

THE YSTERFONTEIN 1 MIDDLE STONE AGE ROCK SHELTER AND THE EVOLUTION OF COASTAL FORAGING

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ABSTRACT

The Ysterfontein 1 rock shelter (33°20'S, 18°09'E) is located in the eponymous town, on the west coast of South Africa, roughly 70 km north-northwest of Cape Town. The floor is diorite at 7 m above mean sea level and the roof is calcrete. Road construction removed the entrance and exposed 3.8 m of stratified sands that completely filled the rear. The uppermost layers, to a depth of 1–1.5 m, contain few artefacts or faunal remains per unit volume, and they dip into the shelter. Tooth-marked bones and occasional coprolites indicate that small carnivores and hyaenas sometimes lived inside the shelter. However, the low ceiling and the sediment dip suggest that the encroaching sands originated on the back face of a dune that stood near the shelter mouth. Middle Stone Age (MSA) activity on the dune crest probably accounts for the occasional artefacts and intertidal shells. Below 1.5 m depth, the layers lie more horizontally, and stacked hearth lenses, numerous artefacts, and abundant intertidal shells document MSA occupation. An accelerator mass spectrometry (AMS) radiocarbon reading on ostrich eggshell places the occupation before 46 ka (thousand years) ago. It probably postdates 115 ka ago, since storm surges during a period of high sea-level that ended about then would probably have flushed any pre-existing deposit. The artefact assemblage lacks markers of the Howieson's Poort and Still Bay variants of the MSA, and it may predate either or both of them. Optically Stimulated Luminescence analysis of sand grains from various stratified units may provide a more precise age estimate. The MSA fauna resembles faunas from other west coast MSA sites in the rarity or absence of fish, the heavy emphasis on a limited range of shellfish, and the large size of limpets and tortoises. Like faunal collections from MSA sites on the south coast of South Africa, the Ysterfontein 1 fauna suggests that people in the MSA exploited coastal resources less intensively than their Later Stone Age (LSA) successors and that their populations were smaller. Thus, even if MSA artefacts from Blombos Cave and other sites sometimes imply LSA-like culture, they do not appear to have conferred an LSA-like ability to survive and reproduce. This may explain why people in the MSA failed to expand from Africa.

Keywords: Middle Stone Age ecology, stone age coastal foraging, 'Out of Africa' hypothesis.

INTRODUCTION

South Africa is unique for the discovery of deeply stratified shell middens that predate 50 ka (thousand years) ago. Sites of similar antiquity in Morocco, Algeria, Libya, Lebanon, Italy, France, and Gibraltar (Table 1) have produced small numbers of intertidal shells, sometimes with bones of coastal vertebrates, but only the ancient South African sites (Table 2; Fig. 1) have provided true shell middens. They closely resemble much younger middens that date from the Holocene epoch, after 12–11 ka ago,

and that have been found on every inhabited continent (Erlanson 2001; Erlanson & Moss 2001). In Africa, most of the Holocene shell middens are associated with Later Stone Age (LSA) technology, but in South Africa the much older shell middens have Middle Stone Age (MSA) associations. The dating of the LSA/MSA transition is not resolved, because the early LSA is almost unknown in southern Africa and poorly known elsewhere. However, age estimates from Enkapune Ya Muto, Kenya, suggest the LSA was in place 50–45 ka ago (Ambrose 1998). This means that the anatomically modern Africans who expanded to Eurasia at about this time were probably people with early LSA technologies. In Eurasia, they swamped or replaced the Neanderthals and other non-modern humans, and they created the Upper Palaeolithic.

Earlier LSA and Upper Palaeolithic shell middens, with ages between 50–45 and 12 ka old, are unknown, but the early occupants of the Bismarck and Solomon Islands, northwestern Melanesia, have produced unambiguous middens between roughly 35 and 12 ka old (Allen *et al.* 1988; Wickler & Spriggs 1988; Allen 1994; Gillespie 2002; Leavesley *et al.* 2002). The shorelines of the Melanesian islands fall off steeply, and the middens occur in caves whose distance to the coast barely changed even when global sea-levels rose sharply after 14–12 ka ago. In contrast, most contemporaneous African and European middens would have formed on the seaward margins of more gentle continental shelves and they would now be submerged. In their absence, however, the occurrence of MSA and LSA middens in South Africa still provides an opportunity to investigate aspects of coastal foraging before and after the modern human expansion. Cultural changes in Africa are often assumed to underlie the expansion, and a comparison of MSA and LSA middens could help to establish whether or not there was a difference in human ability to exploit natural resources. In this paper we address the possibility of such a difference by comparing the MSA midden in the Ysterfontein 1 rock shelter and local LSA middens. We conclude that the MSA inhabitants of Ysterfontein 1 exploited coastal resources less intensively. The reason was probably that MSA populations were smaller and more sparsely distributed, perhaps because MSA technology could not support as many people.

Ysterfontein 1 (YFT1) (33°20'S, 18°09'E) is located on the west coast of South Africa, 70 km north-northwest of Cape Town. There are four other known MSA middens on the west coast: Boegoeberg 2, Hoedjiespunt 1 and 3, and Sea Harvest (references in Table 2; locations in Fig. 1), and mining disturbance indicates that more middens lie deeply buried below coastal sands (Parkington 2003; Parkington 2006). However,

TABLE 1. North African and European coastal or near-coastal Middle Palaeolithic sites with intertidal shells. The listing proceeds roughly counterclockwise around the Mediterranean Sea. The Abdur Reef site on the Red Sea coast of Eritrea has provided artefacts, shells, and large mammal bones with firm age estimates of about 125 ka ago (Walter *et al.* 2000; Bruggemann *et al.* 2003), and it may one day extend the list. However, most of the artefacts do not appear to lie where they were dropped, and none are directly stratified with shells or bones.

| Site | References |
|---|---|
| Smugglers' Cave (Grotte des Contrebandiers) (Témara), Morocco | Roche & Texier 1976; Bouzouggar <i>et al.</i> 2002 |
| Zouhrah Cave (El Harhoura 1), Morocco | Debénath & Sbihi-Alaoui 1979; Aouraghe 2004 |
| Mugharet el 'Aliya (Tangiers), Morocco | Howe & Movius 1947; Howe 1967; Bouzouggar <i>et al.</i> 2002 |
| Bérard open-air site, Algeria | Roubet 1969 |
| Haua Fteah, Libya | McBurney 1967; Klein & Scott 1986 |
| Ras el-Kelb Cave, Lebanon | Copeland & Moloney 1998; Reece 1998 |
| Moscerini Cave and possibly other coastal caves, Italy | Stiner 1994; Stiner 1999; Stiner 2001 |
| Ramandils Cave, France | Cleyet-Merle & Madelaine 1995 |
| Devil's Tower Rock Shelter, Gibraltar | Garrod <i>et al.</i> 1928; Lalueza-Fox & Pérez-Pérez 1993 |
| Gorham's Cave, Gibraltar | Waechter 1964; Eastham 1989; Barton <i>et al.</i> 1999; Barton 2000; Pettitt & Bailey 2000; Rink <i>et al.</i> 2000 |
| Vanguard Cave, Gibraltar | Barton <i>et al.</i> 1999; Barton 2000; Fernández-Jalvo & Andrews 2000; Pettitt & Bailey 2000 |

Ysterfontein 1 has produced by far the largest artefact and faunal samples, and it is likely that further excavation will provide even larger samples.

The south coast of South Africa has produced five MSA midden sites: Die Kelders cave 1, Blombos Cave, Herolds Bay, the Pinnacle Point caves and the Klasies River Main Cave complex (Table 2; Fig. 1). We do not consider Herolds Bay and the Pinnacle Point caves in this paper, because their MSA samples are small. We have also excluded Die Kelders 1, because acidic ground waters have reduced its once-abundant MSA shells to tiny fragments, and only bones of seals and marine birds survive to document coastal exploitation. The two remaining south coast sites, Blombos and the Klasies River complex, are central to our conclusions, since in key respects, they contrast with local LSA middens in the same way that MSA and LSA middens contrast on the west coast. West and south coast environments differ significantly, and terrestrial and especially shellfish species in the MSA sites show that the difference is long-standing. This increases the likelihood that differences in culture, as opposed to differences in palaeo-environment, explain why MSA coastal exploitation differs from LSA exploitation in broadly the same way on both coasts.

YFT1 EXCAVATION HISTORY AND METHODOLOGY

In the early 1980s, contractors enlarging the parking lot for the small boat harbour in the town of Ysterfontein (also known as Yzerfontein) cut back the slope along the access road and exposed 3–4 m of sands resting on a diorite platform 5 m above the road and 7 m above mean sea-level. Shortly afterwards, Avery observed the infrequent presence of marine shells, bones, ostrich eggshell fragments and MSA artefacts in the sands. In February 1998 and April 1999, John Parkington and University of Cape Town students collected artefacts and shells that had eroded from the exposure. Inspection of the section indicated that continuing erosion threatened the deposit, and that safe excavation required the placement of scaffolding against the diorite platform.

In May 2002, Halkett, Hart and Yates erected a 6-m-high scaffold and laid out a 50 cm × 50 cm grid over the site (Fig. 2). They excavated in three discrete sectors and established that the deposits were richest and most conspicuously stratified in the easternmost one (squares D–L 32–35 in Fig. 2) (Halkett *et al.*

2003). A follow-up season in 2003 confirmed this result (Klein *et al.* 2004), and there have been excavations in each subsequent year, making a total of 6 seasons over about 32 weeks. This paper covers the first five seasons (including 2006). Sorting of the material excavated in 2007 is proceeding and we plan a 6-week excavation in 2008.

The excavations show that the deposits fill a rock shelter that formed at the contact between the diorite below and calcrete above (Figs 3 & 4). The contractors destroyed the front part of the shelter and discarded an indeterminable quantity of cultural debris. The floor and roof of the shelter are well-defined, but scree obscures its lateral extent. We plan to expand the present excavation westwards and to excavate the sequence to bedrock over as large an area as possible.

We excavate with wooden skewers and domestic vacuum cleaners to limit damage to bones and shells, and we mend fragmented bones and shells, in place, with Paraloid B72 (reversible acetone-based glue) to facilitate subsequent removal, identification, and measurement. We record all objects to 50 cm × 50 cm grid square and to natural stratigraphic units defined by sediment texture and colour, and by minor nonconformities, including carbonized lenses that mark ancient fireplaces. We sieve the excavated sediment from each square and stratigraphic unit with stacked 3 mm and 1.5 mm mesh screens. In the field we sort the material from the 3 mm screen into categories consisting of artefacts, bones, major types of intertidal shells, and ostrich eggshell, and we retain the remaining material from each screen for possible further investigation in the laboratory. We undertake final sorting and analysis in the Archaeology and Cenozoic Studies laboratories of the Iziko South African Museum in Cape Town.

SITE FORMATION

The YFT1 fill comprises 3.8 m of bedded, highly calcareous sands that incorporate pebble-to-boulder size blocks of aeolianite, calcrete, and especially, diorite (Fig. 4). We have employed relatively small differences in sand texture and colour to define stratigraphic units in the field and grosser differences to lump these into thirteen stratigraphically successive groups that are broadly analogous to 'members' as defined at Boomplaas Cave (Deacon 1979, 1995) and Klasies River Main (Deacon & Geleijnse 1988; Deacon 1995). These thirteen

TABLE 2. South African sites that document MSA and LSA coastal foraging. The listings proceed from southeast to northwest along the South African coastline. Figure 1 shows their approximate locations.

| Site | Age estimation (source) | References |
|-----------------------------|--|---|
| MIDDLE STONE AGE | | |
| Klasies River Main | Between 127 and 57 ka (ESR, geologic context, faunal associations) | Klein 1976; Singer & Wymer 1982; Voigt 1982; Thackeray 1988; Deacon & Geleijnse 1988; Deacon 1989; Deacon & Shuurman 1992; Deacon 1995 |
| Herolds Bay Cave | Between 120 and 80 ka (U-series dating, geologic context, faunal associations) | Brink & Deacon 1982 |
| Pinnacle Point | Between 164 and 40 ka (artifacts, OSL) | Marean <i>et al.</i> 2004; Marean <i>et al.</i> 2007 |
| Blombos Cave | Between 140 and 75 ka (OSL, TL) | Henshilwood 1996; Henshilwood 1997; Henshilwood & Sealy 1997; Henshilwood 1998; Henshilwood & Sealy 1998; Grine <i>et al.</i> 2000; d'Errico <i>et al.</i> 2001; Henshilwood <i>et al.</i> 2001a,b; Grine & Henshilwood 2002; Jacobs <i>et al.</i> 2003a,b; Henshilwood 2004; d'Errico <i>et al.</i> 2005; Henshilwood 2005; Jacobs <i>et al.</i> 2006; Tribolo <i>et al.</i> 2006; d'Errico & Henshilwood 2007 |
| Die Kelders Cave 1 | Between 71 and 45 ka (ESR, geologic context, faunal associations) | Tankard & Schweitzer 1976; Grine <i>et al.</i> 1991; Klein & Cruz-Urbe 1996; Avery <i>et al.</i> 1997; Marean <i>et al.</i> 2000 |
| Ysterfontein 1 rock shelter | Between 119 and = 46 ka (radiocarbon, geologic inference) | Halkett <i>et al.</i> 2003; Klein <i>et al.</i> 2004 |
| Sea Harvest | Between 130 and > 40 ka (radiocarbon, geologic inference) | Volman 1978; Grine & Klein 1993 |
| Hoedjiespunt 1 & 3 | Between 130 and > 40 ka (radiocarbon, infrared stimulated luminescence, geologic inference) | Berger & Parkington 1995; Stynder <i>et al.</i> 2001; Butzer 2004; Parkington 2006: 99–100 |
| Boegoeberg 2 | Between 130 and > 40 ka (radiocarbon, geologic inference) | Halkett, Hart & Parkington, pers. comm. 1996; Klein & Cruz-Urbe 1996 |
| LATER STONE AGE | | |
| Nelson Bay Cave | 12–0.5 ka for layers with shells, fish and other coastal food debris (radiocarbon) | Klein 1972a,b; Deacon 1984a; Inskeep 1987 |
| Noetzie (Knysna) | 5–1.5 ka (artefact and faunal associations) | Orton & Halkett 2007 |
| Die Kelders Cave | 2–1.6 ka (radiocarbon) | Schweitzer & Scott 1973; Schweitzer 1974; Schweitzer 1979 |
| Byneskranskop Cave | 13–0.8 ka (radiocarbon) | Schweitzer & Wilson 1982 |
| Hawston Midden | 1.9 ka (radiocarbon) | Avery 1976 and unpublished |
| Pearly Beach Middens | 2.9–0.8 ka (radiocarbon) | Avery unpublished |
| Bakoond | 4.3–?0.7 ka (radiocarbon, artefact and faunal associations) | Orton 2007b |
| Paternoster 1062 | 2.8 ka (radiocarbon) | Yates 1998 |
| Kasteelberg A and B | 1.8–0.4 ka (radiocarbon) | Smith 1987; Klein & Cruz-Urbe 1989; Smith 1992; Smith 2006a,b |
| Duiker Eiland | 1.9–1.7 ka (radiocarbon) | Robertshaw 1979 |
| Tortoise Cave | 7.7 ka and 4.4–< 0.75 ka (radiocarbon) | Robey 1987; Jerardino 1995 |
| Pancho's Kitchen Midden | 3.7–0.6 ka (radiocarbon) | Jerardino 1997; Jerardino 1998 |
| Elands Bay Cave | 13–8 ka and 4–0.3 ka for layers with shells, fish, and other coastal food debris (radiocarbon) | Parkington 1981; Parkington 1987; Buchanan 1988; Parkington 1990; Orton 2006; Parkington 2006; Parkington, in press a,b |
| Hail Stone Midden | 1 ka (radiocarbon) | Parkington 1979; Parkington <i>et al.</i> 1988 |
| Connies Limpet Bar | 0.4 ka (radiocarbon) | Parkington 1979; Parkington <i>et al.</i> 1988 |
| Dunefield Midden | 0.9–0.6 ka (radiocarbon) | Parkington <i>et al.</i> 1992; Orton 2002; Orton 2002/2003; Tonner 2005; Parkington 2006 |
| Steenbokfontein | 6.1–2.1 ka (radiocarbon) | Jerardino & Yates 1996; Jerardino & Swanepoel 1999 |

groups, in turn, have been divided into two groups, based on their probable mode of accumulation:

