Early Archeological Evidence for Shellfish Collecting

Abstract. *Geologic evidence, supported by infinite carbon-14 dates and Middle Stone Age cultural associations, indicates that two open-air shell middens recently found at Sea Harvest and Hoedjies Punt, Saldanha Bay, South Africa, date from the terminal part of the Last Interglacial, about 70,000 to 60,000 years ago. These middens are among the oldest known records for systematic human exploitation of marine resources anywhere in the world. The faunal contents of the middens suggest that the Middle Stone Age people who accumulated them utilized marine resources less intensively than their Later Stone Age successors in similar coastal settings.*

I report here on two unique open-air shell middens exposed roughly 1.3 km apart within consolidated sands of terminal Last Interglacial age at Saldanha Bay (approximately 33°01′S, 17°57′E), 120 km north of Cape Town on the west coast of South Africa. The sites, known as Sea Harvest and Hoedjies Punt (Fig. 1), contain Middle Stone Age (MSA) stone artifacts, largely whole marine mollusk shells, ostrich eggshell fragments, and rare bone in an essentially primary, stratified context. At present, they are the oldest known open-air shell middens in the world.

The artifacts and food refuse at both sites occur less than 100 m from the shore and roughly 15 m above present sea level in lenses of sandy wash deposited in small gullies or crevices eroded into thick eolianite sequences. Stone artifact edges are in mint condition, and the mollusk shells are fresh. Since shell generally corrodes before bone in other southern Cape archeological contexts, it seems likely that the original proportions of faunal remains are unchanged.

At Sea Harvest the marine shells, artifacts, and ostrich eggshell fragments lie horizontally in discrete lenses, separated from one another by sterile sand. Within each lens the objects are almost all oriented in the same plane and do not occur haphazardly. The deposits at Hoedjies Punt are similar to those at Sea Harvest but have undergone more intensive erosion and postdepositional compaction. It seems reasonable to interpret both the Sea Harvest and Hoedjies Punt middens as the residues of repeated short-term occupations, subjected to transport over no more than short distances.

The sites were discovered in 1973 during field trips to the area by G. Avery, R. G. Klein, and A. J. Tankard. Since the sands containing the occupation residues at both sites were cemented and capped by even more heavily cemented deposits, excavation was not practical. At both sites, collecting consisted mainly of fine-sieving the sands that accumulated at the base of each profile as a result of natural weathering. Avery and Klein made collections at intervals of several months between 1973 and 1977. I joined them in collection activities at Sea Harvest in 1977. The Hoedjies Punt sample is substantially smaller than the one at Sea Harvest because collection was terminated at Hoedjies Punt in 1975 when road builders destroyed the site.

Two separate samples of ostrich eggshell fragments from Sea Harvest gave radiocarbon dates greater than 40,000 years (samples UW-282 and UW-292) (*1*). Butzer places the MSA occupation at Sea Harvest at the very end of the Last Interglacial, about 70,000 to 60,000 years before the present (B.P.) (early in oxygen isotope stage 4), following the deposition of up to 15 m of eolian sands earlier in the Interglacial (*2*). It is probable that Hoedjies Punt is approximately the same age. Both the Sea Harvest and Hoedjies Punt shell middens are roughly contemporaneous with other adjacent fissure fills containing bone but not artifacts or marine shells. The bone assemblages from the fissures are similar to like-aged assemblages from Swartklip, Duinefontein, and other southwestern Cape sites where the accumulators were probably hyenas (*3*).

Table 1. Inventory of stone artifacts for the Sea Harvest and Hoedjies Punt Middle Stone Age shell middens.

Type	Number at	
	Sea Harvest	Hoedjies Punt
Unmodified pieces		
Flakes and flake or blade fragments	223	38
Blades	17	3
Debris	90	26
Chips	4	2
Utilized or retouched pieces		
Flakes and flake or blade fragments	12	4
Blades	1	
Debris	4	1
Denticulated pieces		
Flakes and flake or blade fragments	23	4
Blades	2	
Debris	4	
Tayac or oak leaf points (convergent denticulates)	2	
Composite denticulate-sidescraper		1
Scrapers	2	
Unifacial points	1	
Cores		
Radial	3	
Opposed platform on same side	1	
Core on a flake		1
Ochre	2	
Total	391	80

Until the discovery of the Sea Harvest and Hoedjies Punt middens, the best evidence for exploitation of marine resources in southern Africa prior to the terminal Pleistocene came from Klasies River Mouth Caves 1 and 1A, where the oldest shell midden probably dates from the beginning of the Last Interglacial, about 130,000 years B.P. (*4*). The associated artifacts at Klasies are also Middle Stone Age. Very old open-air shell middens are reported on estuary terraces and raised beaches at the Bay of Maputo, Mozambique (*5*), but a human origin for the shell layers containing supposed MSA artifacts has not been demonstrated.

