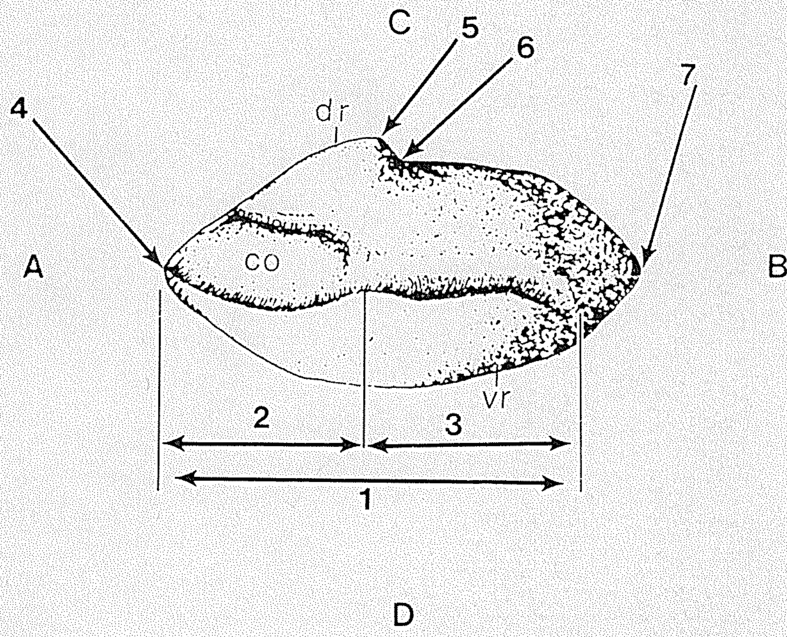
Bulletin of the TEXAS ARCHEOLOGICAL SOCIETY

Volume 58/1987



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TEXAS ARCHEOLOGICAL SOCIETY

The Society was organized and chartered in pursuit of a literary and scientific undertaking: the study of man's past in Texas and contiguous areas. The *Bulletin* offers an outlet for the publication of serious research on history, prehistory, and archeological theory. In line with the goals of the Society, it encourages scientific collection, study, and publication of archeological data.
The *Bulletin* is published annually for distribution to the members of the Society. Opinions expressed herein are those of the writers and do not necessarily represent the views of the Society or editorial staff.

Officers of the Society 1986-1987

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Bulletin of the TEXAS ARCHEOLOGICAL SOCIETY

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Dedication

This issue of the *Bulletin* is dedicated to Dee Ann Story, who recently retired from the staff of The University of Texas at Austin after a long and influential career that involved administration, teaching, and research. This career was closely intertwined with expansion of the Texas Archeological Society after 1950 and recognition of its *Bulletin* as an important regional journal. Story's first publication, the much–thumbed *An Introductory Handbook of Texas Archeology,* of which she is senior author, appeared at Vol. 25 (1954) of the *Bulletin,* and later she contributed a series of informative reports on sites in various parts of Texas that collectively represented all stages of human occupation. Thereafter she served for four years, from 1962 to 1965, as Editor of the *Bulletin* and was elected President of the Society (1969–70). The Texas Archeological Society owes much to Dee Ann Story, and not just for her more formal efforts in its behalf. She has been accessible to everybody and, through letters, personal conversations, and addresses before local groups, has promoted greater interest in the Society.

Story grew up in Houston, and most of her life has been spent in Texas. She took two degrees (B.A. and M.A.) from The University of Texas at Austin and did her terminal graduate work at the University of California at Los Angeles (Ph.D., 1963). After two years at the University of Utah, during which she supervised excavations in Glen Canyon, she returned to Texas in 1960 to become Curator of Anthropology at the Texas Memorial Museum. Two years later she joined the staff of the Texas Archeological Research Laboratory and eventually became its director. She simultaneously held a teaching appointment in the Department of Anthropology, rising through the ranks to become Professor of Anthropology.

Her archeological research began with syntheses of data from all parts of Texas, and this breadth of interest is reflected in her later publications. Two areas have been of special interest to her—Central Texas and East Texas—and she has published syntheses for both areas. In recent years her attention has been directed mainly toward East Texas and the larger Caddoan area, and she has extracted new kinds of data from two sites—George C. Davis and Deshazo. The quality of Story's research was recognized in 1985, when she received a Distinguished Service Award from the Society for American Archeology.

Story has always read widely and, in her courses and seminars in the Department of Anthropology, she presented the latest developments, not only in archeology but also in other disciplines that contribute to better archeological interpretation. In her summer field courses she has been notably innovative in her approaches to excavation, and those who worked with her in the field have learned that the best tool for use in excavation is an alert human mind. Those who prepared reports, theses, and dissertations under her direction found that she does not tolerate fuzzy writing. E. Mott Davis, who is interested in the history of Texas archeology, has compiled a list of more than 80 individuals who either were Story's graduate students or were influenced by association with her. Many of these are now on university faculties or employed by state or national agencies concerned with the study and preservation of archeological resources.

The results of Story's administrative work deserve special recognition. By persistent effort over the years, she transformed the Texas Archeological Research Laboratory in Austin from a repository of artifacts into a first–rate research facility. Even in the leanest years she somehow managed to find funds for its improvement. The physical plant was remodeled and enlarged, collections and records were reorganized, a good working library was accumulated, significant reports were published, and a start was made on computerization of the archeological information. One wonders how Story could be so effective in administration, teaching, and research. My theory is that she never slept.

T. N. Campbell
Austin, Texas

CONTENTS

"We have left of them, bequeathed to us, only a few place names—names of bays, inlets, points of land, straits and creeks...."

Roy Bedichek–*Karankaway Country*

Archeological Investigations at the McKinzie Site (41NU221), Nueces County, Texas: Description and Contextual Interpretations

Robert A. Ricklis

ABSTRACT

This paper decribes excavations and findings at the McKinzie site near Corpus Christi, Texas. Two discrete components were identified; the earlier Archaic component, recognized as a thin shell midden containing a profusion of shells of the brackish water clam *Rangia flexuosa*, is dated to about 5000 B. P. and is inferred to represent an estuarine bayshore adaption at that time. The later component, assigned to the Late Prehistoric Rockport complex, produced evidence for a seasonal, multifunctional, and residential occupation during which small groups carried out various subsistence activities, apparently in circular huts that had central hearth complexes and, possibly, small storage pits. A model of seasonally oscillating settlement and subsistence patterns is developed for the Late Prehistoric stage in the area, providing an ecological context for the Rockport complex component.

INTRODUCTION

The McKinzie site (41NU221) is a multicomponent site on the dissected Pleistocene river terrace that overlooks the modern floodplain of the lower Nueces River near Corpus Christi, Texas (Figure 1). Excavations were carried out at the site during 1984 and 1985; this paper describes the results of that work and offers interpretations relevant to questions of prehistoric chronology and cultural adaptations for the Texas Coastal Bend area.

Investigations at the McKinzie site revealed two discrete prehistoric components. The earlier and stratigraphically lower component is from a fairly early period in the long-lived Archaic stage of the region. Data for the Archaic component are limited, but an approximate chronological placement of this component can be made. Additionally, certain inferences can be drawn regarding seasonality of occupation and subsistence activities for both components. The later component is assigned, on the basis of diagnostic ceramic and lithic artifacts, to the Rockport complex, a Late Prehistoric adaptation to the central Texas coast involving a hunting-fishing-gathering subsistence base (see Suhm et al. 1954, Campbell 1958c). The Rockport complex was the more extensively investigated of the two components. The spatial relationships among various features and the distributions of cultural debris are inferred to represent a culturally significant pattern, which, coupled with information on seasonality and length of occupation, sheds light on the nature of a single seasonal occupational episode assignable to the Rockport complex.

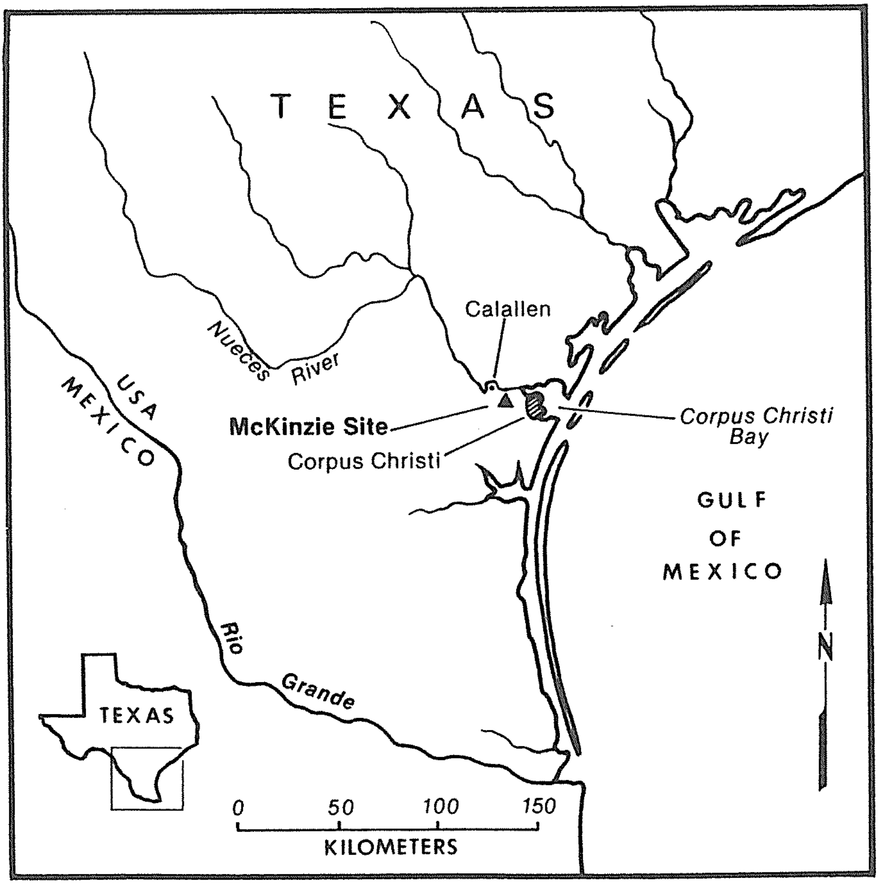

Figure 1. Map of the Coastal Bend area of Texas showing location of the McKinzie site.