Groups 1–3 (0.8–1 m thick). Individual units in these groups tend to dip into the shelter, and they contain few cultural or faunal items per unit volume. This is particularly true of Groups 1 and 2, which have very few artefacts. Group 1 abuts the calcrete roof. Groups 2 and 3 formed when the shelter floor was a metre or less from the roof. Tooth-marked bones in Groups 1 and 2 imply that mongooses, jackals, or other small

carnivores sheltered in the site, and bones of tiny fish (<10 cm) and small mammals probably originated from the small carnivores' decomposed scats. A coprolite in Group 3 shows that hyaenas sometimes visited, although a patch of burned sediment in Group 3 argues that people occasionally entered as well. However, the low roof and inward dip of the layers suggest that the sands of Groups 1–3 and many of the enclosed objects slid down the back face of a long-vanished dune that stood in front of the cave. MSA activity on the dune crest

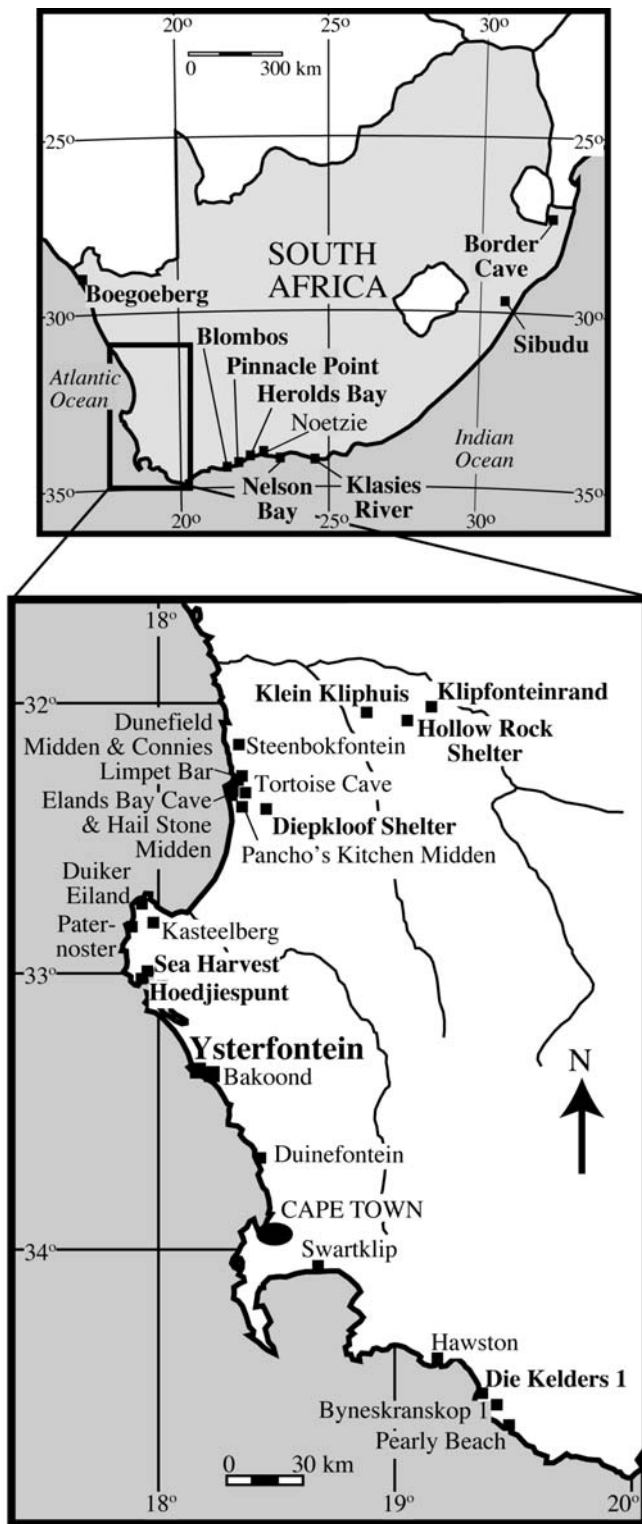


FIG. 1. The approximate locations of MSA and LSA sites mentioned in the text. Boldface marks the MSA sites, some of which (Klipfonteinrand, Klein Kliphuis, Diepkloof Shelter, Die Kelders 1, Blombos, Nelson Bay and Klasies River) also have LSA occupations.

probably accounts for the occasional artefacts and the more numerous intertidal shells.

Groups 4 and below (2.5–2.8 m thick). Individual units in these groups tend to be more horizontal than those in Groups 1–3. Compared to units in the higher-lying groups, the units from Groups 4 and below are significantly richer in artefacts, shells and bones per unit volume. Calcrete debris that probably signals roof collapse separates Groups 6 and 7

(‘Lower Calcrete’ in Figs 4 & 5). A lens of carbonized/carbonaceous sediment that is the uppermost unambiguous hearth occurs near the top of Group 4. Additional carbonaceous lenses, 50–100 cm across, are common in the lower-lying groups, where they appear stacked, as at Klasies River Main (Deacon 1995). Wind transport, perhaps supplemented by sandy feet, probably introduced the sands in Groups 4 and below, and people probably contributed the shells and most of the bones. Two coprolites in Group 4, together with aspects of the fauna that we consider below, imply that hyaenas could also have contributed some of the bones in Groups 4 and 5. Hearth lenses, abundant artefacts, and densely packed shell (Fig. 5) indicate that people accumulated most material in Groups 6 and below.

Disturbances, produced by dune molerats, other burrowing mammals or possibly by roots, intruded the YFT1 strata at all levels. The intrusions contain similar artefacts, shells, and bones as adjacent undisturbed stratigraphic units. When we were unable to determine the stratigraphic origin of an intrusion, we excluded its contents from the analysis.

DATING

The diorite platform that is the floor of YFT1 stands at ~7 m above mean sea-level, which coincides closely with the maximum height of the Last Interglacial sea, near the close of Oxygen Isotope Stage (OIS) 5e. The maximum has been most recently fixed between 122 and 119 ka ago (Hearty *et al.* 2007), and if the shelter existed then, storm surges would probably have flushed its contents. Further excavation in the lowermost levels, just above bedrock, may confirm this. An accelerator mass spectrometry (AMS) radiocarbon reading (Beta 171203) on ostrich eggshell places the top of the sequence before 46 ka ago. The sediments therefore probably accumulated sometime between 119 and 46 ka ago. However, sand samples extracted from Groups 1, 6, 12, and 13 have provided single-grain Optically Stimulated Luminescence (OSL) ages of 128.6 ± 6.3 ka, 120.6 ± 6.6 ka, 132.1 ± 8.0 ka and 127.5 ± 8.8 ka, respectively (Zenobia Jacobs, pers. comm. 2007). The OSL ages may be correct, but the method relies on largely unverifiable, site-specific assumptions concerning the geochemical history of the deposit. We therefore conclude that its age has yet to be resolved.

The position of the past shoreline may aid age resolution, since intertidal shells abound throughout the YFT1 sequence, and archaeologists have long assumed that foragers would not routinely carry quantities of shell or other food items more than 10 km (Higgs *et al.* 1967; Higgs & Vita-Finzi 1972; Bigalke 1973; Erlandson 2001). The offshore topography at YFT1 indicates that a drop in sea-level of about 50 m would be required to displace the shore at least 10 km in all directions from the present site location (Fig. 6). Therefore, the history of global sea-level changes after 150 ka ago suggests that people probably did not occupy YFT1 during OIS 5d, between roughly 119 ka and 110 ka ago, or during most of OIS 4, between about 71 ka and 59 ka ago (Fig. 6). Assuming that MSA occupation must postdate the OIS 5e high stand at 122–119 ka, sea-level history places it sometime within OIS 5c to 5a, between about 110 and 71 ka ago, or in the latter part of OIS 3, between roughly 59 and 50 ka ago. The sporadic occurrence of a warm water (south coast) mussel species, discussed below, favours an OIS 5c–5a age. The artefacts, also discussed below, further support such an estimate, since they probably predate the Howieson’s Poort variant of the MSA, whose appearance coincides closely with the OIS 5a/4 transition at roughly 70 ka ago (Deacon 1995; Vogel 2001; Tribolo *et al.* 2005a,b; Valladas *et al.* 2005; Rigaud *et al.* 2006).

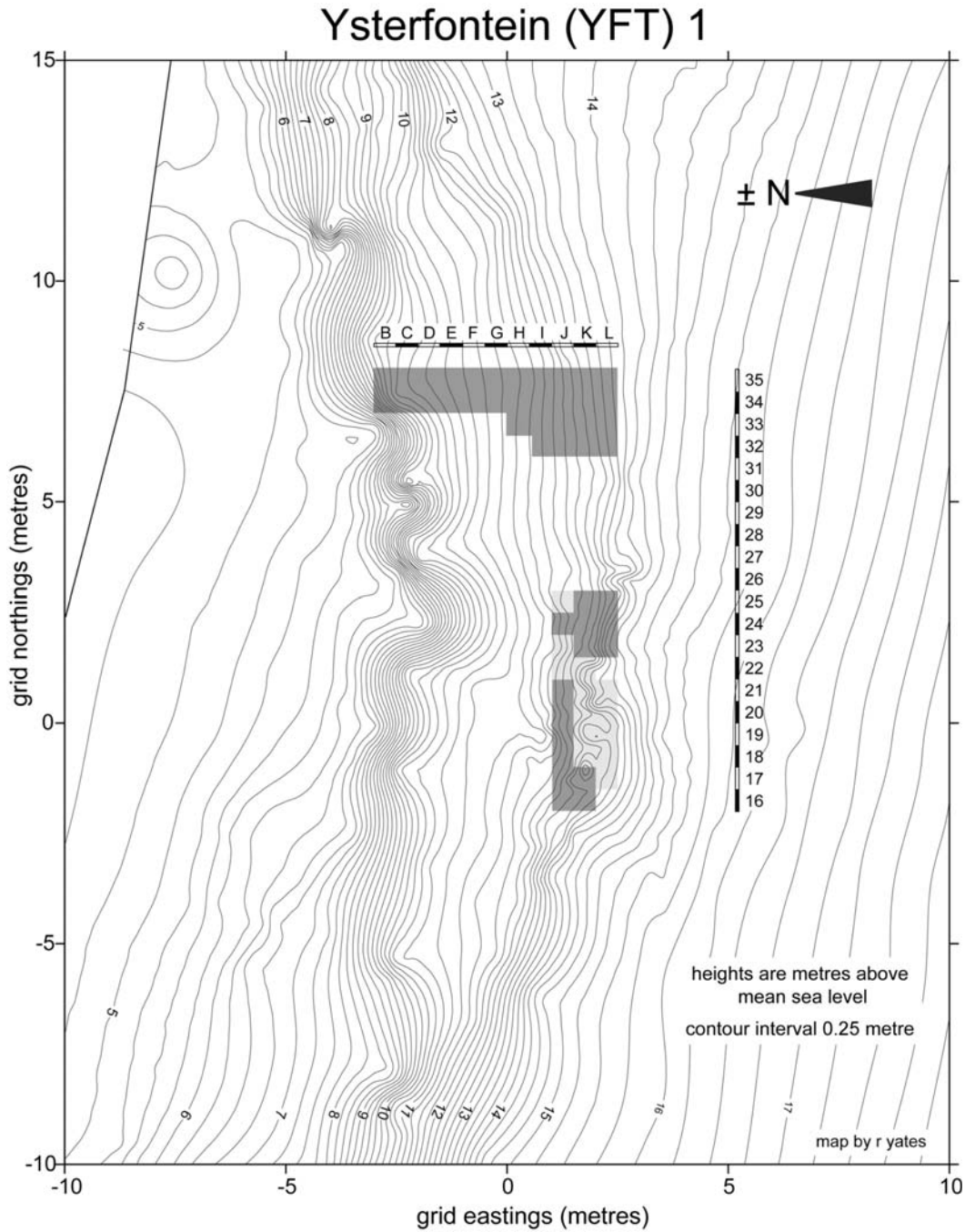


FIG. 2. Topographic map of YFT1 (original by Royden Yates). Dark grey indicates the excavated sectors and light grey indicates the areas cleaned for initial testing. The remains described in this paper are mainly from squares D–L 32–35.

ARTEFACTS

YFT1 has provided no worked bones or bone artefacts, and in this respect, it is similar to most other MSA sites (d'Errico & Henshilwood 2007). So far, only the MSA layers of Blombos Cave have produced shaped bones whose stratigraphic origin, number, and repetitive form unequivocally imply a bone artefact industry or tradition (Henshilwood *et al.* 2001a; see also Backwell *et al.* 2008). Sarah Wurz (Iziko South African Museum) is analysing the YFT1 stone artefacts and will describe them separately. At present the assemblage comprises more than 7000 flakes or flaked pieces and it includes radial cores and flakes, and blades with faceted butts that place it within the MSA. Silcrete is the most common raw material overall, followed by calcrete, quartz, and diorite, but the materials vary in frequency among stratigraphic groups. The assemblage includes relatively few formal (retouched) tools, but continu-

ous, scraper-like retouch occurs on a few pieces, and denticulate retouch is relatively common. Both flakes and blades are denticulated, often on both edges, and the blades or flake-blades are sometimes broken or snapped. On some tools the lateral edges converge to a point and the artefacts appear remarkably refined (Fig. 7).

