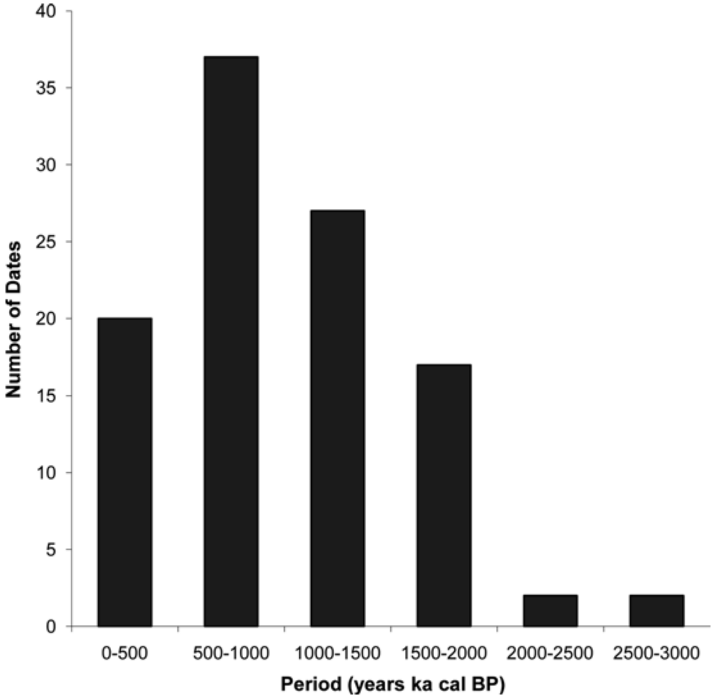

Fig. 19.3 Dates from shell mound sites in northeast Australia (Ulm and Reid 2000)

Fig. 19.4 Typical shell midden scatter in central Queensland dominated by *Donax deltoides* (Photograph: Sean Ulm)

radically altered in the last few thousand years emphasising differences between coastal and inland people (Hall 1999).

In the last 2000 years shell mounds emerged as a conspicuous feature of the archaeological landscape across tropical northern Australia (Figs. 19.3 and 19.5). Over 500 mounds occur on mangrove-lined estuaries in the Weipa area alone, with the largest in excess of 12 m high, although most are less than 1 m (Bailey 1994). Bailey (1999:106) estimated that the Weipa mounds contain 200,000 tonnes of shell or ten billion individual shells. All mounds investigated in the southern Gulf of Carpentaria (Robins et al. 1998), Weipa (Bailey 1999) and Princess Charlotte Bay (Beaton 1985) are dominated by the cockle *A. granosa*, which comprises more than 95% of the shell weight, with lower representation of mangrove-associated gastropods (*Telescopium* sp., *Terebralia* sp.) and bivalves (*Polymesoda* sp.) as well as occasional fish and terrestrial animal bones and stone artefacts. For Princess Charlotte Bay, Haberle and David (2004:172) link the appearance of shell mounds to the emergence of new centralised consumption places with associated novel foraging and disposal practices.

Bailey (1999) and Hiscock (2008; Hiscock and Faulkner 2006) convincingly argued that changing environmental conditions impacting on the abundance of *A. granosa* offer the most plausible explanation for the cessation of mound formation. These explanations are less successful when generalised across all areas. Hiscock (2008:274) argued that economies creating shell mounds ceased between 800 and 600 years ago as changing ecological conditions removed shorelines favourable to abundant *Anadara* communities, with a shift to foraging strategies less focused on the shore. He notes a single more recent exception on Cape York Peninsula. However, a review of dates from *Anadara* shell mounds in northeast Australia shows that mounds continued to be created in the last 500 years, with 16 sites from Weipa, Princess Charlotte Bay and Mornington Island showing continuous mound construction during this period, albeit at lower intensity than between 500 and 1,000 years ago (Fig. 19.3).

It could be that reduced mound-building in the last 500 years reflects changes in economy impacting on centralised shellfish foraging, such as the more inland-focused strategies suggested by Hiscock (2008). However, simply citing the persistence of favourable *Anadara* habitats into the most recent period in these areas cannot tell the whole story. As we have seen, mounds dominated by oyster rather than *Anadara* were constructed at the Seven Mile Creek Mound around 4,000 BP and at the Booral Shell Mound around 3,000 BP (Table 19.1), providing a precedent for mounding behaviours evident at the later *Anadara* mounds. As Morrison (2003) and McNiven and Feldman (2003) noted, mounding behaviours have a symbolic dimension suggesting intergenerational transmission of "ritualised" knowledge relating to mound-building and pointing to the importance of social factors in addition to environmental parameters in structuring discard behaviours.

Stone-walled tidal fishtraps are another site type common across northeast Australia, sometimes covering many kilometres of shoreline (Fig. 19.6). In the southern Gulf of Carpentaria, fishtrap complexes on Bentinck Island occur on average every 900 m along the shoreline (Memmott et al. 2008). Although none of these structures anywhere in northeast Australia has been directly dated, adjacent

Fig. 19.5 Large shell mound at Weipa dominated by *Anadara granosa*, note person dwarfed in foreground (Photograph: Michael Morrison)

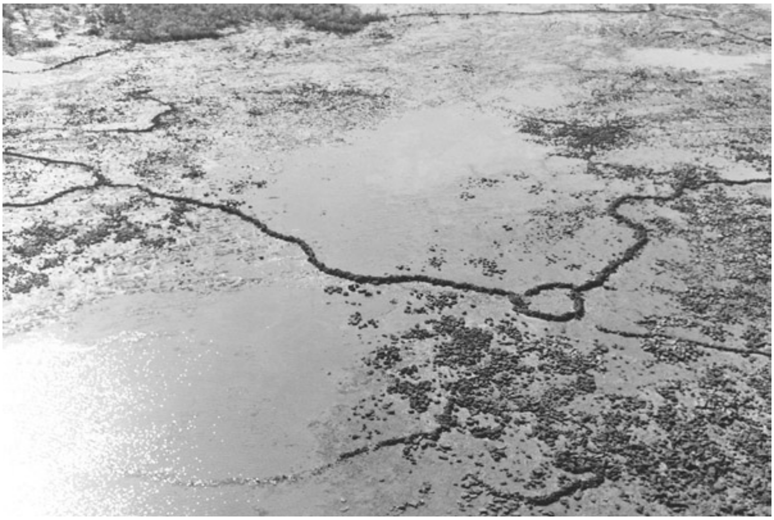

Fig. 19.6 Stone-walled fish trap complex, Bentinck Island, southern Gulf of Carpentaria (Photograph: Richard Robins)

shell midden deposits at several sites have returned late Holocene ages, indicating that most if not all of the facilities can be assigned to this period (Fig. 19.7) (Barham 2000; Bowen 1998; Frankland 1990).

Recent research across Torres Strait has revealed a distinctive series of cultural changes from around 3,500 RCYBP (David et al. 2004), but it is not until after

Fig. 19.7 Eroding shell midden in central Queensland (Photograph: Sean Ulm)

2,500 years ago that widespread occupation of the islands of Torres Strait occurs in the form of numerous coastal middens, which Barham (2000) associates with the origins of the distinctive marine-oriented societies observed among contemporary Torres Strait Islander communities. Villages appear in the archaeological record of Torres Strait around 700 RCYBP, which David and Weisler (2006) associate with the development of much more intensive engagement with the marine environment, including the construction of ritual structures from large shellfish and dugong remains (McNiven and Feldman 2003).

Discussion

What emerges from this overview is how little we actually know about coastal foragers in northeast Australia. What we do know is based on a few well-studied but widely separated archaeological sites. All the large-scale archaeological projects undertaken along the coast have yielded evidence broadly consistent with a model of ephemeral use of coastal resources from before the mid-Holocene with patterns of dramatic change in the very late Holocene towards increased rates of occupation. But how are we to understand these patterns? Some have suggested that the patterns may simply be an artefact of preservation, with the record skewed towards recent sites (e.g. Bird 1992; Rowland 1989). Others have focused on environmental factors, particularly resource productivity and availability (e.g. Bailey 1983; Beaton 1985; Morwood 1987; Rowland 1999; Walters 1989), or the interplay of environmental and cultural factors (Haberle and David 2004). Arguments have also been advanced associating the patterns with inferred changes in social structure, especially trends towards socio-economic intensification, perhaps including population growth (e.g. Barker 1996; Lourandos 1997), or cultural responses to external contacts (David and Mura Badulgal 2006).