Data from previous limited surveys and test excavations in Nueces and San Patricio counties, suggest too that Rockport complex sites, as defined by fairly consistent artifact assemblages containing Rockport ware pottery (see Suhm and Jelks 1962:131-135), Perdiz and Fresno arrowpoints (ibid., Turner and Hester 1985) and small end scrapers, do not have ecological homogeneity as reflected in (a) spatial and microenvironmental locations, (b) the predominant faunal remains, or (c) the apparent intensity of occupation. This ecological heterogeneity will form the inferential basis for a preliminary model of settlement and subsistence patterns for the Late Prehistoric occupation of the Corpus Christi Bay/Nueces River area.

The model, which will posit a pattern of seasonal oscillation between large fall-winter camps of aggregate groups and smaller dispersed spring-summer encampments, will offer a cultural ecological context for the Late Prehistoric occupation at McKinzie. The model is testable and may serve not only as one basis for additional systematic research into the nature of aboriginal adaptation in the Coastal Bend area but also as one step toward an integrated perspective on the prehistory of this part of the western Gulf Coast.

THE ENVIRONMENTAL CONTEXT

The Texas Coastal Bend, part of the Gulf Coastal Plain (Fenneman 1938), consists geologically of sediments deposited by large Pleistocene river systems during interglacial periods when sea levels approximated those of the present (Brown et al. 1976:16). The topography is essentially flat, broken only by stream channels, embayments, and dune formations. Because the sediments consist primarily of fine-grained clay, the area today is devoid of any naturally occurring lithic material larger than small pebbles.

The area is included in the Tamaulipan Biotic Province as defined by Blair (1950), a region characterized on a large scale by mild winters, hot summers, and a biotic matrix adapted to a xeric environment, but in which there are small-scale variations in precipitation, net moisture, and associated biotic communities. There is a trend toward increasingly xeric conditions from north to south along the central part of the Gulf coast. The Corpus Christi Bay/Nueces River area is a zone of transition, where annual rainfall averages about 85 cm (35 inches) to the north and 75 cm (30 inches) or less to the south. Vegetation cover north of this zone is characterized by savanna grasslands, and south by higher incidence of various thornbrush species and cacti (Brown et al. 1976; Jones 1983).

The shore of the mainland is characterized by bays, lagoons, and estuaries. Several kilometers offshore is a long chain of barrier islands—sands deposited by wave action since the establishment of modern sea level at about 2800 to 2500 B.P. (Brown et al. 1976) (Figure 2).

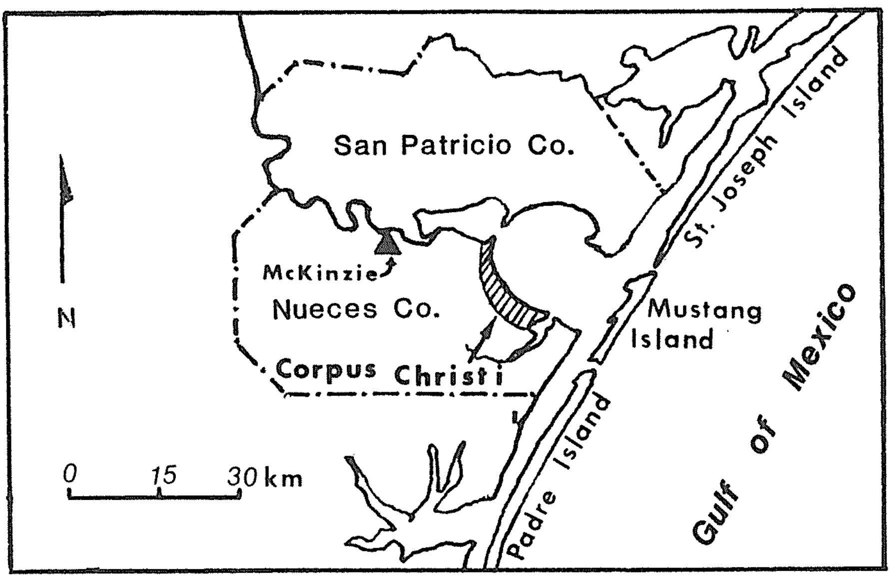

Figure 2. Map showing San Patricio and Nueces counties, Texas.

In the Corpus Christi Bay/Nueces River area, major geological soil zones and associated floral assemblages are recognizable. The three barrier islands—St. Joseph, Mustang, and Padre islands—that separate Corpus Christi Bay from the Gulf of Mexico are mostly treeless, covered with grassy vegetation, predominantly spikerush, fimbry, glasswort, and sea purslane (Jones 1983:13,14, 54, 65).

The outermost 5 to 10 km of the mainland is the Ingleside strandplain, a sand of Pleistocene origin. The characteristic Galveston-Mustang soil here supports several kinds of oak and sweetbay, and an understory of beautyberry and yaupon.

Directly inland from the strandplain are the Pleistocene clays, the most extensive geologic formation in the Coastal Bend, on which are developed extensive blackland soils. These soils are largely under cultivation, but before the latter part of the last century the area was grassland savanna. Common floral species were short grasses such as buffalo grass, the taller bluestem, scattered mesquite, and prickly pear cactus (Jones 1983).

The extensive and dense stands of mesquite and other thornbrush that abound in the area apparently are largely modern phenomena. Before the mid-nineteenth century, savanna conditions predominated (Bogusch 1952, Jones 1983). Apparently the spread and dominance of thornbrush has resulted from both the cessation of aboriginal burn-offs and the disturbance of the natural groundcover by cattle grazing.

Before this invasion of thornbrush, trees were confined largely to river valleys and patchy groves on higher ground within the savanna matrix. River floodplain moisture supported various species, including ash, elm, box elder, willow, retama, huisache, and cottonwood. The scattered upland groves included hackberry, chittimwood, anaqua, live oak, and mesquite (Jones 1983:xvii).

Terrestrial faunal species in the area are those listed by Blair for the Tamaulipan Biotic Province—61 species of mammals, notably whitetail deer, coyote, javelina, bobcat, cottontail, jackrabbit, mouse, and rat. Thirty-six species of snake, 19 of lizard, two of land turtle, three urodeles, and 19 anurans are also noted.

Bison were reported in early historic times along the coastal littoral, though it is unclear how dense the herds were. Dillehay (1974) has postulated that bison herds pushed southward into Texas three times during the Holocene,

between 10,000 to 6000 and 5000 B.C.
between 2500 B.C. and A.D. 500, and
between A.D. 1200 and A.D. 1300 to 1500.

No data could be found indicating the presence of bison in southern Texas before the 1200/1300 episode, but ample evidence has come to light of bison in the area after about A.D. 1300 in interior southern Texas (Black 1986, Hall et al. 1982, Hester and Parker 1970, Hester 1977), and this is true to some degree of the same period on the coast.

Fish abound in the bays and lagoons, notably redfish (red drum), trout, croaker, gafftop and hardhead catfish, and black drum, which enter the shallower parts of bays and tidal passes in large numbers to spawn, primarily during the winter months (Simmons and Breuer 1962).

Shellfish are abundant in the bays from the north shore of Corpus Christi Bay northward. South of Corpus Christi Bay, shellfish decrease in abundance until at Baffin Bay they are virtually absent, apparently due to the hypersalinity of coastal waters resulting from the low volume of discharge of fresh water in the more xeric conditions of deep South Texas (see Hester 1980a).

PALEOENVIRONMENTAL PROCESSES

The scale and rapidity of environmental change along coastlines is accentuated by processes of sea level change, erosion, and sedimentation, which have profound effects on the localized primary productivity and dependent biotic communities and, in turn, on the nature of human adaptations. Also, these geologic processes can affect the quality of the archeological record so severely that sites (especially older ones) representing important aspects of adaptive systems can be lost to investigation.

One fundamental process is the eustatic sea level rise during the Holocene. The details of fluctuations in sea level rise have been interpreted differently (cf. Curray 1960, Nelson and Bray 1970, Frazier 1974), but there is general agreement on the broader patterns in this process. Sea level began to rise rapidly at about 18,000 to 16,000 B.P. and fluctuated several times before about 1800 to 2500 B.P., when it reached its present level (Brown et al. 1976:21). Between about 10,000 and 7500 B.P. a standstill was maintained, with sea level some 60 to 80 feet lower than at present. At about 7500 B.P. the sea began to rise rapidly, so that by about 5000 to 4500 B.P. it was about 20 feet below the modern level. Between 5000 to 4500 and 2500 B.P., rise was gradual, with a level approximating modern sea level established by the latter date. With the stabilization of the coastline by the middle of the third millenium B.P., wave action depositing offshore sediments resulted in the formation of barrier islands. Except for some tidal passes, Corpus Christi Bay became separated from the open Gulf, and continuous wave action in the bay produced the present shoreline (Brown et al. 1976:21).