YFT1 has yielded neither backed elements, especially segments and trapezes that define the Howieson's Poort variant of the MSA, nor bifacial points that define the Still Bay variant. The assemblage is large enough to exclude sample size as a likely explanation. Moreover, the Sea Harvest site, Saldanha Bay (Volman 1978), has produced a remarkably similar assemblage in similar geomorphic context. This raises the question of the chronological relationship between YFT1 and Sea Harvest on the one hand, and the Howieson's Poort and Still Bay variants on the other. Recent excavations at



FIG. 3. Top: YFT1 rock shelter seen from a hill above the parking lot at the Ysterfontein small boat harbour. Bottom: the rock shelter from across the road below. Excavation is mainly in the area to the left of the scaffolding tower.

Diepkloof (Parkington *et al.* 2005; Rigaud *et al.* 2006) and Sibudu Cave (Wadley 2007) show that the Still Bay precedes the Howieson's Poort. This result was anticipated by unfinished or partial bifacial points below the Howieson's Poort occupations at Nelson Bay Cave (Volman 1981) and Klasies River Main (Singer & Wymer 1982). Luminescence age estimations and geologic inference at various sites place the Howieson's Poort between about 70 and 55 ka old (Deacon 1995; Vogel 2001; Tribolo *et al.* 2005a,b; Valladas *et al.* 2005; Rigaud *et al.* 2006), and luminescence readings on sands and burned artefacts at Blombos Cave show that the Still Bay was underway 80–75 ka ago (Jacobs *et al.* 2003b).

A denticulate-poor assemblage overlies the Howieson's Poort at Klein Kliphuis (Mackay 2006), whereas an assemblage with well-made denticulates underlies it at Klipfonteinrand (Alex Mackay, pers. comm. 2007) (Fig. 1). This suggests YFT1 and Sea Harvest are older than the Howieson's Poort. An assemblage with denticulates underlies the Still Bay at Hollow Rock Shelter (Evans 1994), and could imply that YFT1 and Sea Harvest also predate the Still Bay. Alternatively, YFT1 and Sea Harvest may fall between the Still Bay and the Howieson's Poort. On-going analysis of artefacts from the deeply stratified deposits at Diepkloof may eventually suggest the answer.

Like most MSA sites, YFT1 has produced pigment chunks that the inhabitants collected and then ground or rubbed to produce powder (Fig. 8). Pigment smears from grinding or rubbing also occur on at least two diorite chunks and one

diorite cobble. Red pigment chunks dominate at YFT1 and other southern African MSA sites. Besides YFT1, black pigment has been reported only from Hollow Rock Shelter and Border Cave (Watts 2002). YFT1 supports previous evidence that during the MSA interest in pigment transcended changes in preferred artefact types, and people may have employed it variously, perhaps in art or ritual (Watts 2002), or more prosaically in hide-tanning and especially, in the production of resinous adhesives (Wadley *et al.* 2004; Lombard 2005; Wadley 2005a; Lombard 2007; Lombard & Wadley 2007). The adhesive would have functioned mainly to fasten stone tools, possibly including some of the YFT1 denticulates, to wooden handles or hafts.

YFT1 has produced no perforated shells like the Blombos Cave specimens that have been interpreted as MSA beads (d'Errico *et al.* 2005). YFT1 lacks tick shells (*Nassarius kraussianus*) on which the perforations occur at Blombos. Tick shells are estuarine scavengers, and their absence at YFT1 may reflect the persistent absence of estuaries nearby.

VERTEBRATES

OVERVIEW

The YFT1 vertebrate fossils are almost entirely from snakes, tortoises, mammals and birds. A few tiny fish bones occur in disturbed sediments at the top of the sequence, where they could have been introduced in scats of small carnivores, or perhaps as regurgitations from roosting cormorants. Bones from fish that may have been consumed by humans are totally absent. Other coastal MSA sites also tend to lack fish, and where fish bones occur, mainly at Klasies River (Singer & Wymer 1982) and Blombos Cave (Henshilwood *et al.* 2001b), they are rare compared to mammal and bird bones. The opposite is generally true at coastal LSA sites, where fish bones often outnumber mammal and bird bones by an order of magnitude. Only LSA sites have provided artefacts that anticipate ethnographically observed fishing gear (Deacon 1984b; Inskeep 1987). These artefacts and the frequency of fish bones suggest that people fished routinely only in the LSA. This is very significant, because fish are abundant in coastal waters, and fishing alone could account for the larger LSA human populations we infer, below, from tortoise and limpet size.

Snakes are represented by 552 vertebrae that we could not identify to genus and species. We do not consider them further here. Tortoises are represented by pieces of carapace and plastron from the angulate (or bowsprit) species (*Chersina angulata*). Speckled tortoises (*Homopus signatus*) have occasionally been observed on the west coast, but only the angulate tortoise is common, and its carapace and plastron heavily dominate all west coast archaeological samples. It thus seems reasonable to assume that angulate tortoises provided the vast majority of tortoise limb bones at YFT1 and other sites. This assumption is important, because the pieces of carapace and plastron tend to be too fragmented to provide individual counts or useful measurements, and for these, we have relied on limb bones, particularly the relatively common distal humeri and distal femora. We rely on distal humeri in the next section, where we emphasize the large average size of YFT1 and other MSA specimens.

The YFT1 mammals and birds represent a variety of species, but the samples are relatively small, and we have divided them into three gross stratigraphic units: Upper, including stratigraphic Groups 1–3; Middle, including Groups 4 and 5; and Lower, including Groups 6–13. The three subdivisions broadly reflect the apparent decline in human activity inside the shelter as the fill approached the roof. Tables

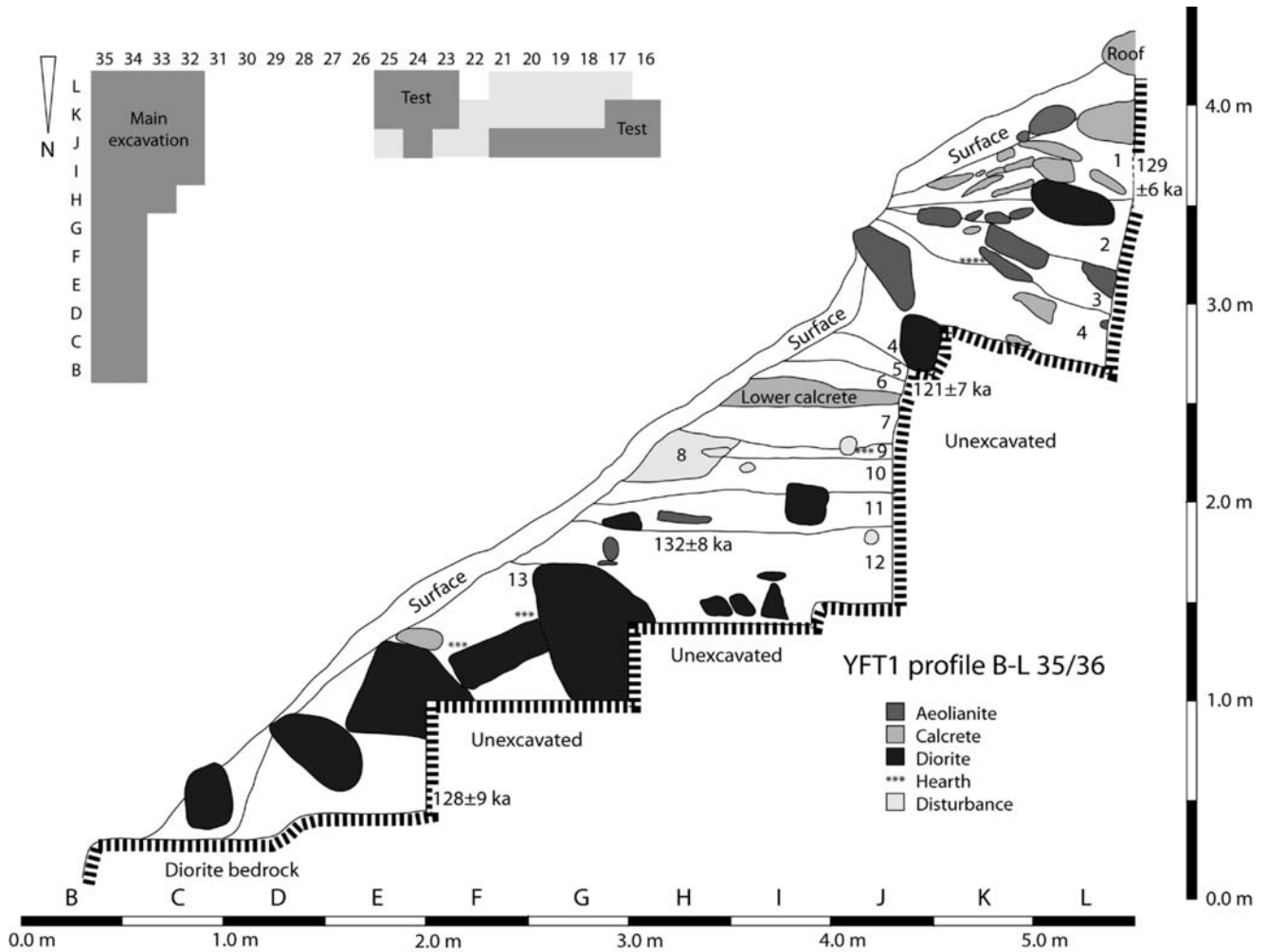


FIG. 4. Profile of YFT1 stratigraphic groups 1 to 13 along the B–L 35/36 line, exposed at the end of the 2007 season. Finer units within each group are not indicated in the section. The locations of OSL samples are approximate. They are correct on the vertical and the north–south axes, but the east–west location is projected onto the 35/36 line. The larger rocks only are indicated, although many associated smaller ones were also found.

3 and 4 list the identified mammal and bird species, the number of identified specimens (NISP) in each major subdivision, and the minimum number of individuals (MNI) that are represented. Ostrich is represented by both bones and eggshell, and the eggshell 'NISPs' in Table 4 are weights. The 'MNIs' are the minimum numbers of eggs required to produce the weights, assuming that an average complete shell weighs about 238 g (Kandel 2004; and similar to the value of 222 g provided by Keffen & Jarvis (1984)).

THE AGENCIES OF BONE ACCUMULATION

Raptors are an unlikely source of bones at YFT1, since the shelter probably lacked suitable roosts. In addition, none of the bones exhibits the kind of acid-etching or 'reduction' that is found on the MSA dune molerats accumulated by large raptors at Die Kelders Cave 1 (Klein & Cruz-Urbe 2000). Porcupines are more likely bone collectors at YFT1, and their bones occur in the deposit. However, YFT1 lacks bones with the tell-tale gnaw marks that characterize porcupine accumulations (Brain 1981; Kerbis Peterhans & Singer 2006). Bones that were probably chewed by jackals, mongooses, or other small carnivores occur in the Upper subdivision, and small carnivore digging might also account for some of the stratigraphic disturbances that are particularly conspicuous there. As discussed below, small carnivores may have introduced some of the abundant dune molerat bones.

Hyaenas could have contributed some of the larger mam-

mal bones, and occasional coprolites place hyaenas in the shelter when the youngest deposits accumulated. The Swartklip fossil hyaena den on False Bay (Hendey & Hendey 1968; Klein 1975) underscores a potential hyaena role, since it includes all the YFT1 terrestrial carnivore and ungulate species. It lacks fur seals, because it dates from a time when sea-level was much lower and False Bay was drained, but near-coastal hyaena dens in Namibia and a fossil hyaena den at Boegoeberg 1, Northern Cape Province, demonstrate that brown hyaenas (*Hyaena brunnea*) can concentrate fur seal bones (Skinner & van Aarde 1991; Klein *et al.* 1999).

A hyaena contribution to YFT1 could explain why five of the seven blue antelopes in the Upper and Middle subdivisions were neonates, with erupting, unworn deciduous teeth. Like the newborn of their closest living relatives (Skinner & Chimimba 2005), newborn blue antelopes probably 'lay out' in dense vegetation while their mothers grazed nearby, and in this state, they would have been more vulnerable to hyaenas than to people. Hyaena activity could further explain why ostrich eggshell is especially abundant in the Upper and Middle subdivisions, both absolutely and relative to other items, particularly intertidal shells (Fig. 9). The Swartklip den and observations on free-ranging brown hyaenas (Mills 1978; Skinner & van Aarde 1991) demonstrate hyaena interest in ostrich eggs. Hyaena teeth produce characteristic damage to eggshells (Kandel 2004), and both Swartklip and YFT1 have provided fragments that match the pattern. Other west coast

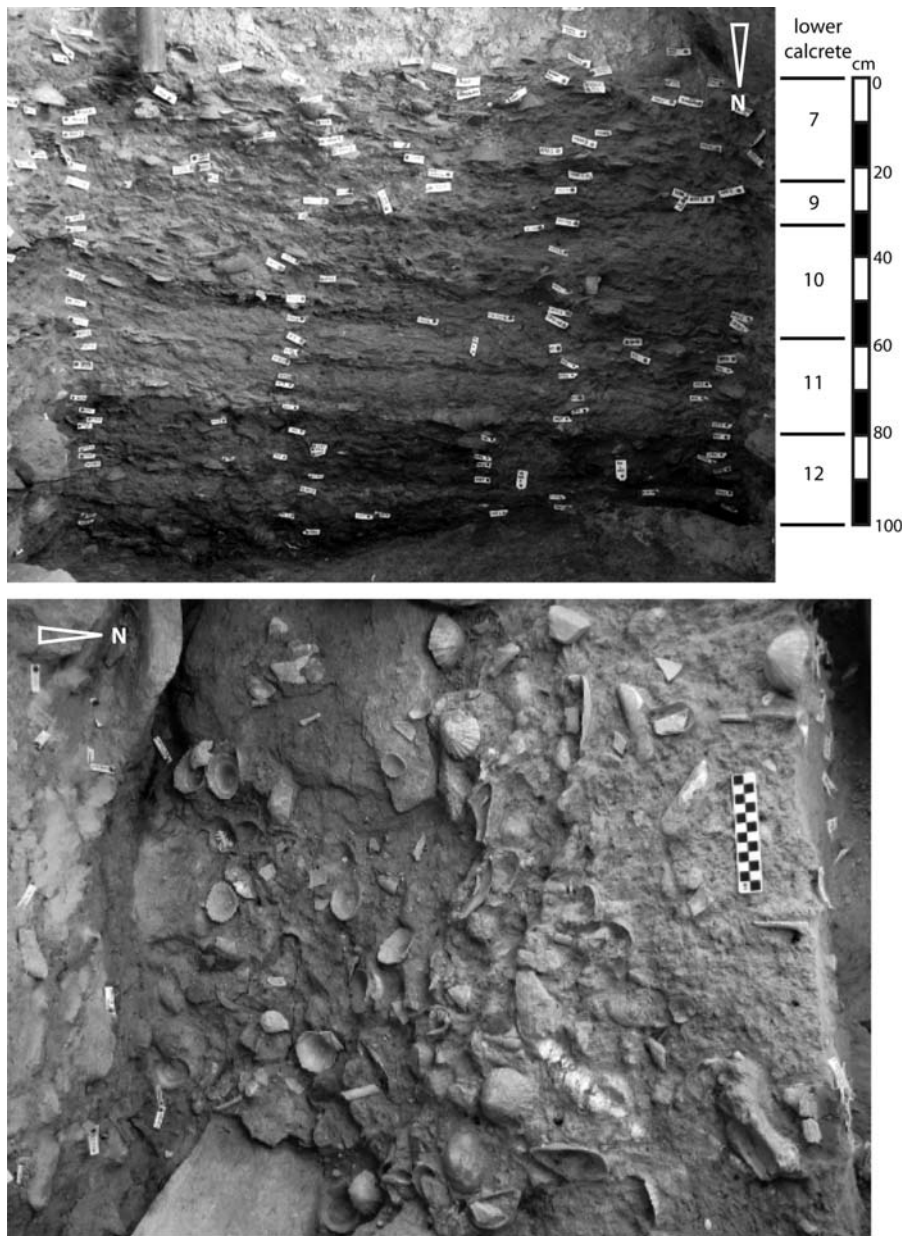


FIG. 5. Top: profile of YFT1 stratigraphic groups 7 to 12 along the J/K 34–35 line. Note the alternating carbonized sediments and the density of limpets and black mussels that protrude from the section. The tags mark finer units within each group. Bottom: exposure of limpets, mussels, and bone from K–L 33–34, towards the base of stratigraphic group 4.