Our interpretations of marine resource use in northeast Australia must be tempered by the large gaps in archaeological knowledge across the region, reflecting the vast length of the coastline, the small number of archaeologists and the short history of the discipline in Australia. Few coastal regions have even basic chronologies. These problems are compounded by a poor understanding of how taphonomic processes have impacted on the available sample. Sea-level fluctuations, coastal erosion, cyclones, storm surges and coastal progradation have resulted in differential destruction of the coastal archaeological record (e.g. Bird 1992; Rowland 1989). Rowland (1989) has estimated that up to 12,000 cyclones may have affected the northeast coast of Australia over the last 6000 years. Bird (1992) has shown that just two cyclones in the late 1980s removed half of the documented archaeological record from Upstart Bay in north Queensland. Taken together, this evidence suggests a very recent origin for virtually all of the coastal landforms where archaeological studies have been carried out, strongly biasing the known archaeological record to the late Holocene.

Assessing the significance of late Holocene changes also depends on accurately characterising the context in which these adaptations emerged. In northeast Australia, understanding the use of coasts is limited by the few instances of direct evidence for use of coastal resources prior to the late Holocene. Although there probably was widespread occupation before this time, there is virtually no associated faunal material. All known Pleistocene and early Holocene sites in Australia which exhibit use of coastal resources are located in rockshelters situated near palaeoshorelines. For most of northeast Australia, where the continental shelf is wide and gently sloping, it is therefore not surprising that archaeological evidence is lacking for coastal occupation prior to mid-Holocene sea-level stabilisation. The early representation of marine resources at Nara Inlet 1 is clearly a function of the proximity of the site to the ocean for much of the Holocene, like much longer patterns of marine use dating from the late Pleistocene in northwest Australia (Veth et al. 2007), but we are still very far from understanding the nature of these early economies. As many commentators have pointed out, virtually all of the evidence for early coastal use before the Holocene was submerged by rising seas, and despite the potential for underwater study, no serious attempts have been made to locate inundated archaeological sites. The simplest explanation for the low number of coastal sites dating to before the late Holocene is that the majority of extant coastal landscapes only became available for occupation in this period. Like the Badu 15 research in Torres Strait discussed earlier, future research needs to identify landforms that have been present close to the sea throughout the Holocene. However, it is salutary to note David et al.'s (2004) own observation that Badu 15 was the only site discovered in the entire western Torres Strait area with the potential for deposits older than the mid-Holocene. We can be more secure about evidence dating to the late Holocene, where landforms containing archaeological deposits have been relatively stable for the last few thousand years. In these contexts, the very recent trajectory towards localisation of resource use and low mobility settlement systems on the coast can be related to long-term trajectories of change. Regional chronologies in many areas suggest a lag between intermittent use of coastal resources in the mid-Holocene and much later widespread intensive occupation. It is possible that diminished predictability of coastal resources linked to fluctuations in marine productivity induced by the final stages of marine transgression led to a reduction in the use of coastal areas in favour of increased use of subcoastal areas, where coastal resource suites formed a part of broad foraging strategies. Indeed, subcoastal occupation only becomes archaeologically visible in southeast Queensland around the terminal Pleistocene/early Holocene (Hall 1999). In some areas with low offshore gradients, coastal resources may have only been reincorporated as an extension of inland-focused economies in the late Holocene, after the end of major transgressive fluctuations increased the predictability of resource abundance and distribution. These changes did not take place in isolation, with evidence for increases in the intensity of occupation of inland areas, perhaps linked to increases in population density, from the mid-Holocene providing a context for changing use of adjacent coasts (Haberle and David 2004; Lourandos 1997).

After 1,500 RCYBP, the coast progressively assumed a more important role in regional mobility strategies. Excavations reveal rapid and widespread changes in site content, an increasingly diversified subsistence resource base and patterns of increase in site establishment and use from this time. These changes involve a localisation of resource use and settlement towards a broad-based economy focused on lower-ranked resources clustered around the shoreline. McNiven (1999:157–158) usefully modelled these changes in the Great Sandy Region as involving fissioning of social groups into smaller entities with "separate and smaller territories". The presence of large artefacts associated with plant-processing hints at the importance of plants in these economies, but terrestrial animal bone is rare in coastal deposits. In fact, very few terrestrial animals are documented in coastal sites. This possibly reflects the coastal orientation of the activities that produced these sites, but localisation of settlement may have put pressure on terrestrial animal populations, particularly marsupials, which Walters (1992) argued would have been quickly reduced through hunting by populations with relatively low mobility.

It is uncertain how these recent changes are connected to the climate change documented over this interval (Nunn et al. 2007). A period of high-frequency ENSO events between c.2,500 and 1,000 RCYBP peaking at 1,300 RCYBP is associated with more variable climate, including periods of aridity (Gagan et al. 2004; Shulmeister 1999). This interval coincides with widespread reductions in occupation across southeast Queensland (McNiven 1992; Ulm 2006). Climate ameliorated in the last 1,000 years, with wetter conditions prevailing (Harrison and Dodson 1993). The alterations in occupation patterns and broadening of coastal resource use in the last 1,500 years may have been in part a response to more variable conditions, much like the reorganisation of settlement-subsistence systems thought to have taken place during the last glacial maximum (Hiscock 2008:81).

Conclusion

Data available for many regions of northeast Australia show that major changes took place in coastal economies since the mid-Holocene towards increased site occupation, intensity of site use, and localisation of resource use which cannot be simply related to taphonomic or sampling factors. Despite 40 years of systematic archaeological investigations on northeast Australian coasts, however, the antecedents of the complex systems recorded ethnohistorically and documented historically for the recent past remain poorly understood. An understanding of the developmental processes giving rise to these late prehistoric systems will require interdisciplinary research focused on the location of early-to-mid-Holocene coastal archaeological deposits and the characterisation of the distribution and abundance of marine resources throughout the Holocene.

The main obstacle to advancing our understanding of variability and change in coastal economies in northeast Australia is that the large areas have seen no archaeological or geomorphological research, many areas have had only limited attention and there are few detailed studies of the archaeological assemblages that have been excavated. The intensive systematic studies conducted in western Torres Strait, central Queensland and southeast Queensland show the enormous opportunities afforded by such an integrated approaches.

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Chapter 20
The Role of Marine Resources in the Diet of Pre-Colonial Aboriginal People and Land Use Patterns Around Port Jackson, Sydney, New South Wales, Australia

Val Attenbrow

Introduction

At the time of British colonisation in January 1788, numerous related clans each associated with specific tracts of land and belonging to several language groups lived in the Sydney region. They were mobile fishers, hunters and gatherers and the foods they ate, raw materials used and how they obtained them differed according to the environment in which they lived – whether along the coast or in the coastal hinterland (Attenbrow 2010b). In this paper I discuss the use of marine resources by people living adjacent to the ocean and estuarine shorelines – particularly those living around the shores of Port Jackson. Marine products were also used as raw materials for tools and weapons, but my discussions are restricted to their use as items of food.

Early colonial records describe the principal subsistence activity of the coastal people as fishing, though it is clear from both the historical and archaeological records that the range of foods eaten was much wider. Even so, the historical descriptions provide no clear indication of the specific resources that were commonly part of the diet, or how the nature of the subsistence activities varied in different parts of the estuary and adjacent coastline. The archaeological record provides a different set of data, and a more comprehensive picture of the use of marine resources by Aboriginal people living in coastal Sydney is gained by examining both the historical and archaeological sources.

Sydney has a long history of archaeological investigations and, despite more than 200 years of urban development which has destroyed and disturbed many sites, it still has a rich extant suite of archaeological sites (Attenbrow 1991, 1992b, 2010b). Archaeological excavations have identified Aboriginal sites with occupational histories extending back some 20000 years in the wider Sydney region (Nanson et al.

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1987:76; Stockton 2009). However, I focus on marine resource use during the last 4000 years, and explanations for the observed spatial variations in Port Jackson (Sydney Harbour). The historical sources cited are publications and other documents written during the early colonial period from 1770 to 1820, principally by officers of the First Fleet who arrived in 1788. The archaeological evidence comes principally from excavated sites around Port Jackson, but reference is also made to sites along the adjacent ocean coast and estuaries (Fig. 20.1).