Outside of southern Africa, evidence for comparably early marine resource exploitation may occur in the Devil's Tower Rock Shelter on Gibraltar (*6*) and at the Haua Fteah in Libya (*7*). At Devil's Tower, the culture involved is Mousterian, but the evidence for primary association of Mousterian artifacts and marine faunal remains is not conclusive (*8*). At Haua Fteah, the artifacts are "Pre-Aurignacian" and the evidence for association with shells is unquestionable. However, the extent to which the shells represent food debris is unclear. Therefore, the Sea Harvest and Hoedjies Punt localities so far provide the best available confirmation of the early exploitation of marine resources found at Klasies, and they show further that such exploitation occurred from open-air sites as well as caves.

A particularly striking feature of the Sea Harvest and Hoedjies Punt sites is the great quantity of ostrich eggshell fragments, roughly three times more numerous than stone artifacts or mollusk shells. I can think of no explanation for this high frequency of ostrich eggshell, which is without parallel at other Stone Age sites in southern Africa.

The Sea Harvest and Hoedjies Punt stone artifact collections are similar to so-called "Stillbay" collections found in surface context at various southwestern Cape sites, but so far the Saldanha middens have not yielded any of the finely worked, bifacial foliate points that especially characterize the "Stillbay" industry (*9*). The samples from Sea Harvest and Hoedjies Punt are characterized by a diversity of raw materials, with an em-

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phasis on fine-grained silcretes (41 percent), quartz (30 percent), and the local quartz porphyry (18 percent). The Sea Harvest and Hoedjies Punt collections (Table 1 and Fig. 2) are remarkable for their very high proportions of flakes, blades, and utilized or retouched pieces compared to stone-working debris. Over 23 percent of the silcrete pieces are utilized or retouched in various ways. This contrasts strongly with MSA collections from various southern Cape caves in which less than 2 percent of the stone is retouched or utilized. Probably most of the stone artifacts at Sea Harvest and Hoedjies Punt were manufactured elsewhere and brought to the sites for later use.

The shell sample from Hoedjies Punt is too small to permit meaningful analysis, but the one from Sea Harvest is demonstrably very similar in species composition and numbers to shell samples from much later terminal Pleistocene-Holocene (Later Stone Age) middens in the area, suggesting comparable environmental conditions (Table 2). So far, terminal Pleistocene-Holocene samples are the only ones available for comparison, because most Last Glacial middens were probably located on now-drowned coastlines, and, unfortunately, the Klasies shell samples are highly selected. Both the Sea Harvest people and terminal Pleistocene-Holocene collectors concentrated on black mussel (*Choromytilus meridionalis*) and limpets (*Patella* spp.) found on rock outcrops in the mid-intertidal zone. However, the mean diameter of the principal Sea Harvest limpet (*Patella granatina*) is close to that of the largest individuals taken recently at nearby localities and is much larger than the mean diameter of specimens from terminal Pleistocene-Holocene midden samples (*10*).

In addition to the fact that it contains larger limpets, the Sea Harvest midden also contrasts with nearby Later Stone Age (LSA) middens in that the shells in it are for the most part intact and they are not densely packed. Perhaps the explanation for both large limpet size and low shell density is that the Sea Harvest people did not utilize marine mollusks nearly as intensively as did later (LSA) peoples in the region. Support for the idea that MSA peoples did not utilize

Table 2. Minimum numbers of individuals by which the various species are represented in the Sea Harvest Middle Stone Age shell midden.

Animal	Number of individuals	Percentage of total mollusks
Mammalia		
Connochaetes gnou/Alcelaphus buselaphus, wildebeest/hartebeest	1	
Arctocephalus pusillus, Cape fur seal	1	
?Procavia capensis, rock hyrax	1	
Leporidae gen. et sp. indet., hare	1	
Otomys saundersiae, Saunders' vlei rat	1	
Reptilia		
Chelonia gen. et sp. indet., tortoise	2	
Aves		
Phalacrocorax neglectus, bank cormorant	1	
Pisces		
Indet. (one vertebra)	1	
Mollusca		
Choromytilus meridionalis, black mussel	16	7.5
?Donax serra, white mussel	3	1.4
Crepidula porcellana, slipper limpet	2	0.9
Burnupena sp.	4	1.9
Patella argenvillei, limpet	11	5.2
Patella granatina, limpet	128	60.4
Patella granularis, limpet	4	1.9
Patella oculus, limpet	32	15.1
Patella sp., indet. limpet	12	5.7
Total mollusks	212	100.0