MSA sites at Boegoeberg 2, Sea Harvest, and Hoedjiespunt (references in Table 2) are also rich in ostrich eggshell, compared not only to regional LSA sites but also to south coast MSA sites, and in a previous report on YFT1, we suggested that during the MSA people along the west coast may have been unusually interested in ostrich eggs (Klein *et al.* 2004). Larger samples have now demonstrated stratigraphic variation in eggshell abundance at YFT1. We believe that hyaenas may account for much of the eggshell at YFT1 and the other west coast sites, particularly at Sea Harvest and Hoedjiespunt, where it was not possible to achieve the YFT1 level of stratigraphic resolution.

Hyaenas are unlikely to have brought many dune molerat bones to YFT1, since bones of such small mammals are uncommon at Swartklip and other fossil dens, probably because the hyaenas completely consumed any small carcasses they obtained. Dune molerats do not accumulate bones themselves, but they dig extensive tunnels, reaching up to 400 m in length when side branches are included, and they feed on roots, bulbs,

forbs, and grasses which they pull down into their tunnels (Davies & Jarvis 1986; Herbst & Bennett 2006). Conceivably, dune molerat tunneling produced many of the stratigraphic disturbances to which we have previously referred, and this raises the possibility that dune molerats died naturally in the site.

On the other hand, dune molerats would have no incentive to tunnel into a rock shelter, partly because the sediments would have been relatively coarse and non-homogeneous and partly because the surface would not have supported suitable food plants. In addition, dune molerats are solitary and territorial. Average population density is less than one per hectare, and individuals do not tunnel into the territories of their neighbours. Molerat bones are remarkably rare in open-air archaeological sites, including Dunefield Midden, Kasteelberg B, and Bakoond (references in Table 2), even where numerous mounds signal molerat activity nearby. Archaeologically, molerat bones abound only in caves or rock shelters, such as Blombos Cave, Die Kelders Cave 1, Byneskranskop Cave 1,

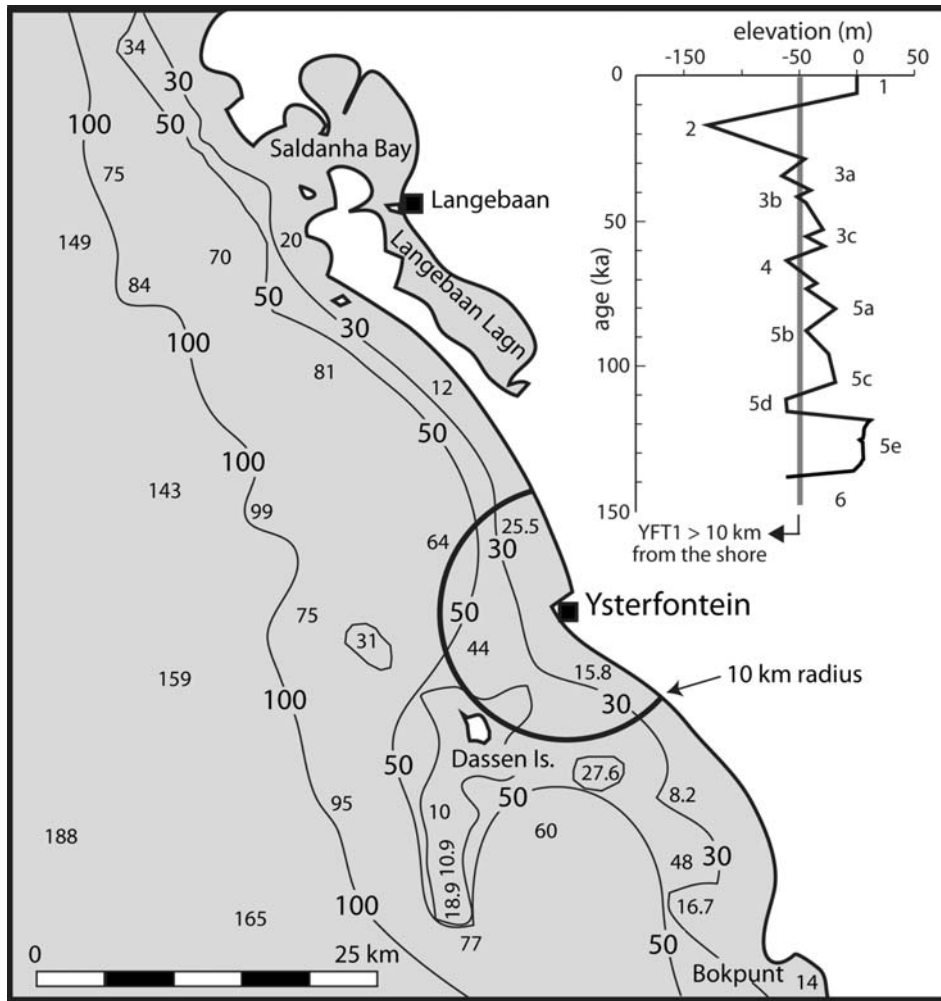


FIG. 6. Left: offshore bathymetry in the vicinity of Ysterfontein (modified after South African Navy 1981). Depths are in metres below sea level. Right upper: Global sea level history during the last 150 ka (modified after Miller et al. 2005: fig. S2; Hearty et al. 2007: fig. 10). The figure indicates that a drop in sea level of about 50 m would be required to displace the shore at least 10 km from YFT1.

Elands Bay Cave, and Tortoise Cave (references in Table 2), where people or other predators almost certainly accumulated them. We cannot rule out the possibility that many of the YFT1 dune molerat bones were a result of natural deaths in the shelter, especially in the Upper layers, but it seems more likely that people or small carnivores brought in the majority.

In summary, people and carnivores probably accumulated most of the YFT1 bones, and carnivores were perhaps particularly important in the Upper subdivision when people were rarely, if ever, in the shelter. People were probably much more important accumulators in the Middle and Lower subdivisions, where numerous artefacts, stacked fireplaces, and dense accumulations of shell document human presence. Macroscopically obvious stone tool marks on bone confirm a human role (Fig. 10), and many additional marks might become apparent under magnification. We plan a microscopic study of bone surfaces after the 2008 season, when the bone sample will be much larger. We predict that stone tool damage will confirm the suggested importance of people as bone accumulators in the Lower and Middle subdivisions.

PALAEOENVIRONMENTAL IMPLICATIONS

The Cape dune molerat is common in sandy areas near YFT1 today, and its abundance in the deposit suggests long-term persistence of the sandy soils and plant species on which dune molerats depend. Historically, the distribution of the dune molerat coincided roughly with the distribution of the

angulate tortoise, and their co-occurrence at YFT1 is mirrored at Diepkloof, Elands Bay Cave, Die Kelders Cave 1, Blombos Cave and many other archaeological sites along the west and southwest coasts of South Africa (references in Table 2). However, both dune molerats and tortoises are rare at sites like Klasies River, Nelson Bay, and Noetzie within the forested strip that stretches along the south-central coast from roughly George to Humansdorp (approximately 23°30'S to 24°40'E), and they do not appear to have become more common there even when fossil ungulates indicate that forest cover had given way to grassland. The key variable past and present may have been rainfall, which historically fell mainly in winter on the west and southwest coasts and more evenly throughout the year on the south-central coast. In this light, the abundance of dune molerats and tortoises at YFT1 suggests that rainfall remained largely confined to winter when the deposits formed, even if other indicators we summarize below indicate that rainfall was greater or more effective.

The fur seal and marine birds occur nearby today, and like the associated shells, they signal the proximity of the shore when the deposits accumulated. In contrast, the zebra, blue antelope, southern reedbeek, black wildebeest, greater kudu, and long-horned buffalo were unknown in the region historically and have not been found in any regional site that post-dates 10 ka ago. The long-horned buffalo became extinct about 10 ka ago, but its habits can be broadly inferred from its anatomy and the habits of its surviving relatives, particularly



FIG. 7. A silcrete convergent denticulate from the MSA layers at YFT1 (photograph: T.E. Steele).

the Cape buffalo (*Syncerus caffer*). Historically, the vegetation in the YFT1 region was dominated by sclerophyllous (fynbos) shrubs that supplied too little food to sustain the extralimital ungulates, and their occurrence implies vegetation in which both grasses (vital for all but the kudu) and broad-leaved browse (crucial for the kudu) were significantly more common. In addition, the reedbuck, and probably also the spur-winged goose and coot, imply standing fresh water where none exists today.

Average dune molerat size can be used to check and supplement the palaeoenvironmental implications of the ungulates and birds. Dune molerat size and rainfall are positively correlated at present (Klein 1991), probably because greater rainfall increases the density of plants on which dune molerats feed. The distal humerus is the best proxy for estimating past dune molerat size, because it is particularly robust and it tends to be especially common in fossil samples. Measurements of distal humeri show that the MSA molerats at Blombos Cave (Henshilwood *et al.* 2001b) and Die Kelders Cave 1 (Klein & Cruz-Urbe 2000) tended to be significantly larger than their LSA counterparts, and the Die Kelders humeri include the largest on record. The LSA humeri at both sites postdate 2 ka

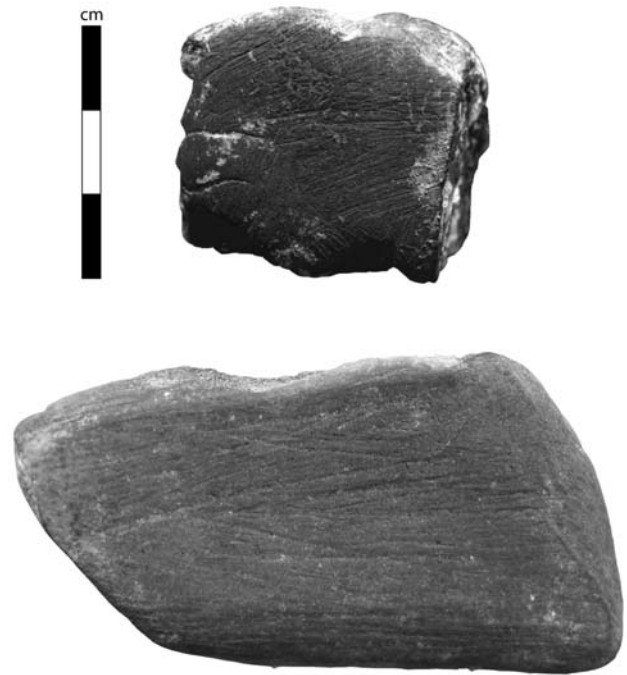


FIG. 8. Top: ground lump of black (manganiferous) pigment (photograph: T.P. Volman). Bottom: red (ferruginous) pigment from YFT1 (photograph: T.E. Steele). Red pigment lumps dominate at YFT1 and other southern African MSA sites. So far, besides YFT1, black pigment has been reported only from Hollow Rock Shelter and Border Cave (Watts 2002).

ago, and they closely approximate local historic specimens in average size. The MSA humeri thus present especially strong evidence that the MSA occupations occurred under moister-than-historic conditions. Molerat humeri from adjacent YFT1 stratigraphic groups have been combined to provide numerically meaningful samples, and there are no humeri from stratigraphic groups 10–13. Figure 11 shows, however, that the humeri in groups 1–5 and 6–9 averaged larger than historical rainfall would predict, and they complement the ungulate species to imply a relatively humid palaeoenvironment. The caption to Figure 11 provides supporting detail.

IMPLICATIONS FOR HUMAN BEHAVIOUR

Contrasts between MSA and LSA mammal faunal assemblages on the south coast suggest that people in the MSA exploited ungulates and fur seals less effectively (Klein & Cruz-Urbe 1996), but the YFT1 faunal sample is too small for meaningful comparison to local LSA assemblages. In addition, the west and south coasts have long differed in their ungulate communities, and any MSA/LSA ungulate contrast would have to take this into account. The YFT1 bird fauna is also small, but it tentatively suggests the dominance of penguins over cormorants that also characterizes south coast MSA sites. Cormorants tend to dominate penguins in LSA faunas on both coasts, and the MSA/LSA difference may reflect a difference in technology. A difference in technology also probably explains why fish are much more common in LSA sites. Only LSA assemblages contain artefacts that resemble ethnohistoric projectile armatures (Deacon 1984a; Deacon 1995) and projectile weapons could have allowed people in the LSA to prey more effectively on airborne birds.