Sydney Aboriginal middens include a range of cultural materials – shell which forms the dominant component, as well as flaked and ground stone tools, shell and

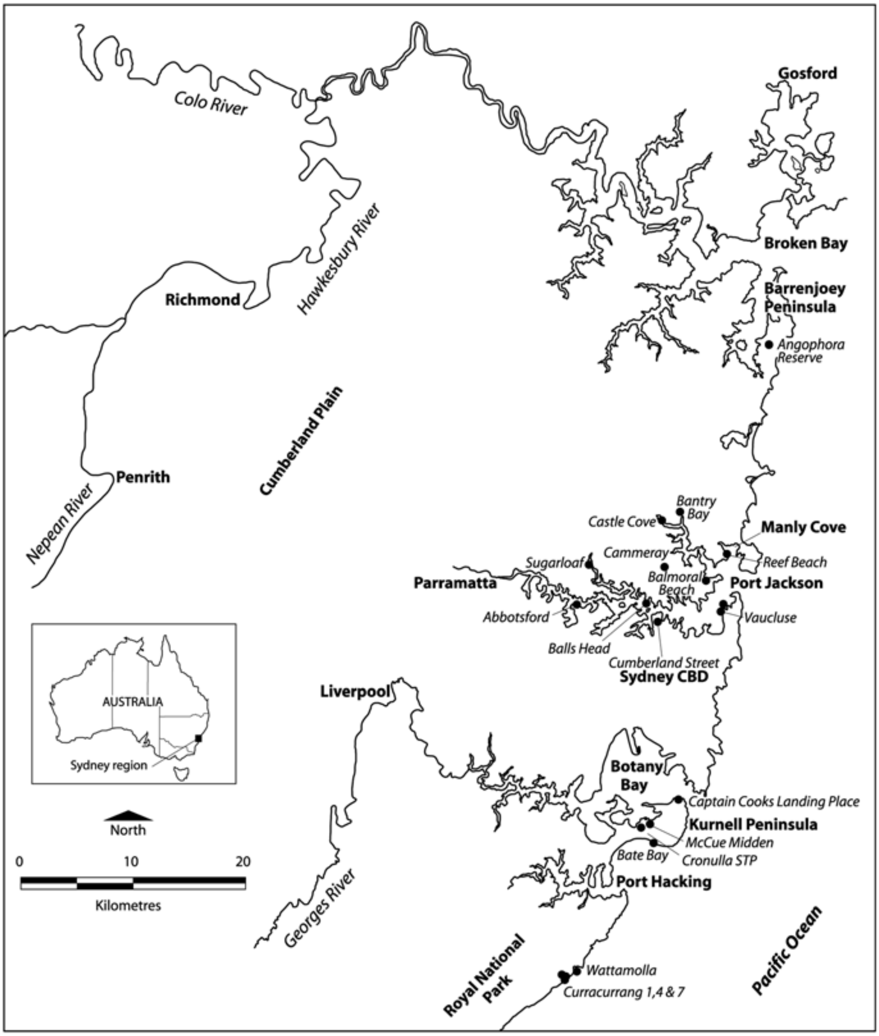

Fig. 20.1 Location of excavated Sydney region Aboriginal sites referred to in text

bone artefacts tools, animal bones and charcoal from hearth fires, as well as human burials (Attenbrow 1991:Table 3, 2010b). Excavated faunal assemblages provide evidence for the families and species of fish caught and shellfish gathered, as well as marine mammals and reptiles that were part of the diet. In the sandstone environment of coastal Sydney, however, such organic remains rarely survive in levels older than 4000 years. The biases that are introduced by preservational factors are pointed out where relevant in the discussions below. Nonetheless, for this 4000 year period the Port Jackson middens provide evidence that the use of marine resources varied in different parts of the estuary. The archaeological record suggests that while shellfishing was carried out in all parts of the estuary, fishing was focused principally around the estuary mouth.

Port Jackson

The Sydney coastline is dominated by spectacular sandstone clifflines up to 80 m high, broken only by the mouths of the deep and extensive estuaries of Port Jackson, Broken Bay, Botany Bay and Port Hacking. The Hawkesbury sandstone forming the clifflines is part of the dissected Hornsby plateau. The estuaries are drowned river valleys (rias) and estuarine conditions generally extend inland about 30 km from the coastline (Fig. 20.1). Port Jackson, also known as Sydney Harbour, is one of the largest estuaries along the NSW coast and, with its tributaries and bays, has an area of 45 km^2 and a shoreline of approximately 240 km (Stockton 1977:25). Along the estuarine reaches of the tributary rivers, the foreshores are a complex of alternating cliffs, small bays and inlets with sandy beaches, tidal mudflats with mangroves, intertidal rock platforms, and rocky/bouldery areas. In many parts, high sandstone cliffs drop straight down into the water. Elsewhere the land adjacent to the shore varies from steep forested ridgesides with sandstone cliffs and outcrops to gentle slopes where the Wianamatta shales occur in the western parts of the catchment. The large sheltered estuarine waters of Port Jackson and its tributaries provide a wide range and abundance of marine resources. The land adjacent to Port Jackson, which was principally timbered country with areas of open forest, woodland, heath, swamps and mangrove communities (Benson and Howell 1990), supported a wide diversity of land animals.

Available Resources and Early Colonial Historical Record

Marine Resources: Their Availability and Aboriginal Use in the Early Colonial Period

The diet of people living in coastal Sydney included a wide range of marine resources – fish, shellfish, crustaceans such as crabs and crayfish, marine mammals such as seals and whales, and turtles – as well as land mammals, birds, reptiles and plant foods. Marine resources played an important part in the diet of the people living along the coast and estuaries. Around Port Jackson and Botany Bay, fish and shellfish were the food items most often noted by Captain Cook and Joseph Banks in 1770 and by the British colonists in the first years of the colony. Scenes of, or including, people fishing are commonly depicted in the early colonial images of Aboriginal people (e.g. Figs. 20.2 and 20.3).

Men are described or depicted as fishing with multi-pronged spears usually from the rock platforms and in shallow waters whereas the women fished from bark canoes using lines with shell fish-hooks. In Australia, this gendered division in fishing practices existed only along the South and Central NSW Coastline (Bowdler 1976; Attenbrow 2010a, b).

Fishing is often described as the main food source of those living along the coast. At one stage, the Judge Advocate Captain David Collins (1798[1975:456]) wrote that "[t]hose who live on the sea-coast depend entirely on fish for their sustenance". However, his comment obviously overstates the case, and Lieutenant William Bradley (1786–92[1969]:133) puts Collin's statement into a broader context (see later), as does marine Captain-Lieutenant Watkin Tench who wrote:

> [they]…wholly depend for food on the few fruits they gather; the roots they dig up in the swamps; and the fish they pick up along shore, or contrive to strike from their canoes with spears. Fishing, indeed, seems to engross nearly the whole of their time, probably from its forming the chief part of a subsistence … (Tench 1789:80–81[1979:48])

Men were observed collecting or carrying shellfish on several occasions, but interestingly there are no reports of women collecting shellfish (Attenbrow 2010b:82–83).

Fish and Fishing

At least 581 fish species, representing 143 families inhabit Port Jackson (Henry 1984:4, 42; Paxton and Collett 1975), though a great many are small in size or limited in abundance and are unlikely to have been of dietary importance to Aboriginal people. The upper reaches of the estuary, which have lower salinity levels and lower habitat diversity, have a lesser number of fish species than the estuary mouth (Paxton and Collett 1975:3–4).

In 1788, Port Jackson was described as being well stocked with a variety of fish: "Jewfish, Snapper, Mullet, Mackrel [sic], Whiting, Dory, Rock Cod, leather jackets [sic] & various others" (Bradley 1786–92[1969]:132). Tench described the range of fish as being "from a whale to a gudgeon", mentioning "sharks of a monstrous size, skait [sic], rock-cod, grey-mullet, bream, horse-mackarel [sic], now and then a sole and john-dory and innumerable others unknown in Europe" as well as bass, leatherjacket and snapper (Tench 1789:128–129, 1793:176[1979:69, 272]).

Although the British colonists mentioned the names of many fish that inhabited the estuaries, and recorded the local Aboriginal names for many different species (Attenbrow 2010b:63–64), they seldom identified the particular fish species that they saw the local inhabitants catching or eating. There are only rare references to bream and mullet, shark and stingray (Collins 1798[1975:137];

Fig. 20.2 Nouvelle-Hollande: Nouvelle-Galles due Sud. Grottes, chasse et pèche des sauvages du Port Jackson [New Holland: New South Wales: Cave, hunting and fishing by the people of Port Jackson], from Peron and de Freycinet (1824:Plate 31). Reproduced with permission of the Australian Museum Research Library

Fig. 20.3 *Aborigines fishing, cooking and eating in canoes.* Watercolour by unknown artist but often attributed to Philip Gidley King (the elder), undated, though probably 1788–92. Reproduced with permission of the Mitchell Library, State Library of New South Wales

Tench 1793:195–196[1979:287, 288]). Although there were great numbers of stingray and shark in Port Jackson and Botany Bay, it was initially reported that they were not eaten (Bradley 1786–92[1969]:132; Collins 1798[1975:455]). However, in winter 1788, it was noted that: "These people last summer would neither eat shark nor stingray; but the scarcity of fish in the winter, I believe obliges them to eat anything that affords the smallest nourishment" (Phillip 28 September 1788 [1892:192]). This comment implies they were eaten, at least in winter.