During the final stage of the Pleistocene, the valley of the lower Nueces River was eroded into older Pleistocene fluvial deltaic deposits to such an extent that by the beginning of the Holocene the valley was considerably deeper than at present. With the rapid sea level rise beginning at 7500 B.P. the valley was innundated and, about 4500 B.P., the lower Nueces valley was filled with estuarine waters at least as far inland as a point just west of Calallen (Figure 1) where there are old wave-reworked bars and berms (Brown et al. 1976:121). So during this time period a long bay extended from the open Gulf inland to a point some 35 km west of the present shoreline.

Unfortunately, there is no direct evidence regarding paleoclimatic change for this area, and the general lack of good pollen preservation in South Texas archeological contexts makes reconstruction of prehistoric floral communities and, inferentially, climatic conditions, difficult at best. Recent research with plant phytoliths, however, has demonstrated certain certain fluctuations in grass varieties in the region during the Holocene (Robinson 1979), and such work may offer the best possibilities for the reconstruction of paleoclimatic change.

Hester (1980b:35) has inferred a savanna parkland environment in South Texas for the terminal Pleistocene, and floral and faunal remains recovered from an early Holocene (about 7000 B.C.) hearth at Baker Cave in the lower Pecos area indicate an essentially modern biotic assemblage (Hester 1980b:139-142).

Based on pollen evidence, Bryant and Holloway (1985) suggest a gradual trend toward warmer and drier conditions during the Holocene for southwestern and Central Texas. This generalization for the larger region is the best information available at present for understanding the basic climatic trend in South Texas during the Holocene.

THE SITE

The McKinzie site is on one of the many hilltops that are remnants of the dissected Pleistocene terrace of the Nueces River and extend along the southern edge of the present floodplain, from the head of Nueces Bay to near the west boundary of Nueces County. The site is some 200 meters south of the present channel of the Nueces River and 4 km upstream from the head of Nueces Bay. The location offers a commanding view of the broad floodplain to the north and, under prehistoric grassland conditions, also would have commanded a good view of the surrounding uplands in other directions.

Shells of the brackish water clams, *Rangia cuneata* and *Rangia flexuosa*, and chert debitage are scattered over the entire hilltop, indicating that, at one time or another, prehistoric human activity extended over every part of the rise.

Much of the site remains intact, but a significant amount of it has been damaged (Figure 3). The roadcut of an unimproved dirt road crosses (roughly north-south)

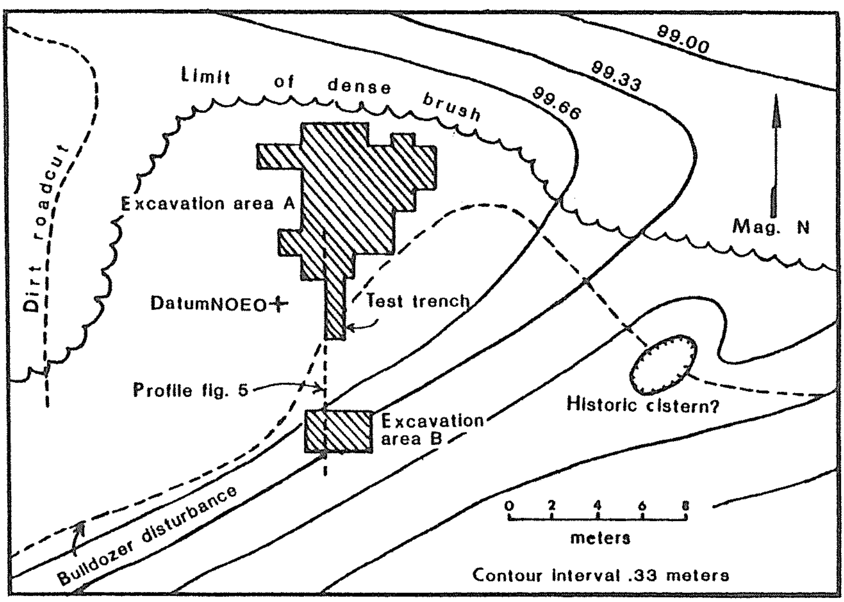

Figure 3. Topographic map showing excavated parts of the McKinzie site.

the site at its eastern end, and a similar, though presently unused, north-south cut crosses the approximate center of the site. An area of about 1 hectare (2 acres) of the southeastern part of the site was severely disturbed by soil removal in February 1984. This activity exposed an extensive spread of *Rangia flexuosa* clamshell, which, as will be indicated, was deposited during an Archaic occupation of the site.

According to Robert McKinzie (personal communication), the original McKinzie family homestead was on the crest of the hilltop, near the easternmost end of the site, from the nineteenth century to about 1930. Though this homestead is no longer standing, evidence of its existence survives in the form of various metal, glass, and ceramic artifacts of the period, especially in the roadcut at the east end of the site. Though more thinly scattered, such items were noted on the surface near the excavations, and a few fragments of clear bottle glass, some square and round nails, and pieces of fence wire were recovered at depths of as much as 10 cm in the excavations. A circular depression about 1 meter deep and 5 meters in diameter may be the remains of a cistern said to have been associated with the McKinzie homestead.

The several disturbances to the site have revealed a soil profile characterized by an A horizon (roughly 50 cm thick) consisting of a dark brown sandy clay loam and a tan sandy clay B horizon. This is typical of the Willacy complex, a neutral-to-alkaline soil that characterizes the edge of the Pleistocene terrace on which the site lies (Franki et al.1960).

The vegetation cover on most of the site, and on the surrounding upland terrace, is dominated by dense thornbrush of mesquite and hackberry and ground cover of short grasses. Directly north of the site the floodplain is treeless, except for a narrow zone along the river banks. Short grasses interspersed with barren sand patches characterize the present floodplain.

Initial Reconnaissance and Testing

The first visit to the site was made in late May 1984, when the southeastern part, which had been stripped largely of topsoil during the previous February, was still exposed. Vegetation cover had not yet been reestablished due to drought conditions. Many *Rangia flexuosa* shells and occasional chert flakes were on or close to the recently exposed subsoil. In the northernmost edge of the exposed area, near the crest of the hill, a bulldozer had cut through the original soil profile to reveal a dense lens of *Rangia flexuosa* shell, some 10 to 15 cm thick, which seemed to be concentrated particularly in the area later selected as excavation area B. Exposed within this shell lens were several chert flakes, marine fish otoliths, and, in addition to the profuse *Rangia flexuosa*, a scattering of oyster shell fragments.

The dense thornbrush covering the crest of the hill made a thorough surface survey impossible, but the general pattern of distribution of cultural debris was obtained by careful examination of the ground surface along the various dirt roadcuts. Scattered Late Prehistoric material—small sandy paste potsherds and lithic debitage—was noted only where the roadcut cut across the crest of the hill. Careful examination of the exposed areas on the hill to the south of the crest produced no such material, suggesting that Late Prehistoric occupation was restricted largely to a strip along the crest of the hill. In the areas of shallow disturbance along the crest that produced Late Prehistoric material, most of the visible shell debris was of the species *Rangia cuneata*. On the other hand, the dense *Rangia flexuosa* lens, which was initially inferred to have originated during an earlier Archaic occupation because of the apparent absence of pottery, contained no *cuneata*.

So intial observations suggested that McKinzie was a multicomponent site with (1) a preceramic Archaic component associated with a zone of *Rangia flexuosa* midden, and (2) a Late Prehistoric component, the remains of which apparently were in the upper part of the loam topsoil, primarily along the crest of the hill. Although the Archaic component appeared to be associated with *Rangia flexuosa*, it seemed that the Late Prehistoric component was associated mainly with *Rangia cuneata*, an inference later verified by excavation.

In order to test the validity of these inferences and to ascertain the degree to which the components might be stratigraphically discrete, a 1-meter square test unit was staked out near the crest of the hill within what would later be disignated excavation area A. This unit was troweled in 10-cm arbitrary levels, and all soil was put through a quarter-inch mesh screen.

Below about the top 2 cm of loose, windblown sandy soil containing grass rootlets, four zones were defined in the test unit, numbered here from the top down.

Zone I (2-10 cm)

A dark brown sandy clay loam containing relatively abundant cultural material, including 22 pieces of chert debitage, a sandstone milling stone fragment, and a small sherd of sandy paste pottery with asphaltum coating the interior surface; scattered bits of orange burned soil and gray-white ash, mostly between 7 and 10 cm, also scattered *Rangia* shells and fragments, mostly *Rangia cuneata*. The small sherd of sandy paste pottery suggested a Late Prehistoric occupation. Distinguished from Zone II by soil differences and relatively abundant cultural material.

Zone II (10 to 37-40 cm)

Dark brown sandy clay loam containing scattered fragments and occasional complete valves of *Rangia flexuosa* and *cuneata*, occasional land snail shells, and very little lithic debitage (eight pieces from level 2; four from level 3, and six from level 4); has no ash and burned soil; a discrete, homogeneous stratum.

Zone III (37-40 and 50-55 cm)

Lying on the sterile tan B horizon Pleistocene clay was a profusion of *Rangia flexuosa* (but no *Rangia cuneata*), encountered throughout the unit between 37 and 40 cm and extending to the 50 to 55 cm depth—a 10–to–15-cm-thick shell midden stratum (Figure 5) from which forty-four pieces of chert debitage and a Catan dart point were recovered; zone also had a scattering of oyster shells and marine fish otoliths and relatively abundant lithic material; near base, dark loam soil became mottled with clay particles, grading into the Zone IV clay below (Fig. 4-6, 9, & 10).