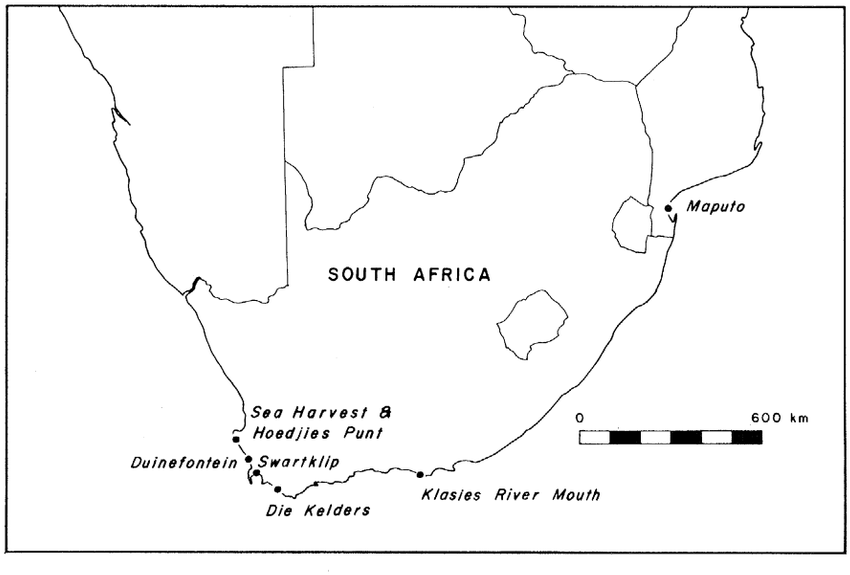
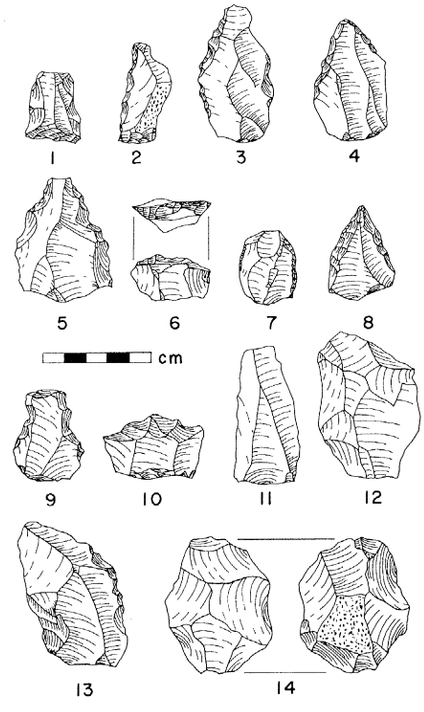


Fig. 1 (above). Approximate locations of southern African sites mentioned in the text. Fig. 2 (right). Stone artifacts from Sea Harvest: *1–3*, *9*, *10*, and *13*, denticulates; *4* and *5*, tayac or oak leaf points; *6* and *7*, scrapers; *8*, unifacial point; *11*, blade; *12*, flake; and *14*, radial core. Raw material: *1–8*, silcrete; *9* and *10*, quartz; *11*, *12*, and *14*, quartz porphyry; and *13*, diorite.



marine resources as intensively as their LSA successors has already come from analyses of vertebrate remains from MSA and LSA coastal caves in the southern Cape (*11*). Thus, the MSA deposits at Klasies River Mouth and in the probably early Last Glacial levels of Die Kelders Cave (*12*) contain numerous seal and penguin bones but very few remains of fish and flying birds. In LSA sites with comparable numbers of seal and penguin bones, remains of flying birds and of fish are abundant to superabundant (*13*). The most economical explanation for this contrast is that MSA peoples were technologically incapable of active fishing and fowling. Implements such as gorges and line (or net) sinkers, which are reasonably interpreted as fishing and fowling gear, are so far known only in LSA contexts.

In sum, then, the Middle Stone Age open-air shell middens at Sea Harvest and Hoedjies Punt not only contain some of the earliest evidence in the world for marine resource utilization but, in combination with evidence from other sites, they suggest that such utilization was less intensive during the Last Interglacial and earliest Last Glacial than in the terminal Pleistocene and Present Interglacial.