Shellfish and Shellfishing

Rock platforms, estuarine mud flats with mangroves, and sandy beaches around foreshores of Port Jackson provide habitats for a relatively large number and variety of edible shellfish. Each of these environments has a different although often overlapping range of species, and because of the diverse nature of the shoreline, many species are available within a very short distance of most locations around the estuary. Over 2000 shellfish species have been recorded in Port Jackson but, as with fish, the greater proportion of these species are very small (<15 mm maximum dimension) and not of dietary importance to humans. In the lower estuary, because of Port Jackson's broad mouth (1.5 km wide), many ocean shellfish species also inhabit the shorelines there and the range of species is much greater than in the mid- and upper estuary.

In 1788, Bradley described Port Jackson as having “a great quantity of shellfish in the Coves that have Mudflats at the bottom”, and recorded that “[w]e found vast quantities of Oysters & other shellfish in the Harbour & Oysters of an amazing size in the uppermost Coves” (Bradley 1786–92[1969]:79–80, 133). These large oysters would have been mud oysters (*Ostrea angasi*) and not rock oysters (*Saccostrea glomerata*).

There are few accounts of shellfishing, though people were observed collecting shellfish from the rocks and out of the sand and mud in shallow water, diving for them in deeper waters, as well as cooking and eating them; shellfish were also recorded scattered around their huts (e.g. Bradley 1786–92[1969]:75, 76, 113; Clark 1788 in Fidlon and Ryan 1981:109–110, 267; Hunter 1793[1968]:63–65; Phillip 15 May 1788[1892:132–135]; Tench 1793:195[1979:287]; Worgan 1788[1978:16]). The only shellfish named in the historical accounts are oyster, cockle, “muscle” (mussel) and limpet. They also refer to “a large worm called *Cahbro*” (Collins 1798[1975:462]) which is *Teredo,* a shellfish that inhabits rotten wood in the upper reaches of estuaries. It is likely that the names given by the British observers do not reflect all the shellfish species they actually saw and that the authors were using the terms “cockle” or “mussel” generically.

Other Marine Animals

No marine mammals are permanent inhabitants of Port Jackson, though whales, seals, and dolphins are regular visitors – more often in winter (June to October) and more often on the open coast than inside the estuaries. Dugongs (*Dugong dugon*) are rare visitors to Sydney. Southern Right whales (*Eubalaena glacialis*) breed off the NSW Central Coast during September–October. Humpback whales (*Megaptera novaeanglaise*) migrate North from the Antarctic seas in winter to breed, and in spring move South to feed in the Antarctic. Whales and dolphins (Fam. Dolphinidae) sometimes become beached or stranded on the shores, especially after storms (Linda Gibson, 1999, personal communication). Recent documented whale beachings indicate such events occur relatively frequently. In the past, the Australian fur-seal (*Arctocephalus pusillus doriferus*) inhabited the NSW Central Coast, and today Southern Elephant Seal (*Mirounga leonina*) and Leopard Seal (*Hydrurga leptonyx*) are infrequent visitors to the Sydney region (Shaughnessy 1999:45). Turtles, such as Green (*Chelonia mydas*), Leatherback (*Dermochelys coriacea*) and Loggerhead (*Caretta caretta*), are uncommon visitors (Dr Alan Greer, 1999, personal communication).

Common crustaceans in Port Jackson include crabs (blue swimmers *Portunus pelagicus*, mud crabs *Scylla serrata*), spiny lobsters or sea-crayfish (*Jasus verreauxi*), prawns (Eastern King Prawn *Penaeus plebejus*, Eastern School Prawn *Metapenaeus macleayi*) and rock barnacles such as the large purple “plated” (*Austrobalanus imperator*) (Dakin 1973:165, 182, 202).

There are no historical reports of seals, turtles, or dugongs being hunted in the Sydney region, though seal hunting was recorded along the NSW South Coast

(Lawrence 1968:145). However, the historical records indicate that beached whales were eaten and provided opportunities for large numbers of people to gather and feast. People no doubt anticipated their arrival in winter and kept watch, being prepared for the eventuality so that large gatherings could take place. Such events occurred near Botany Bay in August 1788 and at Manly Cove in July 1790 (Bradley 1786–92[1969]:120, 135; Collins 1798[1975:109]). On the latter occasion flesh was still being taken from the carcass in September, despite its decomposing condition:

> September, 1790. On the 7th instant, captain Nepean, of the New South Wales corps, and Mr White, accompanied by little Nanbaree, and a party of men, went in a boat to Manly Cove, intending to land there, and walk on to Broken Bay. On drawing near the shore, a dead whale, in the most disgusting state of putrefaction, was seen lying on the beach, and at least two hundred Indians surrounding it, broiling the flesh on different fires, and feasting on it with the most extravagant marks of greediness and rapture. (Tench 1793:54[1979:176]).

Lobsters and "craw-fish" were caught in "small hoop nets" in Port Jackson (e.g. Phillip 15 May 1788[1892:132]), but there is no mention of prawns or crabs being caught or eaten.

Land Resources: Their Availability and Aboriginal Use in the Early Colonial Period

The Sydney region is inhabited by a large number of land mammals, birds, reptiles and amphibians, as well as numerous plants that have edible parts. Kangaroos, wallabies, possums, koalas, bandicoots, dingoes, wombats, echidnas, fruit bats ("flying foxes", *Pteropus poliocephalus* and *P. scapulatus*) and other smaller mammals such as native rats and mice, were amongst the land animals that inhabited the region. Most Australian land mammals are not migratory and therefore their seasonal availability and abundance do not vary markedly.

There are numerous species of terrestrial birds – the largest being emu, brush turkey, and lyre bird – as well as a range of water birds such as swans, ducks, and penguins (Hoskin et al. 1991; Roberts 1993). Some birds are migratory, particularly water birds such as the shearwater or mutton bird (*Puffinus teniurostris*). Among the reptiles, there are snakes (including pythons), lizards and tortoises. Goannas (monitor *Varanus rosenbergi*) are the largest of the lizards in the Sydney region in terms of body weight.

Sydney vegetation communities include over 200 plant species which have edible parts, such as seeds, berries, fruits, tubers/roots/rhizomes [yams and fern-roots], leaves, flowers, nectar and honey, as well as *Macrozamia* kernels which require special processing to remove the toxins. Studies of food plants in the NSW South and Central Coasts indicate that a greater range of edible plant foods is available in summer, spring and autumn than in winter (Poiner 1976; Vinnicombe 1980:Part VI). Tubers and roots are available all year round, though the nutrients in them vary considerably seasonally.

There are very few historical records of hunting and/or eating land animals and birds and collecting plant foods in the Sydney region – far fewer than those of fishing. Several early writers did, however, mention that other animals beside fish and shellfish were eaten by the people around Port Jackson; for example, Hunter (1793[1968]:60–61) and Tench (1789:88[1979:51]) as well as Bradley, who wrote in October 1788:

> For a considerable time after our arrival it was supposed that the food of the Natives was entirely Fish, but the winter convinced us, that if they had not had some other resource great numbers of them must perish, as it is they are very hard put to it when the Fish is scarce; ..... There is no doubt but they lay wait for the Kanguroo [sic] & Birds, many of the trees are notch'd that has not had a Canoe taken from them from which I suppose they get into these Trees to seek or wait for any thing that may come in their way (Bradley 1786–92[1969]:110, 133–134).

Kangaroos, wallabies, possums, gliders, fruit bats ("flying foxes") and kangaroo-rats were recorded as being eaten. Only among the hinterland groups were dingos, koalas and wombats noted as food items. Tench reported that "they esteem lizards, guanas [sic, goannas], and many other reptiles, delicious fare", but it was only "[w]hen prevented by tempestuous weather, or any other cause, from fishing" that "particular reptiles" were hunted (Tench 1793:177, 195[1979:273, 287]). Hunter (1793[1968]:469) reported that it was in winter and early spring, particularly during dry weather, that the men resorted to burning the grass to catch rats and other animals, while the women continued to fish.

The only types of bird reported as eaten were crows and hawks (Collins 1798[1975:455]), and "parrots and parroquets [sic]" (Sir John Franklin in Ross 1976:25), but as with fish and shellfish the number of species is probably underreported.