TORTOISE SIZE

The MSA tortoise humeri from Die Kelders 1 and Blombos Cave on the southwest coast tend to be significantly larger than local LSA specimens (Klein & Cruz-Urbe 2000; Henshilwood *et al.*

TABLE 3. The Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI) they represent for each mammal species in the Upper, Middle, and Lower subdivisions of YFT1. The NISPs and MNIs for the bovid species were estimated from only dentitions and horncores. The NISPs and MNIs for the bovid size classes were estimated from all skeletal elements. The small bovids identified to species are steenbok and steenbok/grysbok, the large–medium bovids are blue antelope, southern reedbuck, black wildebeest, and kudu, and the large bovids are eland and long-horned buffalo. So far, there are no small–medium bovid dentitions or horncores, but springbok (*Antidorcas australis*) is a likely species for the postcranial bones.

| Vernacular names | Linnaean names | Upper | | Middle | | Lower | |
|----------------------|---|-------|-----|--------|-----|-------|-----|
| | | NISP | MNI | NISP | MNI | NISP | MNI |
| Mammals | Mammalia | | | | | | |
| Hare | <i>Lepus</i> sp. | 11 | 4 | 10 | 2 | 1 | 1 |
| Cape dune moleerat | <i>Bathyergus suillus</i> | 1518 | 44 | 38 | 3 | 958 | 32 |
| Porcupine | <i>Hystrix africaeaustralis</i> | 3 | 2 | 2 | 2 | 1 | 1 |
| Black-backed jackal | <i>Canis mesomelas</i> | | | 1 | 1 | | |
| Honey badger | <i>Mellivora capensis</i> | 2 | 1 | 1 | 1 | 1 | 1 |
| Hyaena | Hyaenidae gen. et sp. indet. | 2 | 2 | 3 | 1 | | |
| Wildcat | <i>Felis libyca</i> | 5 | 2 | 2 | 1 | | |
| Caracal or serval | <i>Felis caracal</i> aut <i>F. serval</i> | 8 | 2 | 3 | 1 | 2 | 1 |
| Cape fur seal | <i>Arctocephalus pusillus</i> | 93 | 6 | 84 | 4 | 28 | 5 |
| Rock hyrax | <i>Procavia capensis</i> | 1 | 1 | | | | |
| Indeterminate equid | <i>Equus</i> sp. | 1 | 1 | | | | |
| Black rhinoceros | <i>Diceros bicornis</i> | | | | | 2 | 1 |
| Rhinoceros | Rhinocerotidae gen. et sp. indet. | | | 4 | 2 | 3 | 1 |
| Steenbok | <i>Raphicerus campestris</i> | 1 | 1 | 2 | 1 | | |
| Grysbok/steenbok | <i>Raphicerus</i> sp./spp. | 10 | 2 | 6 | 3 | 5 | 3 |
| Blue antelope | <i>Hippotragus leucophaeus</i> | 14 | 5 | 2 | 2 | 4 | 4 |
| Southern reedbuck | <i>Redunca arundinum</i> | 8 | 3 | 7 | 3 | 28 | 5 |
| Black wildebeest | <i>Connochaetes gnou</i> | 1 | 1 | 2 | 1 | 2 | 1 |
| Greater kudu | <i>Tragelaphus strepsiceros</i> | 7 | 3 | 3 | 1 | 2 | 1 |
| Eland | <i>Taurotragus oryx</i> | 4 | 3 | 1 | 1 | 1 | 1 |
| Long-horned buffalo | <i>Pelorovis antiquus</i> | 1 | 1 | | | | |
| Small bovid/s | | 40 | 5 | 40 | 4 | 24 | 5 |
| Small-medium bovid/s | | 12 | 3 | 13 | 2 | 17 | 6 |
| Large-medium bovid/s | | 79 | 7 | 39 | 4 | 135 | 9 |
| Large bovid/s | | 15 | 4 | 3 | 2 | 8 | 2 |

2001b), and Figure 12 shows that west coast MSA and LSA tortoise humeri differ in the same way. The figure employs the same boxplot format as Figure 11, in which the key features are the median, represented by the line near the middle of each boxplot and the 95% confidence limits for the median, represented by the gray bar around each median. Medians whose 95% confidence limits do not overlap differ significantly in the conventional statistical sense.

In Figure 12, the tortoise humeri from adjacent YFT1 strati-

graphic groups are combined to provide numerically meaningful samples, and included in the figure are tortoises from Hoedjiespunt 1 and Diepkloof, the only other west coast MSA sites that have provided adequate numbers for comparison. The specimens from Diepkloof have been divided among six successive culture-stratigraphic units, defined by Rigaud *et al.* (2006) and Cedric Poggenpoel (pers. comm. 2007), but the chronological relationships between the Diepkloof units, Hoedjiespunt 1, and YFT1 are uncertain. The arrangement of

TABLE 4. The Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI) they represent for each bird species in the Upper, Middle, and Lower subdivisions of YFT1. For ostrich eggshell, the 'NISP' is the weight in grams and the 'MNI' is the number of eggs necessary to provide the weight.

| Vernacular names | Linnaean names | Upper | | Middle | | Lower | |
|---------------------------|--------------------------------|-------|-----|--------|-----|-------|-----|
| | | NISP | MNI | NISP | MNI | NISP | MNI |
| Birds | Aves | | | | | | |
| Common ostrich – bones | <i>Struthio camelus</i> | | | | | 3 | 1 |
| Common ostrich – eggshell | <i>Struthio camelus</i> | 6995 | 31 | 3961 | 18 | 1044 | 9 |
| Cape spurfowl | <i>Pternistis capensis</i> | 2 | 1 | | | | |
| Spur-winged goose | <i>Plectopterus gambensis</i> | ?1 | ?1 | | | | |
| Ludwig's bustard | <i>Neotis cf. ludwigii</i> | 1 | 1 | | | | |
| Red-knobbed coot | <i>Fulica cristata</i> | 1 | 1 | | | | |
| Kelp gull | <i>Larus dominicanus</i> | | | 1 | 1 | | |
| Cape gannet | <i>Morus capensis</i> | 3 | 2 | 9 | 2 | 2 | 2 |
| Crowned cormorant | <i>Phalacrocorax coronatus</i> | 7 | 4 | | | 1 | 1 |
| White-breasted cormorant | <i>Phalacrocorax lucidus</i> | | | 4 | 1 | 5 | 2 |
| Bank cormorant | <i>Phalacrocorax neglectus</i> | 4 | 2 | 5 | 1 | 1 | 1 |
| Cape cormorant | <i>Phalacrocorax capensis</i> | 89 | 9 | 8 | 2 | 15 | 5 |
| Greater flamingo | <i>Phoenicopterus ruber</i> | 3 | 2 | | | | |
| Great white pelican | <i>Pelecanus onocrotalus</i> | 1 | 1 | | | | |
| African penguin | <i>Spheniscus demersus</i> | 47 | 6 | 13 | 2 | 99 | 11 |

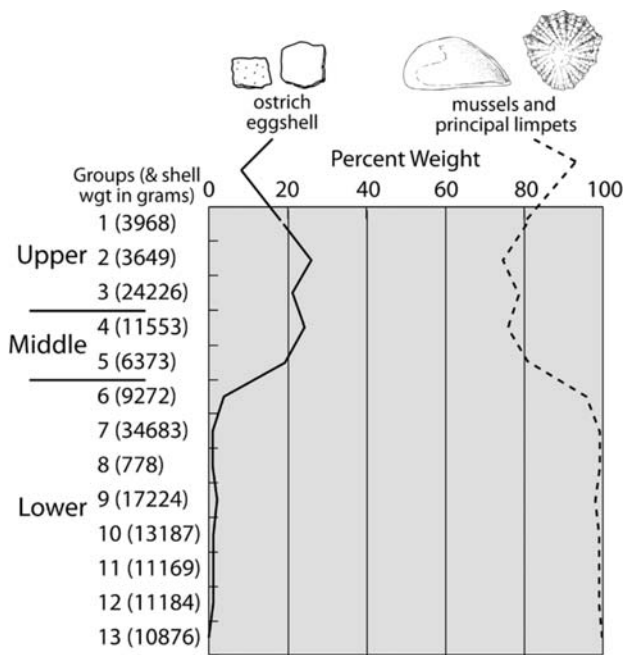


FIG. 9. The weights of ostrich eggshell and of granite limpets, granular limpets, Argenville’s limpets, and black mussels as percentages of the combined eggshell, limpet and mussel weights in each YFT1 stratigraphic group. The numbers in brackets are the combined weights in grams.

YFT1 and Hoedjiespunt 1 below Diepkloof in the figure is strictly for presentation purposes.

The LSA samples in the figure span the interval between 12.5 and 0.7 ka ago. There are no samples that predate 12.5 ka ago. Other west coast sites have also provided samples that postdate 12.5 ka ago and particularly, 4.5 ka ago. Table 2 lists some of the key sites, and Figure 1 shows their locations. Their inclusion would clutter the figure, and it would not alter the basic pattern: tortoise humerus size varies within both the MSA and the LSA, but on average, the MSA humeri all tend to be significantly larger than their LSA counterparts. Tortoise collection requires no special expertise or technology, and people in both the MSA and the LSA probably undertook it casually while they foraged for other terrestrial animals and plants. While foraging, they took the largest tortoises first, since these were the most conspicuous and meatiest. Any increase in the number of person hours devoted to foraging would thus tend to reduce average tortoise size, and the most likely explanation for an increase in person hours is an increase in the number of foragers. This number in turn would depend on the interaction of environment and culture.

We noted above that the YFT1 mammal fauna suggests the surroundings were at least as rich as the surroundings of any LSA site, and the same case can be made for Hoedjiespunt 1 and Diepkloof. If we accept that average tortoise size reflects human population density, the implication is that populations in the MSA were mostly more sparsely distributed for technological, not environmental reasons. However, variation in technology could also explain fluctuating human population density within the MSA and LSA. Technological variability is less obvious within the MSA and within the LSA than it is between them, and environment is thus more likely to explain the fluctuating population density that is internal to each. We show below that limpet size exhibits the same basic pattern as tortoise size, and this enhances the likelihood that culture (as opposed to environment) mostly explains the MSA/LSA contrast, since tortoises and limpets come from completely separate ecosystems.

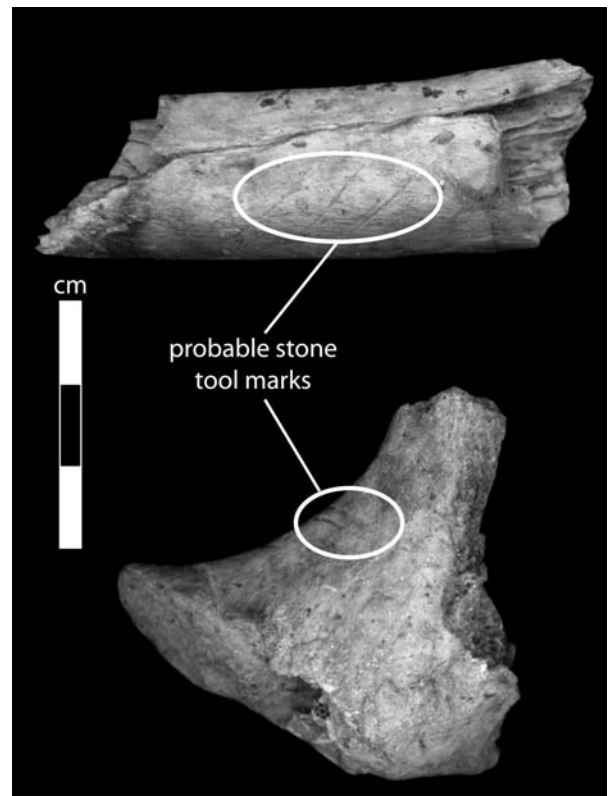


FIG. 10. Top: probable stone tool marks on a rib fragment. Bottom: probable stone tool marks on a large medium bovid pelvic fragment from the MSA layers at YFT1 (photographs: G. Avery).

INVERTEBRATES

Invertebrates, mainly intertidal shellfish, dominate faunal assemblages at most coastal MSA and LSA sites, and YFT1 conforms to this pattern. Diepkloof may appear to be an exception, but it is located 17 km from the coast at the head of the Verlorenvlei and it was probably even further from the sea during most of the MSA occupation. It is thus not strictly a coastal site, and the MSA faunal assemblage includes few shells.

Table 5 lists the YFT1 shellfish species, their shell weights, and the Minimum Number of Individuals (MNI) in the three main stratigraphic subdivisions. The whale barnacles deserve special mention, since they must have been introduced on whale blubber, and they show that beached whales should be added to the YFT1 MSA mammal list. Whale barnacles have also been found at LSA sites (Jerardino & Parkington 1993; Kandel & Conard 2003) and in an MSA occupation at Pinnacle Point (Marean *et al.* 2007), where they likewise imply that people brought home whale tissue, even when whale bones are absent.

With the exception of the brown mussel, the intertidal species listed in Table 5 all occurred on the west coast historically, and they imply fundamental continuity in local intertidal conditions, including cool-to-cold water temperatures. The brown mussel is adapted to much warmer waters on the south and east coasts of South Africa, and it is far less common at YFT1 than its west coast counterpart, the black mussel. However, even its rare occurrence might signal a time, probably during OIS 5, when warm eddies originating from the Agulhas Current allowed viable larvae to establish small, persistent populations in sheltered west coast bays. Similarly, during the Last Glaciation, small numbers of black mussels extended onto the south coast as far east as Klasies River (Thackeray 1988), and black mussels far outnumber brown mussels in the terminal

TABLE 5. The shell weight (in grams) and the Minimum Numbers of Individuals (MNI) for each shellfish species in the Upper, Middle, and Lower subdivisions of YFT1.

| Vernacular names | Linnaean names | Upper | | Middle | | Lower | |
|---------------------|---|---------|------|--------|-----|---------|------|
| | | Weight | MNI | Weight | MNI | Weight | MNI |
| Granite limpet | <i>Patella (Cymbula) granatina</i> | 5428.4 | 265 | 4186.3 | 256 | 15288.6 | 813 |
| Pink-rayed limpet | <i>Patella (Cymbula) miniata</i> | 36.7 | 4 | 21.3 | 4 | 16.4 | 7 |
| Granular limpet | <i>Patella (Scutellastra) granularis</i> | 67.2 | 21 | 68.7 | 32 | 667.8 | 142 |
| Argenville's limpet | <i>Patella (Scutellastra) argenvillei</i> | 2556.2 | 61 | 617.8 | 34 | 4462.5 | 175 |
| Bearded limpet | <i>Patella (Scutellastra) barbara</i> | | | | | 6.0 | 5 |
| Pear limpet | <i>Patella (Scutellastra) cochlear</i> | | | | | 8.1 | 6 |
| Prickly limpet/s | <i>Helcion</i> sp./spp. | 0.7 | 8 | 1.3 | 14 | 5.2 | 96 |
| Keyhole limpet/s | Fissurellidae gen. et sp. indet. | 5.2 | 37 | 0.1 | 1 | 1.8 | 13 |
| Slipper limpet/s | <i>Crepidula</i> sp./spp. | 4.4 | 5 | 3.1 | 5 | 24.7 | 44 |
| Topshell/s | <i>Oxystele</i> sp./spp. | 0.3 | 10 | 2.4 | 3 | 0.6 | 8 |
| Pustular triton | <i>Argobuccinum pustulorum</i> | | | | | 6.5 | 7 |
| Dogwhelk/s | <i>Burnupena</i> sp./spp. / <i>Nucella</i> sp./spp. | 16.5 | 29 | 15.1 | 31 | 80.2 | 121 |
| Ploughshell/s | <i>Bullia</i> spp. | 12.6 | 2 | 4.9 | 4 | 6.4 | 19 |
| Black mussel | <i>Choromytilus meridionalis</i> | 17618.0 | 1024 | 9086.3 | 746 | 86589.7 | 5089 |
| Brown mussel | <i>Perna perna</i> | | | | | 61.1 | 21 |
| Ribbed mussel | <i>Aulacomya ater</i> | 24.3 | 47 | 15.6 | 41 | 117.0 | 163 |
| White (sand) mussel | <i>Donax serra</i> | 103.9 | 58 | 92.7 | 76 | 2328.1 | 393 |
| Corrugated Venus | <i>Venerupis corrugata</i> | 16.2 | 18 | 3.0 | 7 | 108.9 | 131 |
| Chiton/s | Polyplacophora gen. et sp. indet. | 2.7 | 3 | 0.2 | 1 | 2.0 | 6 |
| Whale barnacles | <i>Coronula</i> sp./spp. | 9.3 | 3 | | | 1.5 | 12 |
| Other barnacle/s | Buccinidae gen. et sp. indet. | 53.1 | 44 | 15.0 | 33 | 90.9 | 138 |

Pleistocene deposits at Nelson Bay Cave, 12–11 ka ago (Klein 1972a). The implication is that south coast waters were cooler during glacial intervals.