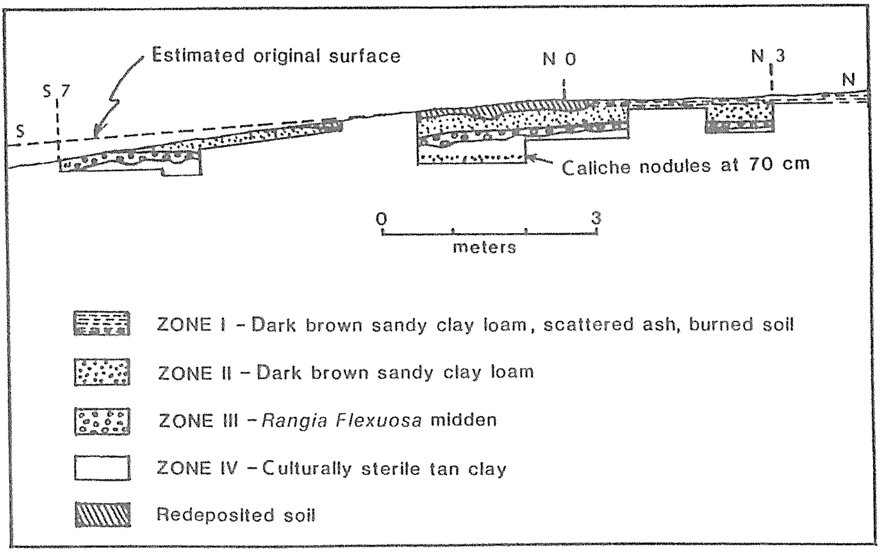

Figure 4. North-south profile along grid line E1, McKinzie site excavation.

Zone IV (below 50-55 cm)

Culturally sterile tan Pleistocene clay.

THE EXCAVATIONS

Initial impressions from the excavation of the test unit (later integrated into the area A excavation as unit N2E0) suggested that this part of the McKinzie site had a considerable potential to yield data. The narrow vertical distribution of cultural material, ash, and burned soil in Zone I suggested a discrete Late Prehistoric component, possibly representing no more than a single occupational episode. (Figures 5-8).The dearth of information on intrasite patterning in the Coastal Bend area has imposed severe limitations on archeological interpretations of prehistoric adaptations, and the possibility of obtaining such information from a Late Prehistoric component was an incentive to conduct further excavation at McKinzie. The shallow depth of the Zone I deposit meant that exposure of Late Prehistoric features and associated patterns of cultrual debris distribution would be relatively easy.

Zone II appeared to have little potential for data recovery, due to the dearth of cultural material there.

The potential of zone III, however, seemed to be sufficient to warrant further work. The zone was vertically discrete and appeared to correspond to the lens of dense *Rangia flexuosa* shell observed along the northern edge of the bulldozer disturbance (Figures 9, 10, 11), suggesting a stratum of considerable horizontal extent. If diagnostic material and a series of radiocarbon dates could be recovered from Zone III, a step could be taken toward filling the chronological void in the archeological record for the Archaic in the Coastal Bend.

Figure 5. Excavation unit N2E0 (excavated to Zone IV). Zone III *Rangia flexuosa* midden is clearly visible.

Figure 6. Test trench, looking south. *Rangia flexuosa* shells in Zone III are visible in trench walls.

Figure 7. Excavation of Zone I in progress. Arrows (lower right) show thickness of deposit bearing Late Prehistoric materials. Looking northeast.

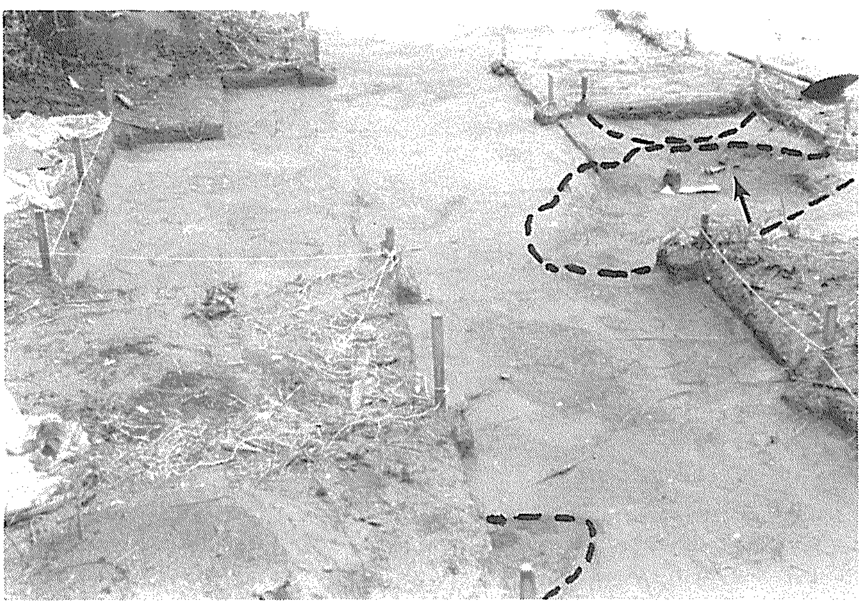

Figure 8. Northern part of Zone I excavation, looking east, showing Features 7, 6, and 5. Arrow in Feature 6 points to cluster of bison bone fragments in situ.

Figure 9. Excavation area B looking northwest. Note patchiness of *Rangia flexuosa* concentration resulting from the undulations in the base of Zone III.

Figure 10. Profile along north wall of Area B excavation. Zone III *Rangia flexuosa* midden and undulating base of this zone are clearly visible.

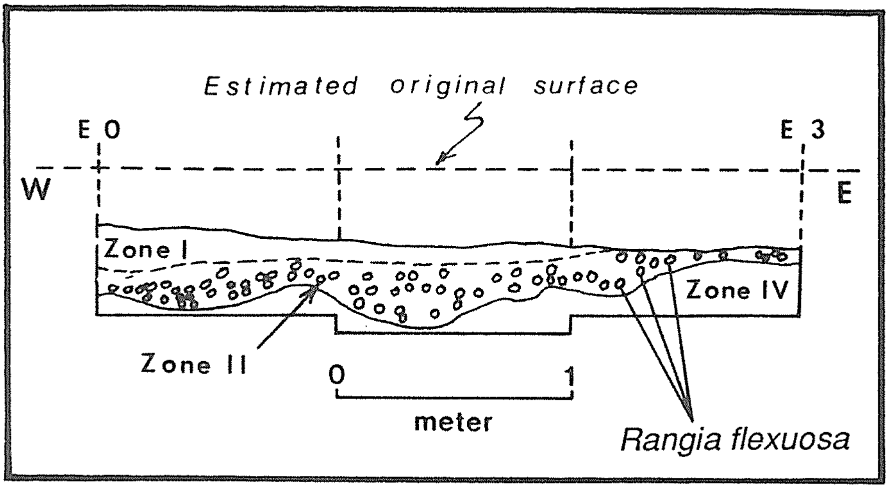

Figure 11. Sketch of profile shown in Figure 10. Ground surface before bulldozer disturbance is extrapolated from undisturbed surfaces in nearby areas.

With these goals in mind, two areas were selected for further excavation (Figure 3). From a datum stake designated N0E0 a magnetic north-south base line was established with the aid a transit, and a contour map was prepared with a contour interval of .333 meters. The datum point N0E0 was arbitrarily assigned the elevation of 100.00 meters.

With the north-south base line as a guide, excavation areas A and B (Figure 3) were staked out in a 1-meter grid. The ground surface at point N0E0 was the vertical datum; the elevations of the existing ground surface were determined and recorded for each 1-meter unit.

The general procedure followed during the excavation of areas A and B was to remove soil in about 1-cm increments within 10-cm arbitrary levels. Vertical and horizontal positions of all artifacts, including lithic debitage and bone fragments, were recorded on unit/level data sheets. Because of the large quantities involved, shell debris was identified by species, counted and recorded by unit level. All soil was put through quarter-inch screens. The use of eighth-inch screen was considered and rejected; the sandy clay loam, which tended to crumble into hard lumps when dry and to be sticky when moist, would have caused considerable difficulty in using such a fine mesh.

Thirty-three and a half 1-meter units were excavated in area A (Figure 12). Of these, 26.5 were excavated to a depth of only 10 cm, i.e., to the base of the Late Prehistoric Zone I deposit. Time allowed the excavation of three of the remaining seven units through the base of Zone III to depths ranging between 45 and 55 cm. These units included the original test unit, N2E0, and two adjacent units, N2W1 and N2E1. Four units were excavated to 15 cm as a test to confirm that Late Prehistoric material was contained within the upper 10 cm of the deposit.