The same can be said about plant foods, and the contribution that each of the more than 200 plant species made to the diet in different parts of the Sydney region is not known. There are few reports of plant collecting and the historical evidence for the plant species eaten suffers from the fact that the Australian plants were new to botanist Sir Joseph Banks who came with Captain Cook in 1770 and none of First Fleet colonists were botanists. Most early accounts are not detailed enough to identify the specific plant species, simply using names such as the "cherry", "fruits", "berries", "currants", "a nut which had violent effects on those who ate it unprepared", "wild fig", "orchis" roots, and "fern-roots" (Attenbrow 2010b:40–42).

Summary of Historical Observations

The foregoing outlines the abundant marine and terrestrial food resources that were available in and around Port Jackson. The historical accounts suggest that marine resources, especially fish, played a major part of the diet of the pre-colonial people who lived around the shores of Port Jackson, but that land animals and plant foods were also part of the diet. It is unlikely, however, that the British colonists saw all of the plants and animals that were caught, gathered and eaten by the Aboriginal people of Port Jackson and it is obvious that the historical records dating to between 1770 and 1820 provide an incomplete account of their diet.

Archaeological Evidence

Despite the large number of shell middens recorded around the estuarine shores of Port Jackson (at least 335), animal bones discarded during Aboriginal use of the sites have been recorded at relatively few (<18%) (Attenbrow 1991). This is partly because of the difficulty of seeing the bleached bones among the more abundant faded shells, until excavated. Even so, in some excavated middens, animal bones form only a minor component of the cultural materials, or are not present at all.

Numerous sites have been excavated around Port Jackson (Attenbrow 1991, 2010b:5–8). However, quantitative data about the faunal assemblages that is suitable for comparative studies is available for only a few sites. In addition, prior to the 1960s retrieval methods were unsystematic and only large pieces of bone were saved. Because of these shortcomings, the following discussions focus on a few relatively recently excavated shell middens.

All radiocarbon ages cited have been calibrated to calendar years using Calib 5.0.1, with southern hemisphere offset for charcoal samples and a delta R value of 3 ± 69 for shell samples (Hughen et al. 2004; McCormac et al. 2004; Ulm 2006).

Archaeological Evidence for Aboriginal Use of Marine Resources

Fishing

The principal archaeological evidence for the fish species caught or eaten in Port Jackson comes from two excavated middens near the mouth of the estuary – at Vaucluse and Balmoral Beach (Fig. 20.1). The faunal assemblage in the former dates back almost 1300 years(Attenbrow and Steele 1995:Tables 1 and 3), and in the latter to between ~2730 and ~3280 years ago (Attenbrow 1993:Table 2; the upper part of Balmoral Beach midden was removed during roadworks in the 1960s).

A third large Sydney region faunal assemblage dating from ~2000 years ago comes from Angophora Reserve on Barrenjoey peninsula (Wood 1992; McDonald 1992). Other comparative faunal assemblages come from Royal National Park (Glover 1974:Table 7; Megaw 1968a; Megaw and Roberts 1974:Table 4; Tracey 1974:Tables 2, 4 and 6) and Kurnell Peninsula (Brayshaw et al. 1992:Table 4.1.1; Dallas 2005; Dallas et al. 2001; Megaw 1968b).

A large number of fish taxa has been identified in excavated Port Jackson assemblages (Table 20.1). Snapper (*Pagrus auratus*) and yellowfin bream (*Acanthopagrus australis*) dominate the identified component of these fish assemblages, with

Table 20.1 Identified fishes from selected excavated Sydney region Aboriginal archaeological sites (see text for sources)

			Broken Bay	Port Jackson Lower Estuary			Port Jackson Middle and Upper Estuary			
Family	Genus and species	Common name	Angophora Reserve	Balmoral Beach	Vaucluse (Mt Trefle)	Woollahra, Milk Beach 4, Collins Cave	Balls Head, C'land St	Sugarloaf, Cammeray	Royal NP/ Kurnell Peninsula	McCue Midden (Kurnell Peninsula)
Arripididae	*Arripus trutta*	Eastern Australian Salmon	♦							
Carangidae	*Seriola lalandi*	Yellowtail Kingfish			♦	♦ [cc]				
Carangidae	*Pseudocaranx dentex*	Silver or White Trevally	♦			♦ [cc]				
Cheilodactylidae	*Nemadactylus douglasii*	Grey Morwong		♦		♦ [cc]				
Cheilodactylidae	*N. macropterus*	Jackass Fish		♦		♦ [cc]				
Cheilodactylidae	*Nemadactylus* spp.	Morwong/ Jackass	♦							
Elasmobranch	*Carcharias taurus*	Greynurse Shark								♦
Elasmobranch	Unidentified	Shark/Ray/ Skate								♦
Elasmobranch	Unidentified	Shark		♦					♦	♦
Girellidae	*Girella tricuspidata*	Luderick/Blackfish		♦						
Girellidae	*Girella* sp.	Luderick/Blackfish		♦					♦	♦
Hemiramphidae	Hemiramphid unidentified	Garfish							♦	
Labridae	*Achoerodus viridis*	Eastern Blue Groper	♦	♦	♦				♦	♦

(continued)

Table 20.1 (continued)

Family	Genus and species	Common name	Broken Bay	Port Jackson Lower Estuary			Port Jackson Middle and Upper Estuary		Royal NP/ Kurnell Peninsula	McCue Midden (Kurnell Peninsula)
			Angophora Reserve	Balmoral Beach	Vaucluse (Mt Trefle)	Woollahra, Milk Beach 4, Collins Cave	Balls Head, C'land St	Sugarloaf, Cammeray		
Labridae	Labrid unidentified	Parrotfish/Wrasse		♦	♦			♦ [cam]	♦	
Labridae	*Pseudolabrus gymnogenis*	Crimson-banded Wrasse							♦	
Labridae	*P. tetricus*	Blue-throated Wrasse		♦	♦					
Labridae	*Pseudolabrus* spp.	Wrasse	♦			♦ [cc]				♦
Latridae	*Latris lineata*	Striped Trumpeter	♦							
Lutjanidae	Lutjanid unidentified			♦						
Monacanthidae	*Meuschenia* sp.	Leatherjacket	♦							
Monacanthidae	Monacanthid unidentified	Leatherjacket		♦	♦	♦ [cc]	♦ [bh]		♦	♦♦
Moridae	*Lotella rhacina*	Rock cod/ Beardie				♦ [cc]				
Mugilidae	*Mugil cephalus*	Sea Mullet	♦							
Odacidae	Odacid unidentified	Weed Whiting		♦						
Platycephalidae	*Neoplatycephalus richardsoni*	Tiger Flathead	♦							

Platycephalidae	Platycephalid unidentified	Flathead		♦					♦	♦
Platycephalidae	*Platycephalus fuscus*	Dusky Flathead		♦	♦	♦ [w] ♦ [cc]				
Pleuronectidae	*Ammotretis* sp.	Flounder	♦							
Plotosidae	cf. *Cnidoglanis macrocephalus*	Eel-tailed Catfish	♦							
Pomatomidae	*Pomatomus saltatrix*	Tailor				♦ [cc]				
Sciaenidae	*Argyrosomus japonicus*	Mulloway	♦		♦	♦ [w] ♦ [cc]				♦
Serranidae	*Acanthistius ocellatus*	Eastern Wirrah		♦						
Serranidae	*Epinephelus* sp.	Rock Cod	♦	♦	♦					
Sillaginidae	*Sillago ciliata*	Sand Whiting			♦				♦	
Sillaginidae	*Sillago* sp.	Whiting			♦					
Sparidae	*Acanthopagrus australis*	Yellowfin Bream, E Black Bream	♦	♦	♦	♦ [w] ♦ [cc]			♦	
Sparidae	*Acanthopagrus* sp.	Bream	♦			♦ [mb]	♦ [bh]		♦	♦
Sparidae	*Pagrus auratus*	Snapper	♦♦	♦♦	♦♦	♦♦ [w] ♦ [mb] ♦♦ [cc]	♦ [cs]	♦ [cam] ♦ [sug]	♦	♦♦
Sparidae	*Rhabdosargus sarba*	Tarwhine		♦	♦				♦	♦
		Eel unidentified								♦

Scientific names updated according to Hutchins and Swainston (1986) and The Australian Museum Ichthyology Department. *Initials* in data columns refer to sites listed in heading

♦ Present at site; ♦♦ most abundant taxa recovered from site leatherjacket (Monacanthidae) and wrasse (Labridae) common elements. Snapper and bream are also the commonest species in excavated sites along other parts of the NSW South and Central Coast (Vinnicombe 1980:Part V, 3).