Table 5 shows that granite limpets, granular limpets, Argenville's limpets, black mussels and white mussels dominate the YFT1 sequence. The three limpet species and black mussels attach to rocks within the intertidal zone, and they are the most numerous, most visible and most easily collected intertidal molluscs on the west coast (Branch *et al.* 1981; Branch *et al.* 1994). White mussels inhabit intertidal sands, where their colonies are sub-surface, relatively diffuse and inconspicuous. Their occurrence in an archaeological site implies the proximity of a sandy beach like the extensive one that occurs near YFT1 today. At YFT1 and many other west coast sites, black mussels dominate other species by a factor of 10 or more, probably partly because they were more common nearby and partly because their high flesh-to-shell ratio suggests that people more often carried them from shore to camp. However, there are LSA middens, for example, on the Namaqualand coast, 300–500 km north of Ysterfontein (Halkett 2003; Orton & Halkett 2005; Orton *et al.* 2005; Dewar 2007; Orton 2007a), where limpets dominate black mussels or even occur alone, and the difference may reflect differences in season of occupation or differences in coastal configuration. With regard to season, black mussels accumulate the toxins from massive phytoplankton blooms ('red tides') that occur mostly in summer, and limpets would thus dominate in sites that were occupied mainly in summer. With regard to shoreline configuration, black mussels are filter feeders that benefit when wave action introduces fresh food, and they prefer rocks that are exposed to the open sea. Limpets are grazers whose feeding is disrupted when waves threaten to dislodge them, and they prefer sheltered embayments or gullies. Depending on local circumstances, even small sea-level changes can reshape the coastline to favour black mussels or limpets, and the sea-level changes that occurred from late OIS 2 through to OIS 1 probably account for major shifts in the black mussel to limpet ratio

over the past 11 ka in the LSA deposits of Elands Bay Cave (Parkington 1981; Parkington, in press a).

Figure 13 illustrates the black mussel to limpet ratio at YFT1 and in the LSA middens that accumulated between about 4.5 and perhaps 0.7 ka ago at Bakoond, about 3 km south of YFT1. Compared to Bakoond or Elands Bay Cave, the YFT1 ratio appears to be relatively stable, and this might mean that YFT1 formed during a period of relatively stable sea-level, perhaps during the latter part of OIS 5.

SPECIES DIVERSITY AND RICHNESS

Despite the widely shared MSA and LSA emphasis on black mussels and three limpet species, YFT1 and other west coast MSA sites differ from local LSA sites in four striking respects (Halkett *et al.* 2003; Parkington 2003): 1. The MSA assemblages are even more heavily dominated by black mussels and the three principal limpets and they tend to be significantly poorer in whelks, topshells (winkles), and barnacles. 2. The MSA assemblages lack chelipeds of the crayfish or 'rock lobster' (*Jasus lalandii*) that are a numerically variable but consistent feature of west coast LSA faunal assemblages, including for example, the assemblage from Bakoond. 3. The MSA assemblages are noticeably poorer in granular limpets relative to granite and Argenville's limpets, and 4. On average, individuals of all three limpet species tend to be significantly larger in the MSA samples. Figure 13 uses the Bakoond sample to illustrate the tendency for granular limpets to be more common in LSA assemblages. The following subsection addresses the MSA/LSA contrast in limpet size.

The rarity or absence of fish in coastal MSA sites and the heavy MSA emphasis on just four or five shellfish species suggests that, compared to their successors in the LSA, people in the MSA exploited coastal resources less intensively or more selectively. More selective exploitation could further explain why MSA assemblages tend to contain significantly fewer granular limpets. Adult granular limpets are more accessible than adults of the other two principal limpet species, because

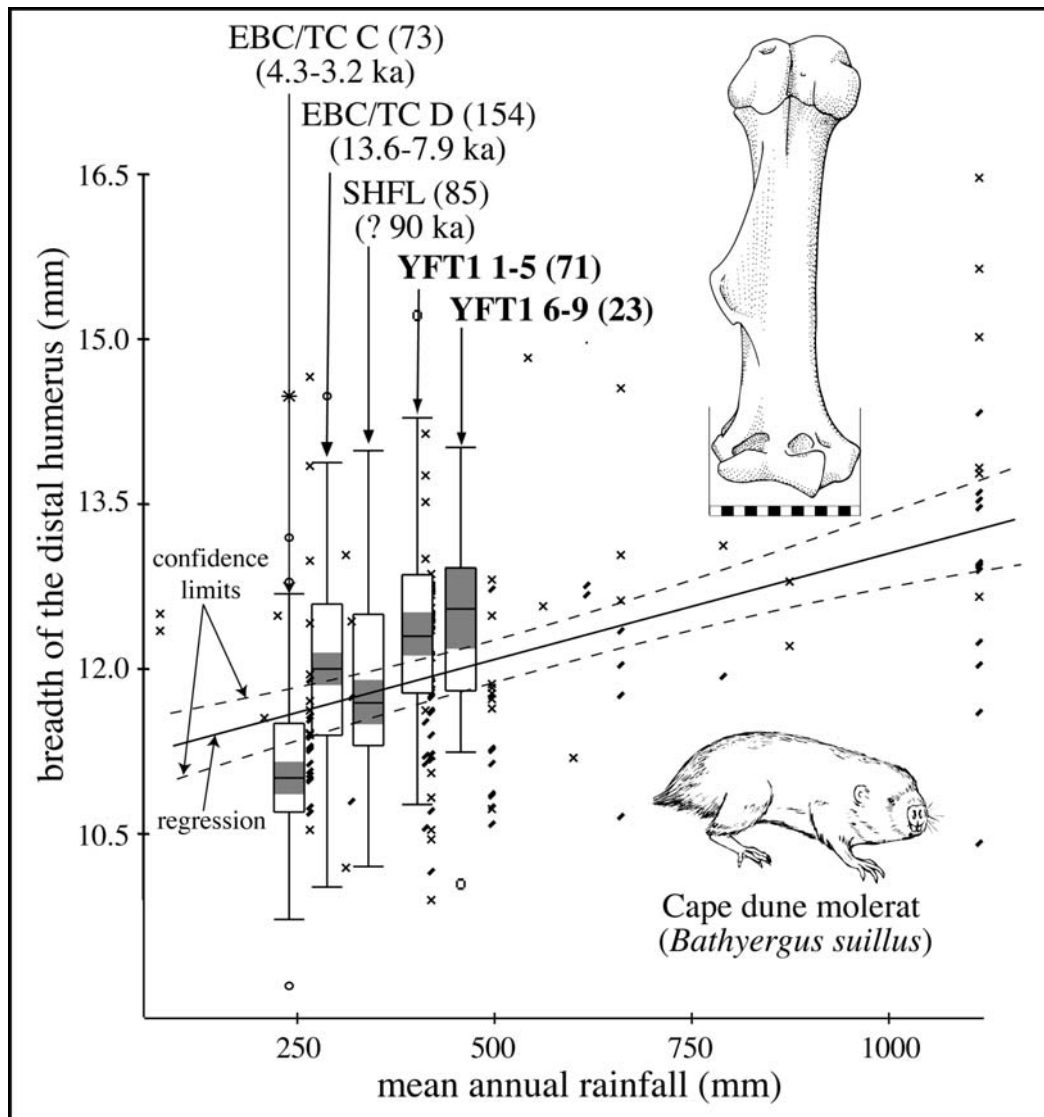


FIG. 11. The least squares regression of molerat distal humerus breadth on rainfall, the 95% confidence limits for the regression, and boxplots summarizing distal humerus breadth in fossil samples from YFT1, from a calcrete crevice (SHFL) adjacent to the Sea Harvest MSA site (Grine & Klein 1993), and two successive LSA occupation pulses or episodes at Elands Bay and Tortoise Caves (references in Table 2). Modern molerat humeri are indicated by bold slashes (females) and crosses (males). The numbers in brackets following the site abbreviations are the numbers of measured humeri, and the numbers below the abbreviations are their estimated ages. A small carnivore probably accumulated the SHFL sample, and its age is conjectural. The key elements in each boxplot are the median, represented by the line near the center of each plot, the open rectangle which encloses the middle half of the data (between the 25th and 75th percentiles), the shaded rectangle which indicates the 95% confidence limits for the median, and the line bisecting each plot, which signifies the range of more or less continuous data. Starbursts and open circles mark outliers (values that are especially far from the median). Chance is unlikely to explain the difference between two medians whose 95% confidence limits do not overlap. Samples whose confidence limits lie above the upper confidence limit for the regression line imply higher-than-expected rainfall; samples whose confidence limits lie below the lower limit imply lower-than-expected rainfall.

they tend to live higher on the shore. However, they are also smaller, and more selective collectors would thus be more likely to ignore them. The smaller populations in the MSA, that we postulate above and again below, probably explain why shellfish were collected less intensively in the MSA.

LIMPET AND MUSSEL SIZE

Figures 14–17 employ the same boxplot format as Figures 11 and 12 to compare limpet and black mussel size between YFT1 and other west coast MSA and LSA sites. Sample size and the availability of appropriate measurements determined which MSA and LSA samples were included in each figure. The caption to Figure 11 explains the boxplot format, and the key elements are the median near the center of each plot and the 95% confidence limits for the median, indicated by a gray bar around the median. Medians whose 95% confidence limits do

not overlap are significantly different in the conventional statistical sense.

In Figures 15 and 16, granular and Argenville’s limpets from adjacent YFT1 stratigraphic groups are combined to allow for statistically meaningful comparisons. The resultant groupings do not correspond to those for the molerats and tortoises above, because the stratigraphic distributions of molerats, tortoises, granular limpets, and granular limpets do not coincide, due at least in part to small sample sizes. The limpets are common overall and the larger samples that are likely to be available from the 2008 excavations should permit finer stratigraphic subdivision. This is important to determine the range of average size in each species, to investigate whether size shifts in one or more species correlate with shifts in species abundance or other variables, and if such correlations exist, whether they also characterize LSA sites like Bakoond. All the

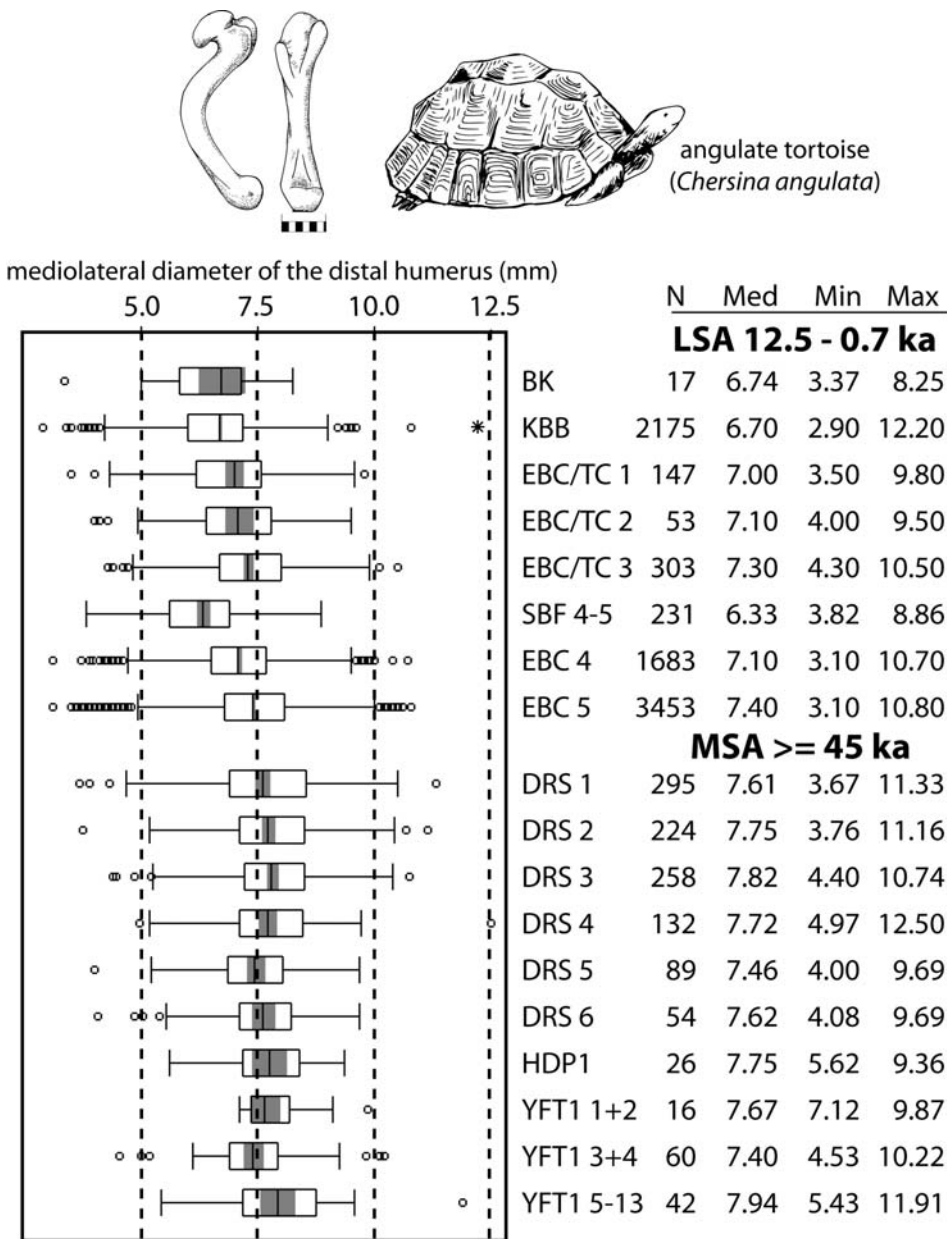


FIG. 12. Boxplots describing the mediolateral diameter of angulate tortoise distal humeri in various MSA and LSA samples. The caption to figure 11 explains the boxplot format. Site names are abbreviated thus: BK Bakoond; KBB Kasteelberg B; EBC/TC 1 Elandsbay Cave Layers 1–4 and Tortoise Cave Layers 1–2A; EBC/TC 2 Elands Bay Cave layer 5 and Tortoise Cave Layers 2B–4; EBC/TC 3 Elands Bay Cave Layers 6–9 and Tortoise Cave Layers 5–13A; SBF Steenbokfontein; EBC 4 Elands Bay Cave Layers 10–14; EBC 5 Elands Bay Cave Layers 15–19; DRS Diepkloof; HDP1 Hoedjiespunt 1; YFT1 Ysterfontein 1.

figures stress Bakoond because it is so near to YFT1, but the limpet and mussel measurements we have from other LSA sites support the same conclusions.