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9. The term "Stillbay" has been used to describe a wide variety of African collections even though no sealed, statistically reliable assemblage has ever been reported from the southern Cape, where the term "Stillbay" was first applied [A. J. H. Goodwin, *Ann. S. Afr. Mus.* **27**, 95 (1929)]. I recently examined all well-controlled assemblages excavated from early Upper Pleistocene contexts in the southern Cape, but found none that are closely comparable to those from Sea Harvest and Hoedjies Punt.
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14. I thank D. M. Avery, G. Avery, R. G. Klein, and J. E. Parkington for faunal identifications and A. W. Fairhall for radiocarbon determinations. I thank R. G. Klein, K. W. Butzer, and L. G. Freeman, who made helpful comments on an earlier draft of the manuscript. This work was supported by grant BNS 76-82734 from the National Science Foundation and the Hinds Fund, Committee on Evolutionary Biology, University of Chicago.

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Formation of Mutagens in Beef and Beef Extract During Cooking

Abstract. *Mutagens, distinguishable from benzo*[a]*pyrene and from mutagenic amino acid and protein pyrolysis products, are formed when ground beef is cooked in a home hamburger cooking appliance or when beef stock is concentrated, by boiling, to a paste known commercially as beef extract. "Well-done" hamburgers contain about 0.14 part per million of the mutagens, and beef bouillon cubes which contain beef extract about 0.1 part per million. Since such mutagens may be potentially carcinogenic and are formed during ordinary cooking procedures, their occurrence raises questions about possible risks to human health.*

It has become evident that environmental agents are responsible for much of the incidence of cancer in populations in the United States and elsewhere (*1*). Efforts to study such agents have been enhanced by the development of Ames' method for detecting mutagens in a system based on histidine-negative strains of *Salmonella typhimurium* (*2*). The method is rapid and inexpensive, and because there is a significant empirical relation between mutagenic activity in the Ames system and carcinogenicity (as determined by tumor incidence in laboratory animals) (*3*), it can be used for screening environmental agents that may be carcinogenic in human beings.

During an investigation of a minor anomaly in the Ames test, we discovered that certain commercial media that are widely used for culturing bacteria, including Ames' *Salmonella* strains, contain active mutagens (*4*). The anomaly is a small but consistent increase in the background rate of mutation in strains TA 1538 and TA 98, both of which are particularly sensitive to frame-shift mutations, when they are grown in the presence of the S-9 microsome preparation. This preparation is obtained by centrifugation of a liver homogenate at 9000*g*, and is used in the Ames system to convert certain test substances to mutagens. We have shown that the medium in which the bacterial inoculum is grown contains substances that are mutagenic in the presence of the microsome preparation. The mutagens occur only in media such as Bacto nutrient broth (Difco) that contain beef extract, a product obtained when beef stock (prepared by boiling beef tissue in water, filtering off the tissue, and removing the fat) is boiled down to 20 percent or less of its original volume. Beef extract is commercially available and is used in certain food preparations such as bouillon cubes (*5*).

We report here studies designed to determine the origin of the mutagens detected in bacterial media that contain beef extract. Beef stock was prepared by boiling 500 g (wet weight) of lean ground beef in two volumes of distilled water. Solids were removed by filtration, the liquid was cooled, and solidified fat was skimmed off. The beef stock was then boiled in an open beaker for 10 hours. At intervals, portions [each representing 0.69 g of the original beef stock (dry weight)] were analyzed by the method used earlier to detect mutagens in bacterial nutrients (based on methylene chloride extraction; see legend to Fig. 1). An initial sample yielded an average of 21 revertant colonies per plate, not significantly different from the control value of 29 revertants per plate. After boiling for 8.5 hours, the beef stock had been reduced to 40 percent of its original volume, and a portion yielded an average of 181 revertants per plate. After 10 hours of boiling, the beef stock was reduced to a dark brown paste (similar in appearance to commercial beef extract) representing about 5 percent of the original volume, and a portion yielded an average of 1572 revertants per plate. Thus, the mutagens are not present in either beef tissue or beef stock, but are produced when the latter is boiled extensively and reduced in volume to form beef extract, thus raising activity per unit of dry weight (*6*).

A dose-response curve obtained from methylene chloride extracts representing increasing portions of a commercial beef extract preparation [Bacto beef extract (Difco)] is shown in Fig. 1. It is evident that this material contains mutagens that are active only in the presence of the microsome preparation. Similar dose-response curves show that, in the presence of the microsome preparation, the mutagens extractable from this source by methylene chloride are equally active to-

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