The identification of shark remains from middens on Kurnell Peninsula (Dallas 2005:139, 141, Table 5.13) and Balmoral Beach (Walshe 1995:Appendix 3, 14–15) gives some support to Phillip's comment that shark was eaten at some times, though it is possible the bones at Balmoral Beach may represent body ornaments or dingo scavenging refuse. However, the limited amount of shark bone recovered (a few vertebrae and teeth from Balmoral Beach and a tooth and several denticles from McCue Midden) may be due to preservational factors. Apart from their teeth, spines, dermal denticles and vertebral centra, sharks have a cartilaginous skeletal structure which is unlikely to survive for long in archaeological deposits (Rick et al. 2002:111, 113).

Shellfishing

The rich archaeological evidence for shellfishing contrasts strongly with the limited observations of shellfish collecting in the historical records. The most visible archaeological sites around the estuarine shores of Port Jackson today are hundreds of shell middens (Attenbrow 1991, 2010b:Plate 12).

In the Sydney region, the oldest evidence for shellfishing is in a rockshelter at Cammeray on the northern side of Port Jackson (Attenbrow 1995:26–29). It is around 6250 years old. Shell-bearing layers in most other radiocarbon-dated deposits are less than 4000 years old, and most are less than 2000 years old (Tables 20.2 and 20.3). The young age for most shell-bearing deposits principally reflects the poor conditions for preservation in the Sydney region sandstone environment and to the recent age of many shell middens. It is not simply because of the late appearance of shellfishing, or the increased use of shell resources, or necessarily increasing population numbers. Middens that formed immediately adjacent to shorelines between 7000 and 2000 years ago also may have been destroyed or partially destroyed by sea levels that were 0.3–1.0 m higher than present between 4800 and 4500 years ago, and again between 3000 and 2700 years ago (Haworth et al. 2004; Lewis et al. 2007).

Up to 50 shellfish taxa have been recorded in excavated Port Jackson middens (Attenbrow 1992b:Table 3), though not all can be considered food sources; many were small (<10–15 mm) and were probably not important, if at all, dietary items. For example: many small species may have come inadvertently into middens by "piggy-backing" on larger shellfish; shells of some small species may have been used for necklaces or other body decorations (Irish 2007). In addition, some shells, particularly of Sydney cockles or mussels, may have been left after the meat was extracted for use as fishing bait (Collins 1798[1975:461]; Tench 1793:194[1979:286]).

Shells in the middens indicate that the diet of the local inhabitants included a large number of different shellfish, but only a few species were commonly eaten;

many species are a minor component or not present at all sites. The species caught in different parts of the estuary are discussed below.

Marine Mammals and Reptiles

There is very little archaeological evidence for the use of marine mammals and reptiles in the Sydney region. Whale bone has been found in very few sites, e.g. Curracurrang 1 in Royal National Park (Megaw 1968a:326), which is hardly surprising given large size of most of their bones. The only other archaeological evidence for the use of marine mammals in the Sydney region are several dugong bones found in apparent association with ground-edged hatchet heads at Sheas Creek, south Sydney. Cut marks and scars on the bones suggest the animal was butchered and killed for food (Etheridge 1905:18; Etheridge et al. 1896). These bones have recently been dated to ~6000 years old (Haworth et al. 2004).

Seal bones have been identified from only one site in Port Jackson, Balmoral Beach (Walshe 1995) but, along with dolphin bones, have been found more often in middens along the ocean coastline in Royal National Park and Kurnell Peninsula as well as Angophora Reserve (Brayshaw et al. 1992:Table 4.1.1; Dallas 2005:Table 5.14; Megaw 1968a:326, 1968b:18; Glover 1974:Table 7; Megaw and Roberts 1974:8; Tracey 1974:Table 2; Wood 1992:Table 6). The seal bone recovered from these sites indicates that these animals were eaten in the Sydney region, so it is probable that they were hunted here as observed further south, despite the lack of historical observations. The relatively small amounts of seal bone recovered in the excavations, however, suggest it was either not a major food item, or that they were butchered and/or eaten away from campsites.

Similarly, while there are no observations by the first British colonists of the capture of marine turtles or their use as food in the Sydney region, several bone fragments from Balmoral Beach have been identified as turtle. So, turtles may well have been captured when they entered the estuary.

Crustaceans

Exo-skeleton fragments from crustaceans have been identified in several middens, but the amounts recovered are very small (Attenbrow 2010b:69). However, crustaceans have very fragile exo-skeletons and usually only the thicker parts such as claws survive both the poor preservation conditions of the Sydney region and excavation processes. Crabs and lobsters are probably under-represented in excavated coastal middens.

Barnacles form a small but common part of excavated faunal assemblages, but the Sydney region species are small, and most, if not all, probably came into the middens unintentionally attached to shellfish species which were collected to be eaten or used.

Table 20.2 Details of excavated Port Jackson Aboriginal shell middens and analysed faunal samples

Site name and excavated square used for analysis	Estimated area of midden (m)	Excavated area/sample (cm)	Depth (cm) of shell in excavated pit or column	Weight of excavated deposit (kg)	Weight of shell (g)	Weight of all animal bone (g or *n*)	Weight of marine animals (g or *n*)	Weight of land animals (g or *n*)	Uniden-tified bone (g)	Age of earliest shell deposits (cal years BP 2 sigma – Table 20.3 has conventional ages BP)	Number of stone artefacts
Lower estuary sites											
Balmoral Beach Square M6 Levels 1 to 21 (Attenbrow 1994:18–19, 1995)	20×>8	50×50 cm	65	203.6	13,139.9	733.05 g	366.33 g	152.53 g	214.19 g	~3500	1,532
Mt Trefle, Vaucluse (Attenbrow 1992a)	20×13	50×100 cm (inside) 100×100 cm (outside)	15 (inside) 70 (outside)	603.0	5,102.2	370.83 g	132.66 g	88.0 g	150.13 g	1093–1474 926–1175	1,506
Milk Beach 4, Vaucluse (Rich 1984)	8×3	20×20 cm and 20×20 cm	50 and 35	Not reported	>1,650 [8 mm sieve only]	*n* = 146 + numerous fragments	*n* = 136 + numerous fragments	*n* = 10 + fragments	0	Not dated	1 Possible
Reef Beach (O'Donnell and Walker 1982; Attenbrow and Bow 2002)	12×2	Irregular shape ~4 m^2	80	Not recorded	Not provided	At least 806.96 g	Not separated			522–914	66
Middle and upper estuary sites											
Abbotsford –Bulk Upper/Ashy/Basal Layers (Kenny 1987)	>6.0×5	Not reported	100	24,494.1	9,428.85	0.0	0.0	0.0	0.0	Not dated	2

Balls Head (Bowdler 1971)	14×7	300×120 cm and 180×120 cm [analysed shell from column 15×25.5]	100	Not recorded	Not provided	Not provided	1 Bream tooth and 1 leatherjacket dorsal spine	1 Macropod tooth	3 Fragments	Not dated	450
Bantry Bay BanB/3, Squares A and B (Specht 1976)	15×4.5	100×100 cm and 100×80 cm	29	Not recorded	36,440.2	0.0	0.0	0.0	0.0	4388–5029	15
Berry Island 3 (Jo Macdonald CHM 2000)	4.0×1.5	5 m^2	50	Not provided	11,337.2	Only a few animal bone fragments	Not recorded	Not recorded		964–1149	5
Cammeray G9 (Attenbrow 1994:26–27, 1995:Table 10)	56–35×11	50×50 (G9)	45	124.3	21,516.6	22.65 g	19.25 g	3.4 g	0.0	2146–2618	127
Castle Cove SSM.22563 Column F (Attenbrow et al. 1997)	16×4	15–20 wide×6–14	73.5	10.4	4,014.4	0	0	0	0	1016–1351	0
Cumberland Street (Attenbrow 1992b)	57×51	57×51	6	16.7	1,099.0	3.9 g				332–642	0
Sugarloaf J3East (Attenbrow 1995;Walshe 1995)	12×1.5	25×25 cm	34	23.9	5,218.8	7.8 g	7.1 g	0.7 g	0.0 g	4139–4368	33

Table 20.3 Details of radiocarbon ages for excavated Port Jackson Aboriginal shell middens referred to in text.