Figures 14 and 15 summarize average size in granite and granular limpets that modern collectors accumulated in 10 minutes from intertidal rocks at localities (BKB Bokbaai, CST Cape St. Martin and NMB Noordwesbaai) near the town of Paternoster (Buchanan *et al.* 1978). No one else had collected from the rocks in recent times, and the collectors harvested the largest specimens first. The average size of the limpets in each sample is thus an estimate of maximum potential size in the absence of human exploitation. Figures 14 and 15 include limpet samples that Yates (unpublished) systematically extracted from a fossil ('Eemian') beach at Steenbokfontein (SBFEB) and that provide an estimate of average (as opposed to maximum) limpet size long prior to the LSA. Figure 17 includes black mussels from the same fossil beach and also from recent beaches at Ysterfontein (YFTB) and Duinefontein (DFTB),

about 35 km to the south. Storm surges produced the recent beach samples, and they probably provide a rough indication of average black mussel size on rocks that are not presently exploited.

Figures 14–16 show that all three limpet species and the black mussels vary in average size within both the MSA and the LSA. However, the figures also show that the limpets from YFT1 and other MSA sites tend to be significantly larger than their LSA counterparts, whereas the mussels may have been smaller. Observations from LSA sites we have not included in the figures confirm the larger size of the MSA limpets, but they suggest that average mussel size within the LSA overlapped or encompassed MSA variation (Parkington 2003). Mussels that are as small, or smaller, than the MSA specimens in Figure 17 are especially common in LSA deposits predating 8 ka ago, and we conclude that only limpet size consistently differentiates the MSA from the LSA.

In average size, only the MSA limpets equal or exceed the

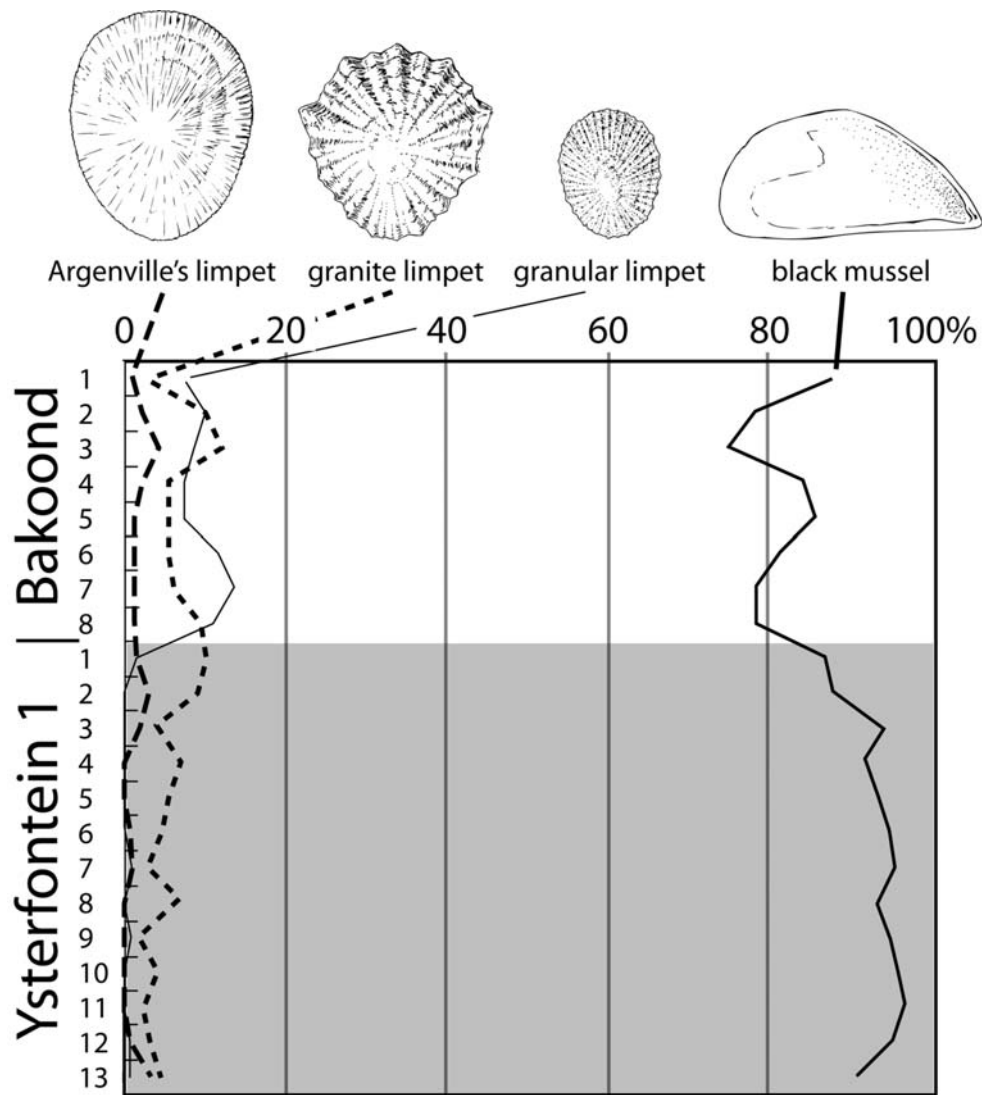


FIG. 13. Percentage representation of Argenville's limpets, granite limpets, granular limpets and black mussels in successive stratigraphic units at Ysterfontein 1 and Bakoond.

large limpets in the fossil beach. The MSA limpets are also much closer in size to the especially large limpets in the ten-minute samples. Like tortoise collection, limpet collection demands no special tools or risk, and the ten-minute samples provide particularly compelling evidence that collection intensity impacts average limpet size. Collection intensity in turn probably reflects the number of person hours devoted to collecting, and a long-term change in the number of hours is most likely to reflect an increase in the number of collectors. Thus, like the large MSA tortoises, the large MSA limpets also imply that by LSA standards, human populations in the MSA tended to be small. Either culture or environment could be responsible, but the mammalian indications for a favourable MSA environment point primarily to culture. Environmental (as opposed to cultural or technological) variation is more likely to explain why population size fluctuated within the MSA and LSA.

On average, both MSA and LSA black mussels tend to be much larger than those on recent beaches, but this probably shows that in the past people rarely collected beached mussels. Instead, they collected mainly from intertidal rocks, where the typical pattern of black mussel growth ensures that the smallest individuals, represented in the beach samples, occur mainly underneath the largest (Buchanan 1988: 19). The tendency for MSA and LSA mussels to vary within a common range may

appear to contradict the limpet observations, but it need not imply that people in the MSA and the LSA exploited mussels with equal intensity. This is because, unlike the limpets, which are strictly intertidal, black mussels also thrive subtidally, and the ribbed mussel, a species that is plentiful only subtidally, tends to be rare in both MSA and LSA sites. The implication is that neither MSA nor LSA people routinely exploited the subtidal zone, and subtidal black mussels would thus provide a ready source for rapid intertidal colonization. It is further pertinent that black mussels mature much more rapidly than limpets, and they reach adulthood far more quickly. In summary, average mussel size is less likely than average limpet size to reflect variation in stone age collection pressure.

Different shellfish species dominate intertidal waters on the south coast of South Africa (Day 1969; Branch *et al.* 1981; Branch *et al.* 1994;), and in general, south coast MSA and LSA shellfish samples have not been analysed as fully as those on the west coast. However, measurements are available for two common southwest and south coast species, the goat's eye limpet (*Patella (Cymbula) oculus*) and the giant periwinkle (*Turbo sarmaticus*), and in both cases, the pattern is similar to the west coast limpets: MSA specimens tend to be significantly larger than their LSA counterparts (Voigt 1982; Thackeray 1988; Henshilwood *et al.* 2001b; Klein 2001; Steele & Klein 2005/06). This also implies that human populations in the MSA were

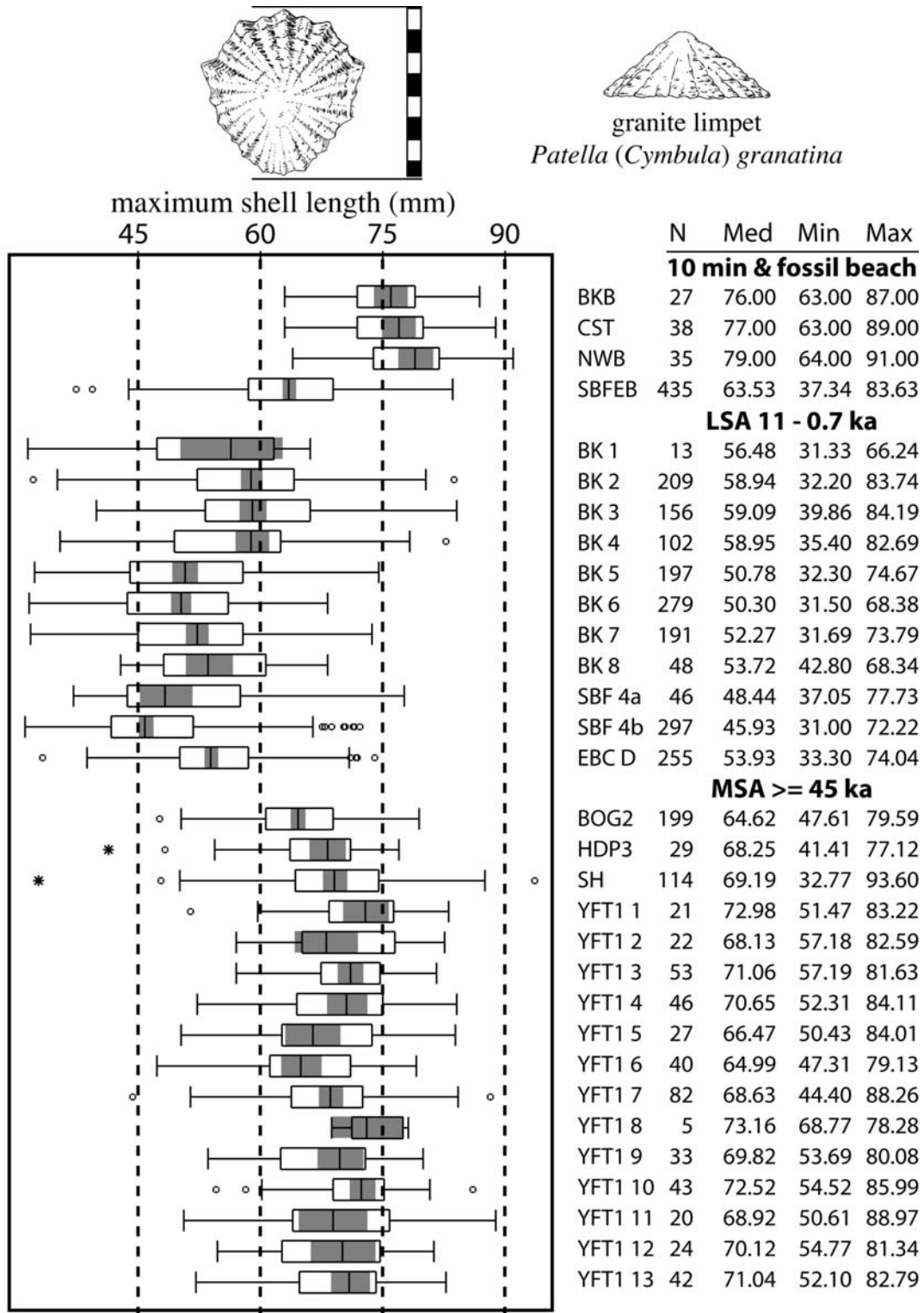


FIG. 14. Boxplots describing granite limpet lengths in various modern and fossil samples. The caption to Fig. 11 explains the boxplot format. Site names are abbreviated thus: BKB, Bokbaai; CST, Cape St. Martin; NWB Noordwesbaai; SBFEB, Steenbokfontein 'Eemian' Beach; BK, Bakoond; SBF, Steenbokfontein; EBC, D Elands Bay Cave Layers 10–16; BOG2, Boegoeberg 2; HDP3, Hoedjiespunt 3; SH, Sea Harvest; YFT1, Ysterfontein 1.

relatively small. As at YFT1, the mammals in south coast MSA sites imply relatively favourable environmental conditions, and the implication is that culture is more likely than environment to explain low population density in the MSA. Brown mussels dominate intertidal waters on the south coast and commonly dominate south coast middens to the same extent that black mussels do on the west coast. Brown mussels have extremely fragile shells that fragment readily in archaeological sites and it is difficult to make consistent measurements

on the fragments. Our subjective impression, however, is that the average size of MSA and LSA brown mussels may overlap, and the reasons may be the same as those for black mussels.