Excavation area B was established in an area where the Zone III *Rangia*

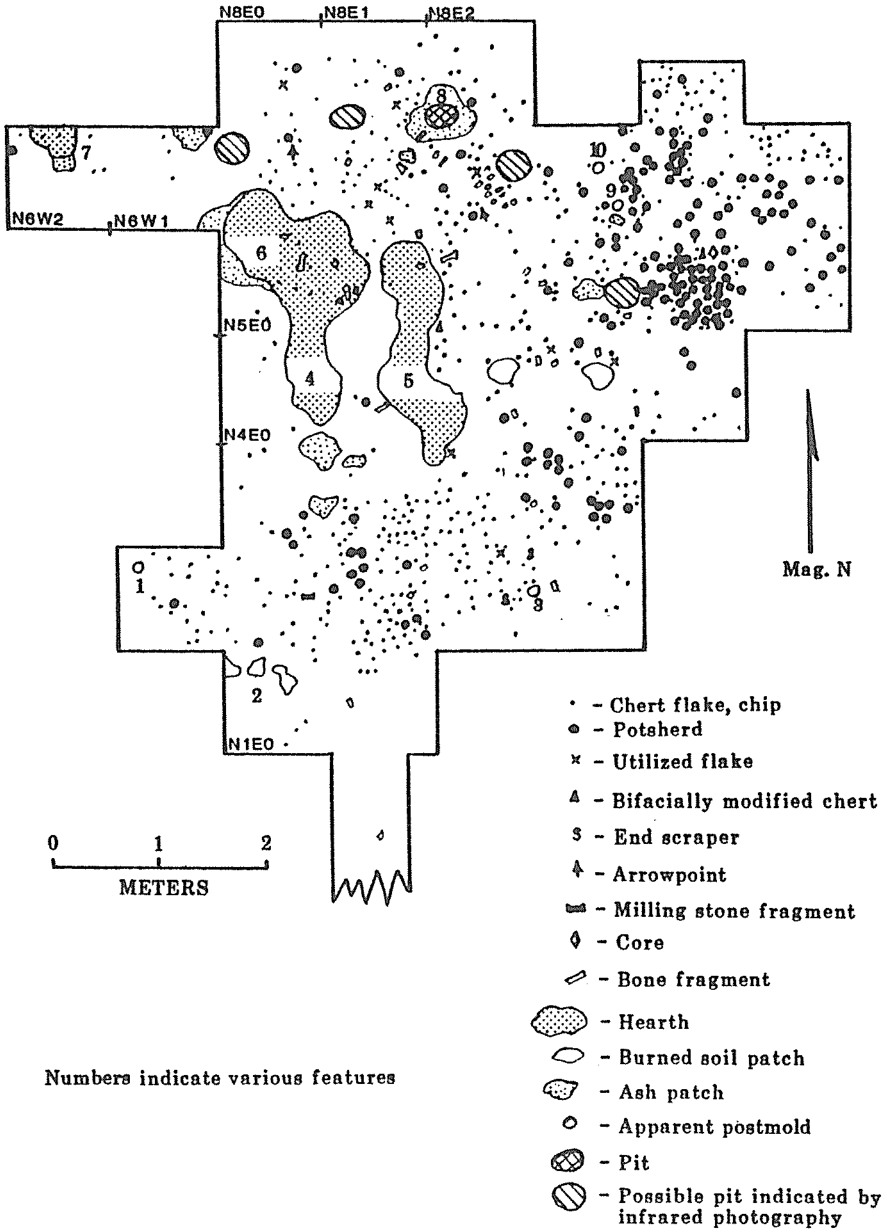

Figure 12. Plan of excavation area A showing features, bone fragments, and artifacts in Zone I.

flexuosa midden was partially uncovered by the soil-stripping activity of February 1984. The bulldozer had removed all or part of the natural soil overburden, allowing ready access to the Zone III midden. Six units were excavated, again in 10-cm arbitrary levels. Though a slight slope in the original surface upon which Zone III lay was noted as excavation proceeded, horizontal unit levels were maintained throughout the area. By using the profiles made of each unit wall in combination with the recorded depths for all cultural material, it was possible to reconstruct accurately a stratigraphic picture of Zone III and its contents.

It was assumed that the shell stratum in excavation area B corresponded to the one encountered in the test area, area A (unit N2E0) (Figure 5). A north-south test trench (Figure 6), 3 meters long by 70 cm wide, excavated between areas A and B made it possible to evaluate the degree of stratigraphic continuity between the two areas. Excavation here was with spades, though trowels were used to smooth out the trench walls, and all soil was screened by 10-cm levels.

The progress of the excavations was recorded on 35 mm color slides and black and white photographs. Upon completion, the excavations were backfilled and the datum at point N0E0 was replaced with a stout steel pipe set in concrete for possible future reference.

ARTIFACTS

Zone III

Lithic

Dart Points (4 Specimens)

Four dart points were recovered from Zone III. A stemmed dart point of the Bell type (Turner and Hester 1985:72) was recovered from excavation area B (Figure 13, A).Both of the heavy barbs diagnostic of the type are broken off on this specimen. The point has short, parallel, retouch flaking on both surfaces of both blade edges, a common characteristic of Bell points (Elton Prewitt, personal communication). Wide, shallow basal thinning flake scars extend to the medial section of the point. The material is a fine-grained dark gray chert, and the workmanship is excellent. Dimensions are length, 35 mm; maximum width (estimated with barbs present), 32 mm; thickness, 5.7 mm.

A small unstemmed dart point (Figure 13, B) recovered from the initial test unit N2E0 conforms morphologically to the Catan type (Suhm and Jelks 1962:172, Turner and Hester 1985:78). Edges have precise pressure flaking but no alternate beveling. The material is fine-grained dark brown chert, and workmanship is excellent. Dimensions are length, 31 mm; maximum width, 20 mm; maximum thickness, 6.3 mm.

A small, triangular dart point (Fig. 13,C) with convex base and slightly convex edges was recovered from excavation area B. This point does not conform well to any established type, though it resembles most closely certain illustrated examples of the Catan type (see Suhm and Jelks 1962, plate 88, C and D; Turner and Hester 1985, lower left specimen on page 78). Broad shallow basal flake scars extend to the point's midsection. There is no alternate beveling of the blade edges. Dimensions are: length, 32 mm; maximum width, 22 mm; maximum thickness, 5.4 mm.

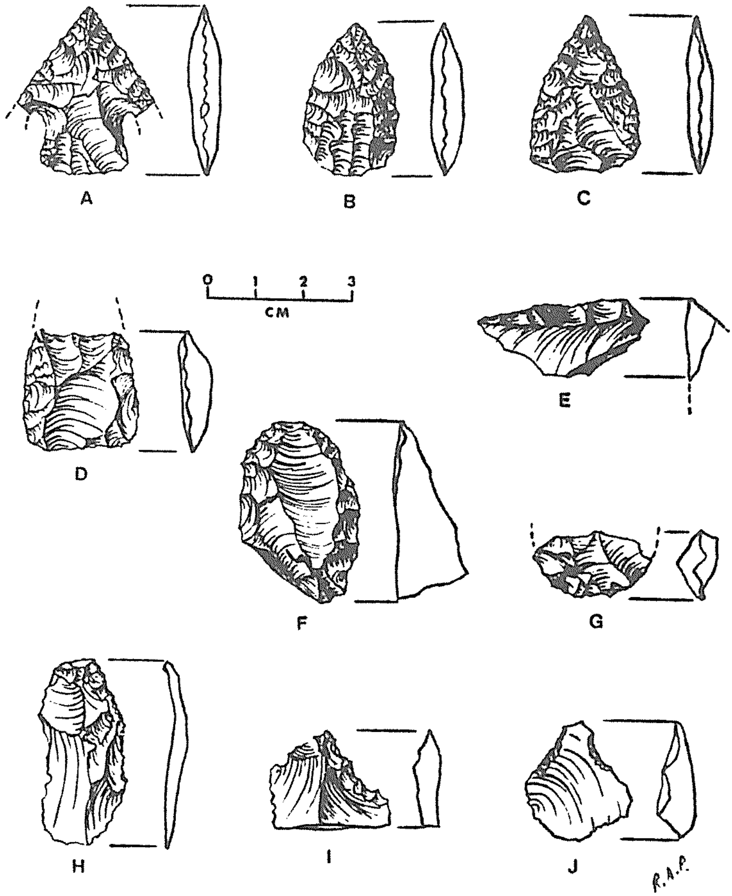

Figure 13. Drawings of lithic artifacts, Zone III. A, Bell dart point; B, Catan dart point; C, Catan-like dart point; D, Tortugas dart point with medial break reworked to gougelike edge; E, probable distal end fragment of Clear Fork tool; F, end scraper; G, biface fragment; H-J, utilized flakes.

A triangular dart point with a medial break reworked into a gougelike edge (Figure 13, D) was recovered from the surface of the exposed Zone III shell midden 40 cm east of excavation area B, unit S6E2. Though a surface find, the context is certain, since the point was securely embedded in the compact Zone III matrix. The point has broad basal thinning flake scars and marked alternate edge beveling, conforming well to the Tortugas type (Suhm and Jelks 1962:249; Turner and Hester 1985:152). The material is a tan, moderately fine grained chert; the workmanship is good. Dimensions are maximum width. 23.6 mm; maximum thickness, 7.3 mm.

Scrapers (2 Specimens)

A thick unifacial specimen of gray chert has flaked beveling on the end and on one side (Figure 13, F). The edge angle ranges between 48° and 63°. Dimensions are length, 39 mm; maximum width, 25 mm; maximum thickness, 17 mm. This specimen was found on the exposed surface of the *Rangia flexuosa* midden, so its association with Zone III is open to question.

A fragment of a large flake with fine-flaked edge beveling was excavated from unit S7E2 in area B. The material is light gray, medium-fine-grained chert. The edge angle is 56°.

Probable Clear Fork Tool Fragment (1 Specimen)

This unifacial artifact (Figure 13, E) of moderately fine grained gray chert was recovered from Zone III in the test trench. The inferred dorsal face has a slightly convex flaked edge that is at a 56° angle to the unflaked ventral face. Minute flakes along the inferred working edge indicate edge crushing resulting from usage.