Site name	Sample provenance	Depth of sample (cm)	Lab No.	Conventional C14 age and standard deviation	Cal age 2 sigma [Calib 5.0.1]	CalBP Med Probability [Calib 5.0.1]	Material	Aquatic zone [site location O = open; Rsh = rockshelter]	Comments	References
Angophora Reserve	Square 10D; Layer I (analytic unit 5, spit 11)	40	ANU-6584	2000 ± 150	1686–2334 BP [0.97] 1617–1675 BP [0.03]	1967	Charcoal	Ocean/estuarine [Rsh]		McDonald (1992a: 46–47, Table 1)
Balmoral Beach 2	BB2/M4/04-shelly	04–09	Beta-55984	3000 ± 80	2473–3053 BP [1]	2777	Shell	Estuary mouth [Rsh]	Top of midden removed during roadworks in 1960s; age of uppermost undisturbed deposit inside rockshelter in Squares M4 and M8	Attenbrow (1993:12, Table 2)
	BB2/M8/07-shelly	19–23	Beta-60308	2960 ± 60	2454–2950 BP [1]	2728	Shell	Estuary mouth [Rsh]		
	BB2/M4/10-BL	45–50	Beta-56286	3080 ± 90	3058–3469 BP [0.97] 3005–3053 BP [0.03]	3280	Charcoal	Estuary mouth [Rsh]	Age of base of shelly layer in Squares M4 and M8	
	BB2/M8/13-SBB	52–57	Beta-60309	3070 ± 70	3076–3412 BP [0.98] 3423–3442 BP [0.02]	3278	Charcoal	Estuary mouth [Rsh]		

Bantry Bay 3	BanB3/Square 3A/spit 4b	16–19	SUA-0593	4520 ± 100	4388–5029 BP [1]	4699	Shell	Estuarine – mid [Rsh]		Ross and Specht (1976:16)
Berry Island 3	Square 5BN/ spit 4	20–35	OZF–209	1195 ± 40	964–1149 BP [0.96] 1157–1171 BP [0.04]	1043	Human bone	Estuarine – mid [Rsh]		ANSTO (email: 18 April 2007), Jo McDonald CHM (2000: Plates 8, 9, App. 4:2.)
Cammeray	CAM/G9/ Sample Y from section = CAM/G9/ spit 11	39	Wk-3052	2330 ± 90	2146–2618 BP [0.90] 2633–2706 BP [0.10]	2372	Charcoal	Estuarine – mid [Rsh]		Attenbrow (1994: Table 9)
	CAM/Square ST9-10/spit 4-LrShell	20	Wk-3219	5840 ± 50	6040–6433 BP [0.99] 6029–6035 BP [0.01]	6254	Shell	Estuarine – mid [Rsh]		
Castle Cove, SSM22563	Column F/spit 15, base of midden	73–75	OZC-901	1650 ± 40	1016–1351 BP [1]	1199	Shell	Estuarine – mid [O]		Attenbrow et al. (1997)
Cumberland Street, Sydney CBD	Lens of shell 67 × 51 × 6 cm deep; beneath 65 cm of historical overburden		Beta-47633	0890 ± 60	322–642 BP [1]	502	Shell	Estuarine – mid [O]		Attenbrow (1992b: 19–20)

(continued)

Table 20.3 (continued)

Site name	Sample provenance	Depth of sample (cm)	Lab No.	Conventional C14 age and standard deviation	Cal age 2 sigma [Calib 5.0.1]	CalBP Med Probability [Calib 5.0.1]	Material	Aquatic zone [site location O = open; Rsh = rockshelter]	Comments	References
Mt Trefle, Vaucluse	MT/Ad/spit 5 (inside shelter)	05–12	Wk-2082	1730 ± 50	1093–1474 BP [1]	1279	Shell	Estuary mouth [Rsh]	Depth and stratigraphy of Squares Ad and Ca-b are different; Square A deposit was on a rock shelf	Attenbrow and Steele (1995:51)
	MT/Cb/spit 10 (outside shelter)	55–63	Wk-2083	1170 ± 60	926–1175 BP [1]	1031	Charcoal	Estuary mouth [Rsh]		
Reef Beach	Shell taken from near base of midden	ca. 60–70	SUA-401	1150 ± 90	522–914 BP [1]	712	Shell	Estuary mouth [O]		O'Donnell and Walker (1982:3, 7, 15–16); Walker (1978:2–3)
Sugarloaf 2	SUG/J3east/5 (31–34 cm)	31–34	Wk-4196	4170 ± 40	3988–4445 BP [1]	4244	Shell	Estuarine – mid [Rsh]		Attenbrow (1995:18, Table 7)

Archaeological Evidence for Land Animal Hunting and Plant Gathering

The identified land animal remains from excavated middens around Port Jackson include mammals (kangaroo, wallaby, dingo, bandicoot, possums, gliders, potoroo and marsupial mice), reptiles (lizard, goanna), birds (brush turkey) and amphibians (frog) (Attenbrow 2010b:Tables 7.2 and 7.3).

The Port Jackson faunal assemblages vary widely in size, with some middens having very little and even no animal bone. The number of identified species also varies quite widely. The largest faunal assemblage comes from Balmoral Beach where a greater number of land animal taxa has been identified than in any other excavated Port Jackson site. At Balmoral Beach macropods and gliders/possums were the most abundant land animal remains (Walshe 1995).

Along the adjacent coast and estuaries, Angophora Reserve as well as several sites in Royal National Park and on Kurnell Peninsula have land animal bone assemblages (Brayshaw et al. 1992:Table 4.1.1; Dallas 2005:Tables 5.14–5.17; Dallas et al. 2001:Tables 4.3–4.6; Glover 1974:Table 7; Tracey 1974:21, Tables 2 and 6; Megaw 1968a:326; Megaw and Roberts 1974:Table 4; Wood 1992:Table 5, 6, 11 and 12).

Angophora Reserve has the largest number of identified species of the excavated Sydney region sites; again because of the large volume excavated. Macropods were the most commonly identified animals at Angophora Reserve. It has a large number of identified reptiles and birds which again is probably due to the large size and good preservation of the faunal assemblage in this midden. The small, fine bones of these animals often do not survive in the relatively acidic soils of the Sydney region. In addition, historical accounts indicate that the bones of birds, reptiles, and other small animals were often crushed and eaten

> … if a bird was shot, and thrown to them, they would immediately pluck off the feathers, put it upon the fire without taking out the intestines, and eat the whole; sometimes they did not pull off the feathers, and, if it were a small bird, did not even throw the bones away (Hunter 1793[1968]:80).

The large number of identified fauna from Angophora Reserve and Balmoral Beach is due, in large part, to the extensive excavations undertaken and the consequent large faunal assemblage recovered. The lack of bone in some middens may be partially due to the small area excavated, but it may also be that the shells derive from shellfish eaten during the day (i.e. they are Meehan's 1982 dinner-time camps), and/or are dumps of shell from which the meat was taken as bait for fishing. Despite the varying size of faunal assemblages from the Sydney region sites, the excavated remains suggest that the hunting of land animals by coastal groups is under-documented in the historical accounts.

The only remains of a plant that can be said unequivocally to have been humanly transported into a Sydney region site come from Angophora Reserve, where kernels ands sclerotestae from the cycad *Macrozamia communis* (locally known as Burrawang) were associated with a hearth dated to ~1000 years ago. This rarity of archaeological evidence for food plants, as well as the poor historical record for their use, is in strong contrast to the long list of over 200 Sydney region plants which are known to have edible parts and to have been eaten in other parts of south-eastern New South Wales (see above) and the ethnographic descriptions from other Australian Aboriginal societies where plant foods were a prominent part of the diet (Gould 1969:18–19; Meehan 1982:146–147). The use of plant foods in the Sydney region appears to be under-represented in both the historical accounts and archaeological record. The sparse archaeological evidence for plant use is principally due the fact that organic remains do not survive well (if at all) in the relatively acidic soils of the Sydney region, and special excavation and retrieval techniques or use-wear/residue studies designed to detect plant remains/residues have yet to be undertaken.

Summary of Archaeological Evidence for the Role of Marine Resources in the Diet of Aboriginal People Around Port Jackson

The archaeological evidence supports the view that the diet of the Aboriginal people of Port Jackson included both marine and land animals. It provides a more comprehensive list of the fish and shellfish and other marine animal species eaten than the historical accounts. It indicates that shellfishing played a more important role than the historical records suggest, though the number and visibility of middens over-emphasises the role of shellfish in the diet. It is clear however, that fishing was an important activity and that fish were an important part of the diet.

Geographical Variation

Another major contribution that the archaeological record provides is evidence for variability in the amount of fishing activity in different parts of the estuary. The historical documents indicate fishing was carried out in many parts of Port Jackson and its tributaries, with the lower estuary perhaps being favoured fishing grounds; the few historical references to hunting and catching of land animals provide no hints as to whether these activities were focussed in any particular part of the estuary. The archaeological evidence, however, suggests that the focus on these activities may have varied in different parts of the estuary. To demonstrate the spatial variation, I have used relative measures comparing weights of fish bone, marine animal bone and land animal remains and shell in each site where these data were available (Table 20.2; Fig. 20.4), and bearing in mind the volume excavated and number of fish taxa identified.