So far, only South Africa has provided sites where shifts in shellfish diversity and size coincide with long-term changes in culture, but Oceanic islands provide rough parallels at sites that record first human colonization and its aftermath. A prime example is Matenkupkum Cave, New Ireland, Papua New Guinea (Allen *et al.* 1989: 557–558), where the oldest levels,

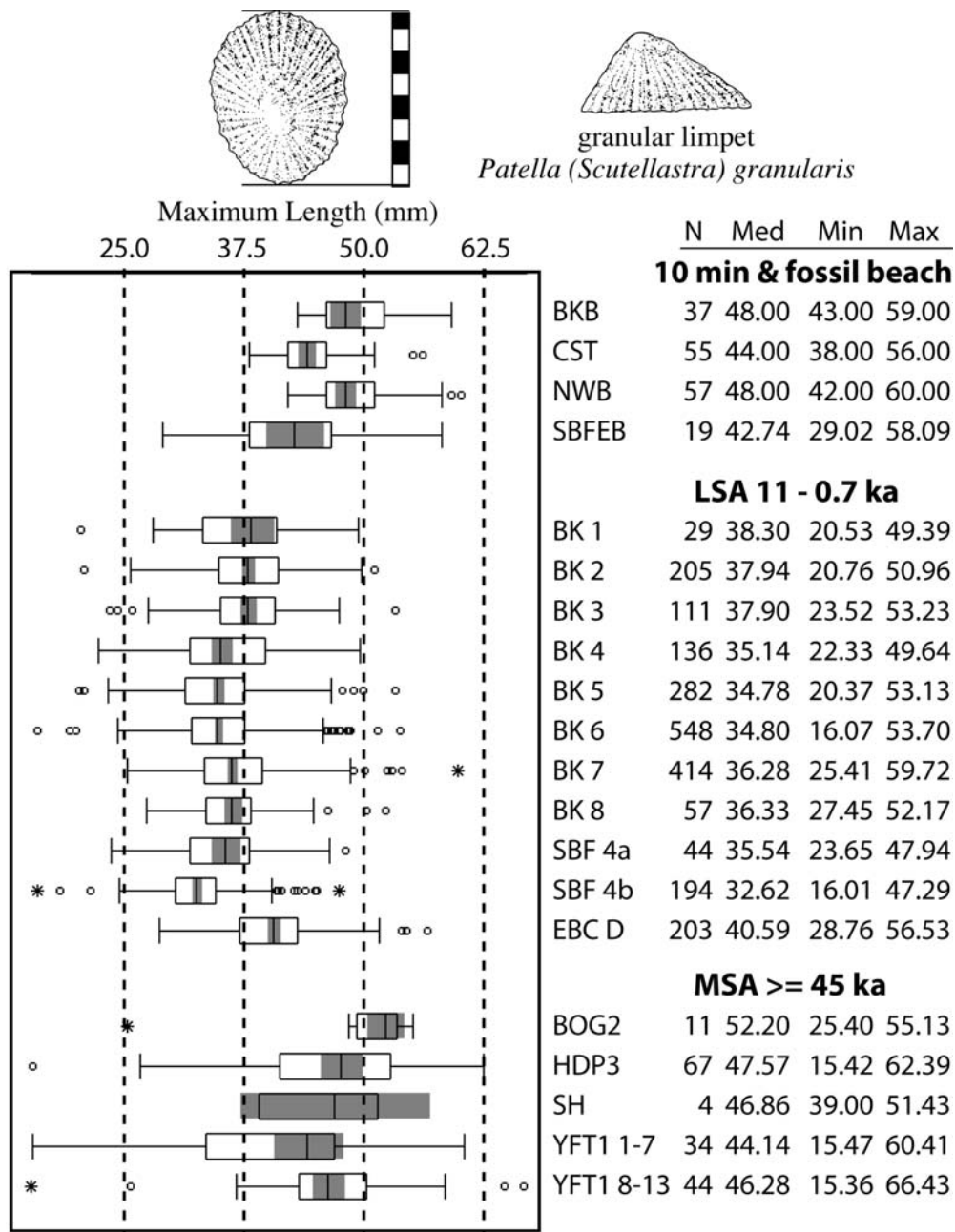


FIG. 15. Boxplots describing granular limpet lengths in various modern and fossil samples. The caption to Figure 11 explains the boxplot format. Site names are abbreviated thus: BKB, Bokbaai; CST, Cape St. Martin; NWB, Noordwesbaai; SBFEB, Steenbokfontein 'Eemian' Beach; BK, Bakoond; SBF, Steenbokfontein; EBC, D Elands Bay Cave Layers 10–16; BOG2, Boegoeberg 2; HDP3, Hoedjiespunt 3; SH, Sea Harvest; YFT1, Ysterfontein 1.

marking initial colonization about 33 ka ago, contained mostly large individuals of the largest available shellfish species. Younger levels not only provided significantly smaller individuals of the same species, but also a wider range of species overall. The contrasts in species size and diversity between the older and younger layers at Matenkupkum broadly recall the contrasts between YFT1 and local LSA sites, and the driving force in both cases was probably an increase in the number of human collectors.

CONCLUSION

The faunal remains from YFT1 and other west coast sites indicate that, compared to those in the LSA, foragers in the MSA exploited coastal resources less intensively and that they were more sparsely distributed, even when they enjoyed favourable environmental conditions. Faunal remains from south coast sites imply the same MSA/LSA contrast, and the long-standing

environmental difference between the coasts strengthens the case that culture, not environment explains MSA/LSA differences. The south coast MSA sites include Blombos Cave, where scored ochre fragments and proposed tick-shell beads are often thought to imply LSA-like culture. The Blombos MSA faunal remains, however, do not imply an LSA-like level of coastal foraging or LSA-like population density, and whatever the cognitive or cultural implications of the artefacts, they do not appear to have conferred a fitness (reproductive and survival) advantage. This may explain why they do not appear to have spread from Blombos Cave and why they did not prompt an Out of Africa expansion.

The expansion occurred only about 50 ka ago, 25 ka after people in the MSA abandoned Blombos, and timing of the expansion suggests that a significant fitness advantage evolved in the transition from the MSA to the LSA. In southern Africa, the main problem with this hypothesis is not the Blombos

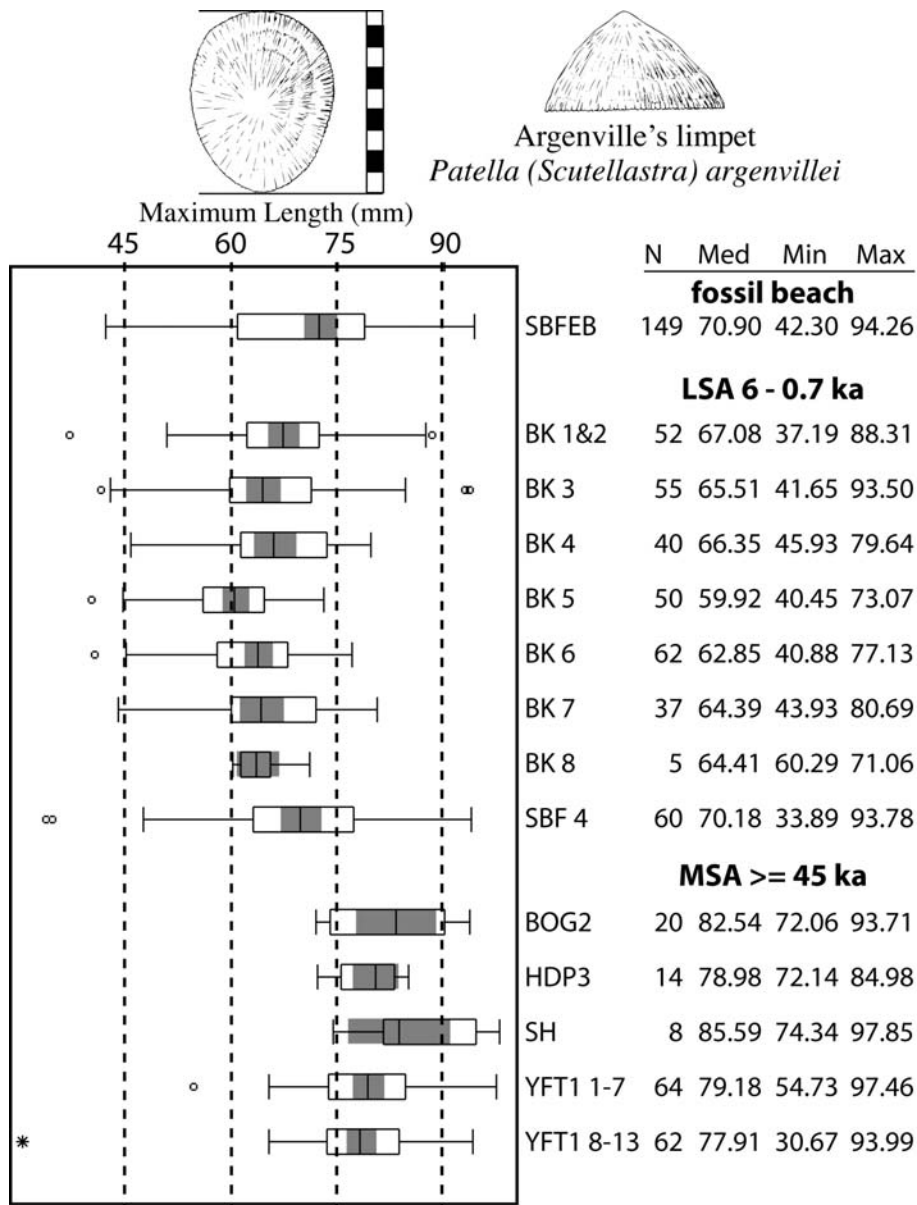


FIG. 16. Boxplots describing Argenville's limpet lengths in various modern and fossil samples. The caption to Figure 11 explains the boxplot format. Site names are abbreviated thus: SBFEb, Steenbokfontein 'Eemian' Beach; BK, Bakoond; SBF, Steenbokfontein; BOG2, Boegoeberg 2; HDP3, Hoedjiespunt 3; SH, Sea Harvest; YFT1, Ysterfontein 1.

artefacts; it is the gap in the archaeological record between the youngest MSA at 55–50 ka and the oldest unambiguous LSA at 25–20 ka ago. A like-aged hiatus may characterize the archaeological record across most of northern Africa (Camps 1974; Camps 1975; Wendorf *et al.* 1990; Wendorf & Schild 1992; Cremaschi *et al.* 1998; Close 2002) and in both the north and south the cause may have been persistent hyperaridity that reduced human populations in the middle of the Last Glaciation (Deacon & Thackeray 1984; Deacon 1995; Beaumont & Vogel 2006). This stands in contrast to eastern Africa, where a deep drill core from Lake Malawi indicates near-historic moisture between 50 and 35 ka ago (Scholz *et al.* 2007). This area of increased moisture may have extended into eastern South Africa, allowing MSA people to persist here until about 40 ka ago (Wadley 2005b; Jacobs *et al.* 2008).

The rarity or absence of an early LSA makes it impossible to determine whether differences in MSA/LSA foraging developed abruptly about 50 ka ago or more gradually between 50 and 20 ka ago. The Out of Africa expansion implies an abrupt

development, but within Africa, only eastern Africa may have been continuously occupied between 50 and 30–20 ka ago (Ambrose 1998). This corresponds with indications for more favorable climatic conditions there, and it implies that eastern Africa is where we should look for evidence of the MSA/LSA transition. Relevant observations may be slow in coming, partly because paleoanthropological research in eastern Africa focuses on much earlier periods and partly because eastern Africa may lack coastal sites like those that illuminate foraging differences in South Africa.

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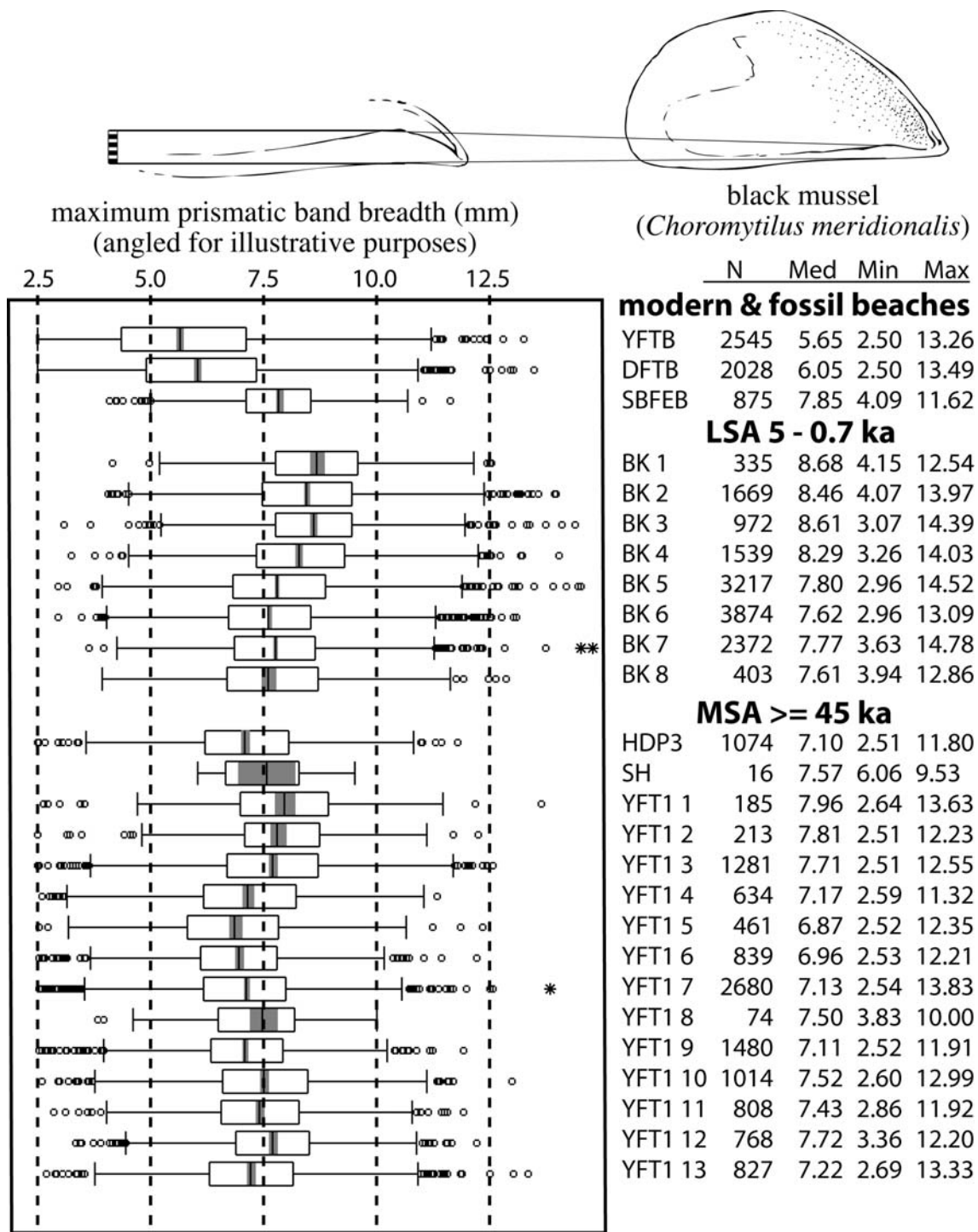


FIG. 17. Boxplots describing the breadth of the prismatic band in modern and fossil black mussel samples. Archaeological black mussel shells tend to be highly fragmented, and only the prismatic band can be measured routinely. This borders the straighter margin of each valve, and on whole valves, its breadth correlates closely with total length (Buchanan 1985). The caption to Figure 11 explains the boxplot format. Site names are abbreviated thus: YFTB, Ysterfontein Beach; DFTB, Duinefontein Beach; SBFEB, Steenbokfontein 'Eemian' Beach; BK, Bakoond; HDP3, Hoedjiespunt 3; SH, Sea Harvest; YFT1, Ysterfontein 1.

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