Biface Fragment (1 Specimen)

This specimen is of moderately fine grained tan chert. It is roughly percussion flaked and is possibly a preform fragment.

Utilized Flakes (10 Specimens)

Ten utilized flakes were recovered from the Zone III excavation (Figure 13, H-J). Three were found in area A, unit N2E0, one was found in the test trench, and the remainder were scattered throughout the area B excavation. Four specimens have use-wear along two edges, and one has concave use-worn edges (Figure 13, J).

Obsidian Flake (1 Specimen)

A single very small flake of gray-brown obsidian was recovered from unit S7E1, excavation area B. This specimen is roughly circular and has a distinct bulb of percussion. Diameter is 6-7 mm, and maximum thickness is 0.7 mm.

Chert Debitage (233 Specimens)

In all, 233 pieces of chert debitage were found in the Zone III excavations. No patterning was seen in the distribution of this material. All specimens are slightly to moderately patinated, as are all of the chert artifacts described above. One hundred twenty-eight pieces are complete flakes; the sample comprises seven (5 percent) primary (cortex) flakes, 15 (12 percent) secondary (secondary cortex) flakes, 47 (37 percent) tertiary (interior) flakes, and 59 (46 percent) biface-thinning (lipped) flakes.

One hundred five specimens are either fragmentary flakes (i.e., proximal end is missing) or amorphous chunks of shattered chert. Of the 95 flake fragments, eight (8.5 percent) are primary, 16 (17 percent) are secondary, and 71 (74.5 percent) are interior flakes.

The presence of the primary and secondary cortex flakes indicates that primary reduction of chert cobbles was taking place on the site, despite the absense of lithic resources in the vicinity. The source of the lithic material is not known, but a recent paper by C. K. Chandler (1984) describes abundant chert cobbles along the banks of the Nueces River some 20 km upstream from the site. This is the nearest known

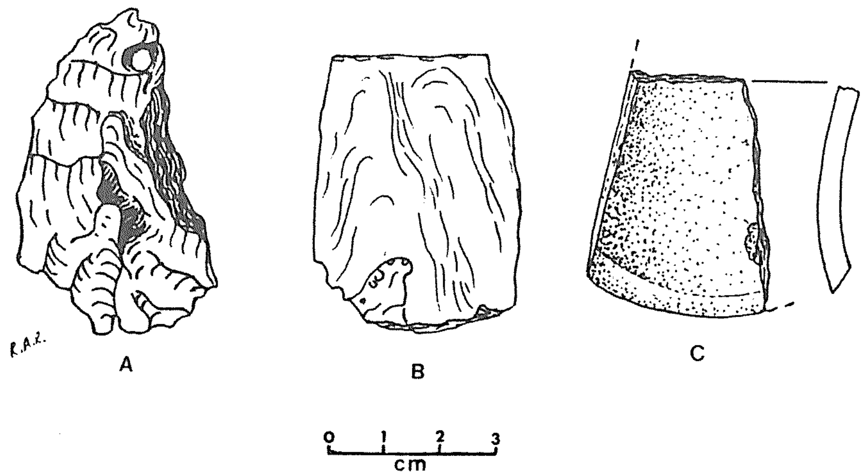

Figure 14. Drawings of shell artifacts: A, artificially perforated oyster shell from Zone III; B, shaped oyster shell from Zone III; C, conch shell adze fragment from Zone II.

source of workable chert.

The rather high proportion of biface thinning flakes in the Zone III sample indicates some emphasis on bifacial tool production during this period of the site's occupation.

Shell (2 Specimens)

A complete oyster shell valve (Figure 14, A) has an artificial perforation 4.6 mm in diameter near the umbo. The function of the artifact is unknown, but Campbell (1958a) has suggested that perforated oyster shells may have served as net weights.

A single fragment of oyster shell (Figure 14, B) is unique in that it appears to have been modified to a rectangular shape.

Zone II

Lithic (47 Specimens)

The only lithic artifacts from Zone II are a few pieces of chert debitage scattered, apparently at random, throughout the zone. Of the 47 pieces recovered, 31 are complete flakes, 2 (7 percent) of which are primary flakes, 6 (19 percent) are secondary, 14 (45 percent) are tertiary, and 9 (29 percent) are biface-thinning flakes.

Shell (2 Specimens)

A small fragment of sunray venus (*Macrocallista*) clamshell with edge flaking is similar to many reported from the Corpus Christi Bay area.

A fragment of conch shell adze (Figure 14, C), a commonly reported artifact from the Archaic sites in the Coastal Bend area (e.g. Campbell 1947, 1952, Mokry 1980), was found in the test trench, level 2 (10-20 cm).

Zone I

Lithic

Arrowpoints (3 Specimens)

Two arrowpoints are identifiable as the Perdiz type. One specimen (Figure 15, B), recovered from unit N6E2, excavation area A, is unifacially flaked, except for the contracting bifacially flaked stem. The shoulders on this point are barbed, though one barb is broken off. The blade edges are serrated. Material is fine-grained brown chert. Maximum thickness is 1.8 mm.

The second Perdiz type arrowpoint (Figure 15, A) is a surface find from the roadcut at the east end of the hilltop. Though not from the Zone I excavation, it clearly comes from the Late Prehistoric, so it is described here. It is unifacially worked except on the contracting stem, which is bifacially pressure flaked; the blade edges are serrated. Material is light brown chert, moderately fine grained. Dimensions are length, 31 mm; maximum width, 23 mm; maximum thickness, 3.2 mm.

A third specimen (Figure 15, C), recovered from unit N6E0, apparently is the distal end of a unifacial arrowpoint with serrated blade edges. It is made from moderately fine grained brown chert.

Bifacially Modified Chert (2 Specimens)

One of the two specimens of bifacially worked chert recovered from Zone I (Figure 15, E) is the distal end of an alternately beveled tool, possibly a knife or a dart point recovered from unit N5E2, excavation area A. The material is a rather coarse-grained chertlike moderately patinated purple stone, unique to the site. Maximum thickness of this fragment is 8 mm.

The second specimen, recovered from unit N5E4, excavation area A, is a relatively large secondary cortex flake of moderately fine grained brown chert (Figure 15, D) that has been bifacially edge flaked to produce a triangular form. Absence of edge pressure flaking suggests an unfinished tool, possibly an arrow-point preform. Dimensions are length 38 mm; maximum width, 28 mm; maximum thickness, 6 mm.

End Scraper (1 Specimen)

A unifacial secondary cortex flake of reddish brown chert (Figure 15, F), recovered from unit N2E3, excavation area A, has a beveled end created by a series of fine pressure flake removals. The edge angle is 68°. Dimensions are length, 28 mm; maximum width, 29 mm; thickness, 6.7 mm.

Prismatic Blades (12 Specimens)

Seven complete and five fragmentary small prismatic blades (Table 1; Figure

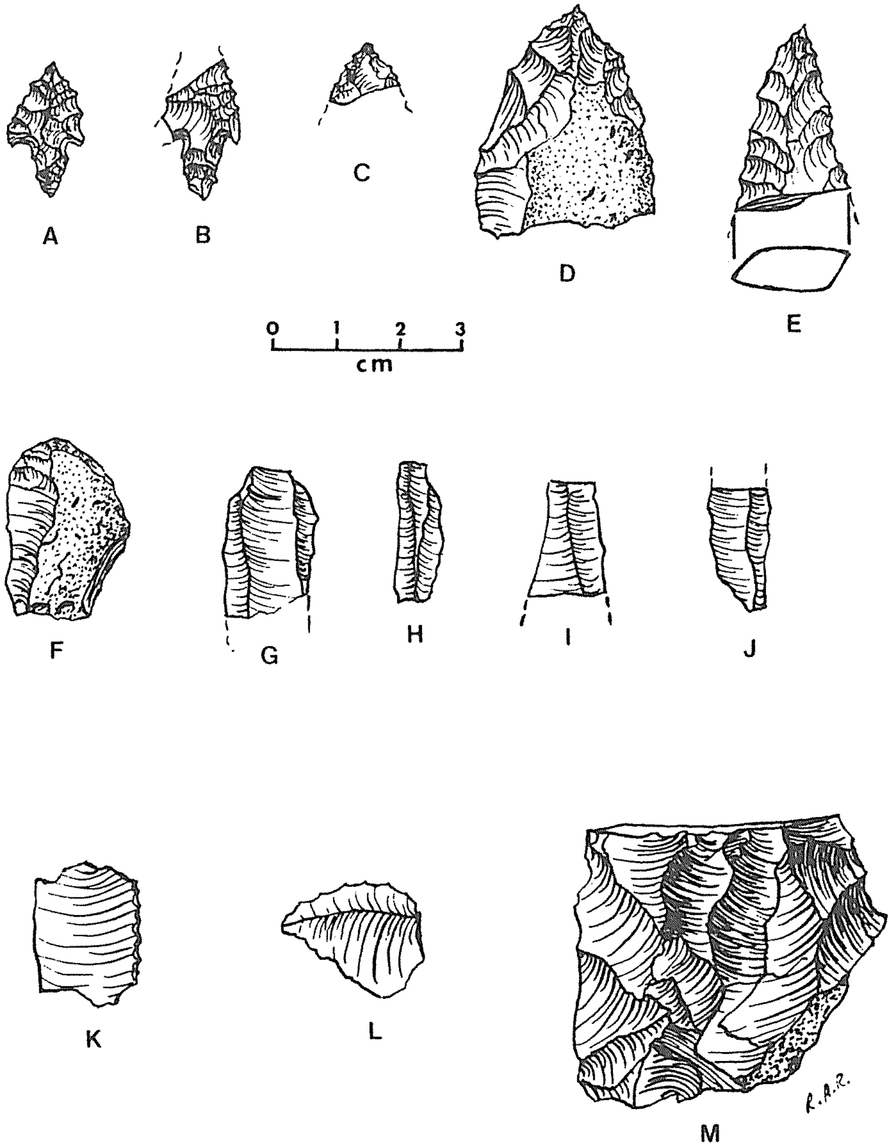

Figure 15. Drawings of lithic artifacts. All are from Zone I excavation except A, which is from the surface east of area A excavation. A-B, Perdiz arrowpoints; C, Distal end of unifacial arrowpoint; D, biface; possibly arrowpoint preform; E, distal end of alternately beveled biface; F, unifacfial end scraper; G-J, small prismatic blades; K-L, utilized flakes; M, prepared platform core.