Fish and Fishing

The amount of fish bone recovered from middens in different parts of the estuary varies geographically. Excavated middens adjacent to the middle and upper reaches

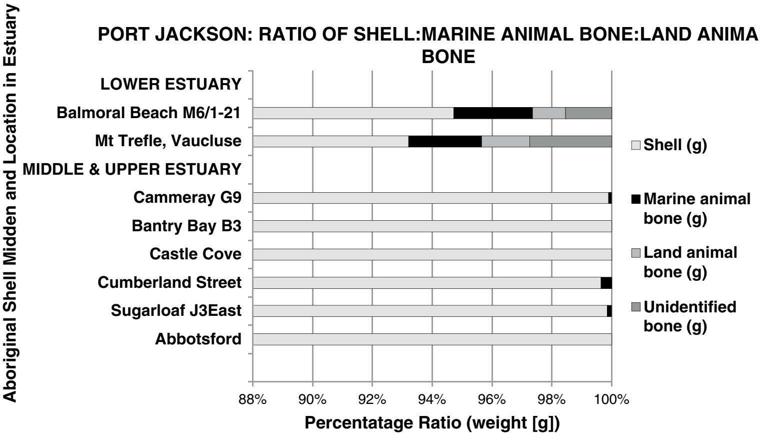

Fig. 20.4 Percentage ratios of shell: marine animal bone: land animal bone: and unidentified bone for excavated Port Jackson Aboriginal shell middens

of the estuary have very few fish remains and a very limited range of identified taxa. For example, the maximum number of taxa identified in assemblages at any mid-estuarine site was two, in contrast to the lower estuary assemblages where 13 and 14 taxa were identified (Table 20.1). An exception is Milk Beach, a small shallow midden at Vaucluse near the estuary mouth, where the volume excavated was very much less than at other sites (Tables 20.1 and 20.2).

This spatial patterning suggests that most fishing activity took place in the lower part of the estuary. This may be simply because there is a greater taxa diversity and a greater biomass of fish in the broad deep waters of the lower estuary than in the middle and upper reaches. The Gamarigal, whose country was the northern shore of lower Port Jackson, were in fact reported as having the best fishing grounds (Tench 1793:193[1979:285]). Variations in preservation factors within shell middens do not seem to play a role, though the post-1788 destruction of many large middens may be a factor. Cultural practices, such as cooking and eating fish in the canoes (Fig. 20.3; Collins 1798[1975]:461), which could possibly explain the lack or paucity of fish bones in middens, were not reported as being restricted to certain parts of Port Jackson and seem unlikely explanations for the sparseness of fish bone in middle and upper estuarine middens. Other cultural explanations relating to variations in resource use, such as a greater reliance on land animals in upper estuarine areas, and/or base camps or main campsites being located in away from the estuary shoreline are discussed below.

A focus on fishing at the estuary mouth is supported by the distribution of shell fish-hooks which are found only in coastal middens, along with stone files probably used in their manufacture (Attenbrow et al. 1998). Around Port Jackson all but one shell fish-hook were found in lower estuary middens.

Shellfish and Shellfishing

The existence of shell middens all around the shores of Port Jackson and the estuarine reaches of its tributaries indicates that shellfishing was a common activity in all parts of the estuary. The species and number of shellfish taxa present in each midden depend on its location within the estuary, that is, whether the midden is in the middle or upper reaches of the estuary or in the lower estuary where ocean species also occur.

The middens near the estuary mouth have a greater species diversity than middle and upper estuarine middens and are dominated by rock platform species (Attenbrow 1992b:Table 3). The most common dominant species are rock oyster (*S. glomerata*), hairy mussel (*Trichomya hirsuta*), black nerita (*Nerita atramentosa*), variegated limpet (*Cellana tramoserica*), Cartrut (*Dicathais orbita*), Splengers triton (*Cabestana spengleri*), Sydney cockle (*Anadara trapezia*) and the large Turban (*Turbo torquatus*). Edible mussel (*Mytilus planulatus/edulis*) has been recorded at very few middens and is present in very small quantities in those sites where it has been recorded. No one species appears to predominate in the estuary mouth middens to the same extent that rock oyster does in the middle/upper estuarine middens.

Fewer species are recorded in middle and upper estuarine middens. Generally, shell middens in the middle and upper estuarine reaches have rock oyster and Sydney cockle (*A. trapezia*) as the dominant species. Other common shell species are Hairy mussel, Hercules whelk (*Pyrazus ebeninus*) and spiny oyster (*Chama fibula*), mud oyster (*O. angasi*), the wink (*Bembicium auratum*) and the small whelk (*Velacumantus australis*) (Attenbrow 1991:49, 1992b:Table 3). The latter two species, along with other infrequently retrieved small species, are usually <10 mm and may not have been collected as food items.

Land Animals

The amount of bone retrieved (number or weight) has not always been recorded for each site, but where such details are available it appears that the amount of land animal bone in each site varies widely (Table 20.2; Fig. 20.4). The largest assemblages of land animal bones are near the estuary mouth and along the ocean shoreline – a similar pattern to fish remains. In Port Jackson, for example, Balmoral Beach and Vaucluse have relatively large bone assemblages compared to Cammeray, Castle Cove, Sugarloaf and Balls Head, while no bones at all were recovered from Abbotsford and Bantry Bay 3 (Table 20.2; Fig. 20.4).

Conclusions

The historical accounts place a strong emphasis on fishing as a principal component of the diet of the people living around the shores Port Jackson, with much less emphasis on land animals and plant foods except in the winter months. The faunal remains retrieved from excavated archaeological sites indicate that people had a mixed or generalised coastal subsistence economy based on both marine and terrestrial resources (cf. Lampert 1971:63–64). The amount of bone and number of land animal species identified indicates hunting was certainly part of their subsistence, and was more important along the coast than the small number of historical descriptions indicates. It is possible that, because hunting (as well as gathering plants and smaller animals) took place in timbered country, hunting and plant collecting simply was not as visible as fishing activities on the open waters of the estuaries and coastline. In the forests and woods people could hide themselves easily or be obscured by the trees and undergrowth (Poiner 1976:200; Southwell 1788[1893:703]). Thus, the chance for the colonists to observe people hunting was much lower. If this were the case, the early writers may have presented a biased view of the subsistence base in this part of the country. However, the relative abundance of fish bone compared to land animal bone in the faunal assemblages support the historical accounts insofar as they indicate that the subsistence activities of the Aboriginal people living around Port Jackson focussed on marine resources, particularly fishing and shellfishing.

Aboriginal people were observed fishing in all parts of the Port Jackson estuary, and, although there were many different groups living around the estuary, the historical records give the impression that they all shared a basically similar subsistence base compared to people who lived in the hinterland, that is, west of Parramatta and Liverpool on the Cumberland Plain and along the western reaches of the Hawkesbury River (Attenbrow 2010b). The distribution of shell middens indicates that shellfishing was undertaken in all parts of the estuary, although estuary mouth sites have a wider range of shellfish with the addition of the ocean species. However, the archaeological record indicates that the proportion of fish and other marine fauna relative to shellfish in middens near the estuary mouth is greater than in middens in middle and upper estuarine locations. In addition, interestingly, the archaeological evidence indicates that land animal remains also occur more commonly in middens near the estuary mouth, and there is very little (and sometimes none) in sites in middle and upper estuarine locations. The excavated faunal remains thus suggest that people living in the coastal zone did not all share the same subsistence pattern and that fishing and hunting land animals was carried out principally in the lower estuary, and that shellfish formed a greater part of the marine component of the diet in the middle and upper reaches of the estuary.

However, this may not be the case. The archaeological patterning need not be explained in simple environmental terms or presence/absence terms, even though the lower estuary does have a greater diversity of fish species than the middle and upper estuary, and the abundance of fish would also be greater as the area and volume of water in which fish were available is greater at the estuary mouth.

The lack/sparseness of fish and particularly land animal remains in the middle and upper estuarine middens is puzzling. One plausible explanation is that in the middle and upper reaches of the estuary the subsistence and camping patterns differed from those in the lower estuary. Shellfish were either eaten and/or the shells discarded at the shoreline, whereas fish were carried to campsites away from the shoreline, perhaps closer to where land animals were hunted and eaten as they may have formed a greater part of the diet than in the lower estuary.

The presently documented archaeological patterning supports the historical accounts that fishing was a significant part of the subsistence economy of people living around Port Jackson. However, fishing appears to have played a greater role in the subsistence activities in the lower estuary than in the middle and upper estuarine reaches, and thus the extent to which fishing was carried out and the role of marine resources in the diet varied substantially in different parts of Port Jackson.

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