15, G-J) were recovered from zone I. All are manufactured from moderately fine to fine-grained chert of various shades of brown.

Table 1. Dimensions of Complete Small Prismatic Blades from Zone 1

Length mm	Maximum Width mm	Maximum Thickness mm
28.5	20.0	2.5
29.0	13.0	3.5
24.0	14.0	3.7
23.6	10.7	3.4
22.5	12.8	2.8
20.0	9.2	2.3
14.7	4.6	1.7

Utilized Flakes (12 Specimens)

Twelve utilized flakes were recovered from zone I (Figure 15, K, L). Six specimens are secondary cortex flakes and six are interior flakes. The material is a moderately coarse to fine-grained chert. Ten are of various shades of brown, one is light yellow-tan, and one is light gray. All are quite small; the largest is 35 by 28 mm.

Core (1 Specimen)

Only one core (Figure 15, M) was found in the Zone I excavation. The specimen, from unit N5E4, is of reddish brown, moderately fine grained chert and retains cortex on about five percent of its surface. Flakes have been struck from both a flat, prepared platform and the lateral edge of the cobble. Dimensions are length, 45 mm; width, 50 mm; maximum thickness, 24 mm.

Quartzite Chip (1 Specimen)

A small chip of hard, fine-grained purple quartzite, recovered from unit N6E1, has minute pitting on its exterior surface. It is probably a chip from a hammerstone, since cobbles of this material often served as hammerstones in southern Texas (e.g. Hester and Hill 1972).

Debitage (596 Specimens)

Five hundred ninety–six flakes, flake fragments, and chert chunks were found in Zone I. Because color variation within cobbles makes it impossible to determine which cobble the flakes came from, it is difficult to determine how many cobbles are represented by the Zone I debitage. A wide range of shades of brown predominates in the sample, together with some reddish, light tan-yellow, and light grays. The debitage was sorted by gross color and grain characteristics into 36 groups, which probably represent at least that many cobbles. Of the total sample of 596 specimens, 275 are flakes, 293 are flake fragments, and 28 are chunks. Most flakes are quite small and, judging by the curvatures of primary flake exteriors, cobbles were generally 10 cm or less in diameter. Flakes were sorted into primary (23, or 8 percent), secondary (51, or 19 percent), tertiary (97, or 35 percent), and biface-thinning (104, or 38 percent).

The 293 flake fragments were divided into primary (20, or 7 percent), secondary (49, or 17 percent), and tertiary (224, or 76 percent).

These data clearly indicate that the Zone I occupants of the site were engaged in all phases of lithic tool production, from initial cobble reduction to biface manufacturing.

Milling Stone Fragments (2 Specimens)

Two specimens of modified sandstone, both of which have slight, relatively smooth concavities on one surface, are identified as milling stone fragments. One specimen was recovered from unit N2E0 in the Zone I excavation (Figure 16, B); the other was in apparent association with a cluster of sandy paste potsherds on a shallow dirt roadcut northwest of excavation area A (Figure 16, A).

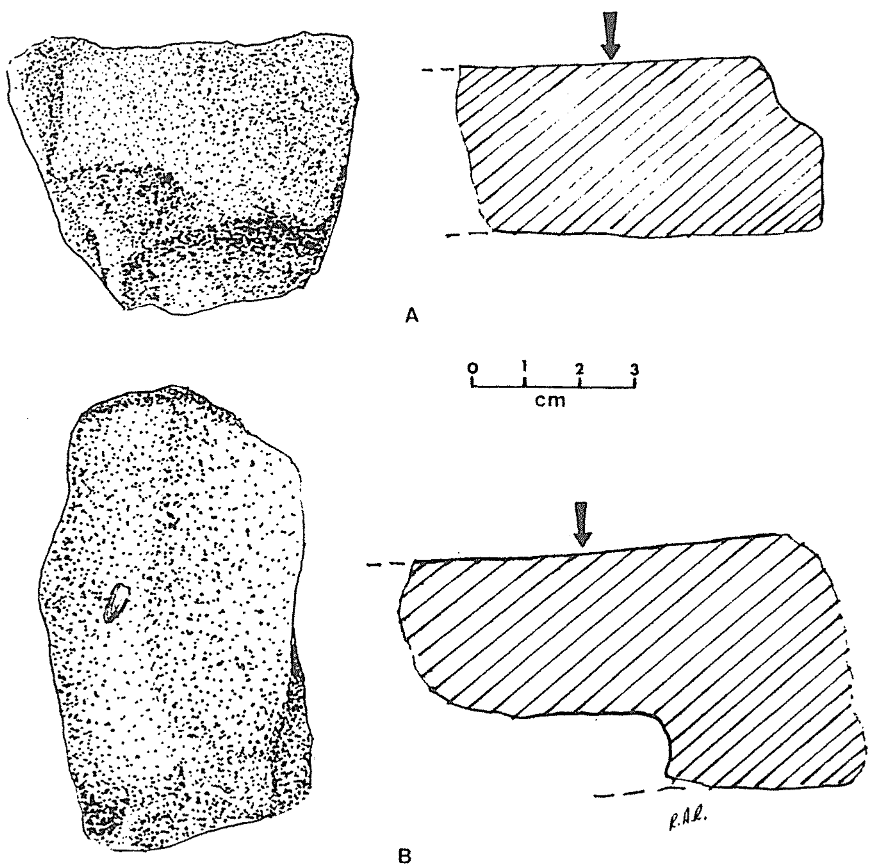

Figure 16. Drawings of milling stone fragments from Late Prehistoric contexts. A, from exposed surface in roadcut; B, from Zone I excavation. Arrows point to utilized surfaces.

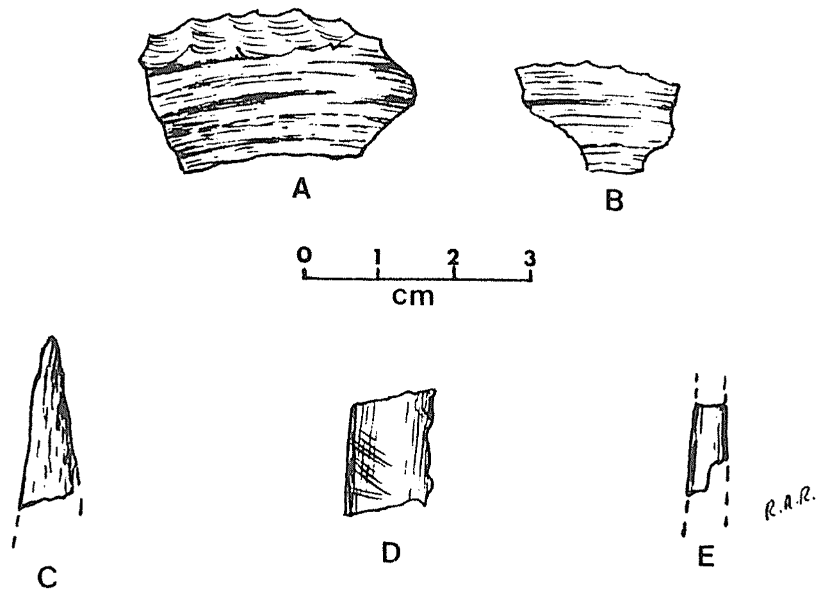

Figure 17. Drawings of shell and bone artifacts from Zone I. A-B, *Rangia cuneata* scrapers; C-E, modified bone, possibly awl fragments.

Shell (2 Specimens)

Two edge fragments of *Rangia cuneata* valves (Figure 17, A and B) from Zone I have serrated edges produced by flaking. These specimens presumably were used as scraping or cutting tools.

Modified Bone (3 Specimens)

Due to their small size (Figure 17, C-E), the original forms from which these small bone tool fragments came cannot be determined. Surface polish and minute striations on all three indicate that they could be awl fragments. Interestingly, these are the only fire-scorched bone fragments found, so it is possible that a fire-hardening technique was used in the production of bone tools.

Ceramic (197 Sherds)

In all, 197 sherds were recovered from Zone I. Except for a single bone-tempered sherd, all are of sandy paste and conform well to the Rockport ware series as defined by Suhm and Jelks (1962:131-135).

On the basis of color, paste, thickness, and surface treatment, the sherds have been sorted into the nine groups described below.

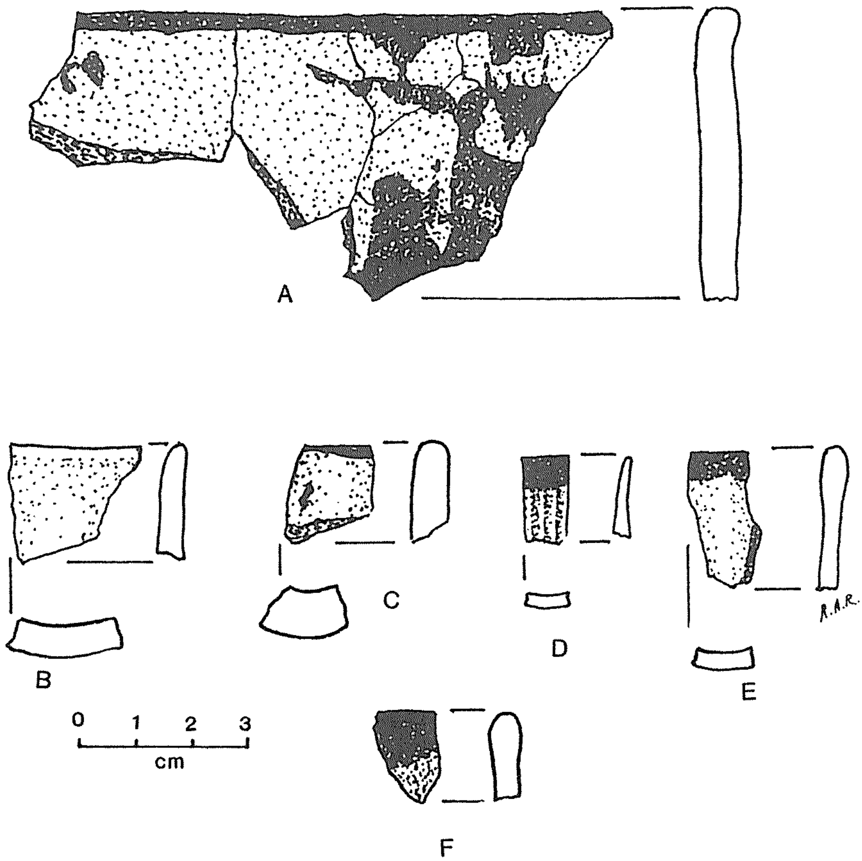

Figure 18. Drawings of rim sherds. A, Rockport Black on Gray rimsherd with asphaltum banding, from wide-mouthed vessel; B-F, Rockport Black on Gray rim sherd from small-mouthed vessels. All except B have asphaltum lip banding. B is a surface find, all others are from the Zone I excavation. Cross sections show contours of exteriors.

Group 1 (134 Sherds) (Figure 18, A and Figure 19, E)

The exteriors of these sherds are smoothed, and some have an asphaltum coating or rather amorphous decoration; interiors are smoothed. The paste consists of about 50 to 60 percent fine angular sand particles of fairly uniform size. Exteriors are gray, grading to orange on a few sherds. Interiors are orange. Close to the surface, cores have a fairly sharp gradient from the gray exteriors to the orange interiors. The sherds range between 5 and 9 mm in thickness.

Eight sherds in this group are rim sherds. All have straight rim profiles and slightly thickened lips. Rims are slightly flattened, with rounded interior and exterior lips. All have a narrow asphaltum band on the lip exterior (see Figure 18, A).

Since the sherds in Group 1 are a considerably homogeneous group they are believed, with some confidence, to come from a single vessel. Curvatures of rim,

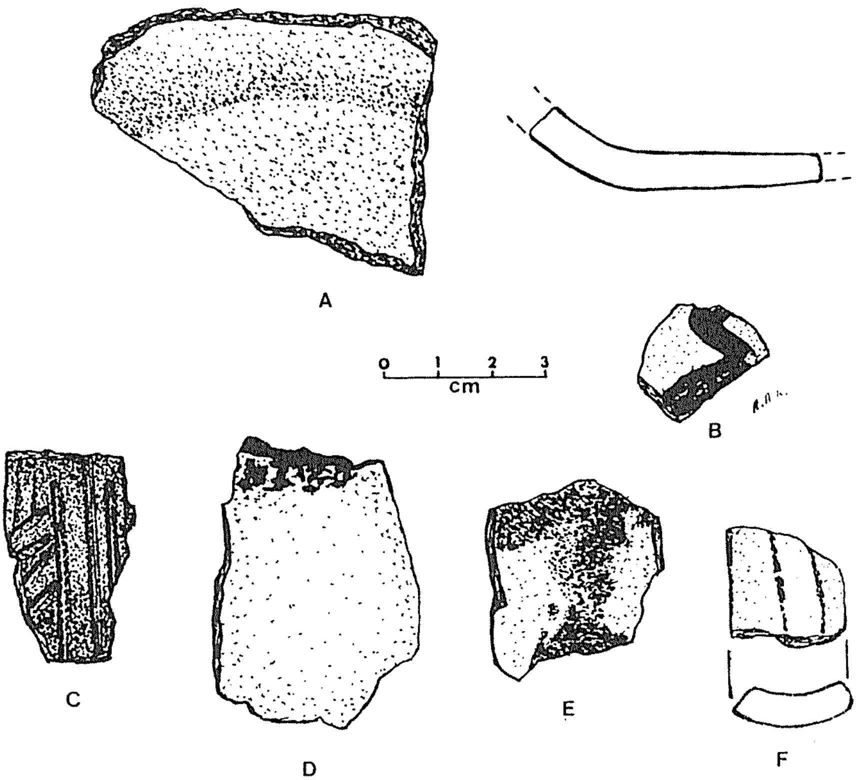

Figure 19. Drawings of sherds from Zone I excavation. A, bone-tempered basal sherd from flat-bottomed vessel; B, D, E, F, Sandy paste sherds with asphaltum decoration; C, interior of sherd with scoring and asphaltum coating.

neck, and body sherds suggest an open-mouthed, somewhat straight-necked, globular-based vessel with an oral diameter of about 25 cm. On the basis of asphaltum lip decoration, this vessel can be assigned to the Rockport Black on Gray type (Suhm and Jelks 1962: 133).

Group 2 (36 Sherds) (Figures 18, E and F, 19, C and D)

The exterior surfaces in this sherd group are smoothed. Nine sherds are scored and have asphaltum-coated interiors, and 10 sherds have interiors smoothed with asphaltum coating; the remaining sherds have plain and smoothed interiors. Except for two rim sherds that have asphaltum banding on lip exteriors, the exteriors of the sherds are without asphaltum. The paste consists of about 50 percent fine sand particles of fairly uniform size. The sherds are uniformly tan throughout, though a few are tinged with pink at the cores. Thickness of the sherds varies from 4 to 6 mm.

Both of the rim sherds in this group have straight profiles, rounded lips, and narrow asphaltum banding on lip exteriors (see Figure 18, E and F).

In view of the fact that some sherd interiors have asphaltum coating and others have none, Group 2 may represent two vessels.

Group 3 (18 Sherds)

The interiors and exteriors of sherds in this group are smoothed. Most sherds have traces of asphaltum on their exteriors. The paste consists of about 50 percent fine sand particles. Exteriors are light tan-gray, and interiors and cores are gray. Thickness ranges between 5 and 7 mm. The homogeneity of the sherds in this group suggests that they came from a single vessel.

Group 4 (3 Sherds) (Figure 18, C)

Sherds in this group are smoothed on both surfaces. One rim sherd has a narrow band of asphaltum on the lip exterior. The paste consists of about 40 percent fine sand particles. Sherd color is uniformly yellowish tan throughout. Thickness ranges between 4.5 and 6.5 mm.

The single rim sherd in Group 4 (Figure 18, C) has a straight profile and a rounded lip with a band of asphaltum on the exterior edge. On the basis of the asphaltum lip banding, this sherd can be assigned to the Rockport Black on Gray type.

Group 5 (3 Sherds) (Figure 18, D)

A thin exterior grayish white film on the sherds in this group may be a slip or a floated surface; interiors are smoothed. Paste consists of about 40 to 50 percent fine sand particles. The sherds are oxidized to an orange-pink color throughout. Thickness ranges between 3.5 and 3.7 mm.

On the exterior of the single rim sherd in the group is what appears to be smoothed-over scoring and a band of asphaltum at the lip (Figure 18, D). The asphaltum banding places this sherd in the Rockport Black on Gray type. In cross section the rim is nearly pointed and slightly everted.

The thickness, sherd curvatures, and homogeneity within the group indicate that a single very small vessel is represented.

Group 6 (1 Sherd)

Both the exterior and interior surfaces of this sherd are smooth and highly burnished. Paste consists of about 50 percent very fine sand particles. Color is very light tan throughout. Thickness is 3.6 mm.

The attributes of this sherd are distinctly different from those in other groups, indicating that it is from a separate vessel.

Group 7 (1 Sherd) (Figure 19, F)

The exterior of this sherd is smooth; the interior is smooth and slightly burnished. On the exterior surface are thin, roughly parallel vertical lines of asphaltum. Paste consists of about 50 percent fine sand particles. The interior and exterior surfaces are light tan; the core is gray. Thickness varies from 5 to 6 mm.

The curvature of this sherd indicates that it is part of the neck of a bottle. On the basis of the asphaltum decoration, the sherd can be assigned to the Rockport Black on Gray type.

Group 8 (1 Sherd)

The exterior of this sherd is smoothed; the interior is smoothed and coated with asphaltum. Paste consists of about 60 percent fine sand particles. The exterior is orange; interior and core are gray. Thickness is 4.9 mm.

Group 9 (1 Sherd) (Figure 19,A)

The exterior of this sherd is smooth and slightly burnished; the interior is roughly smoothed. Aplastics in the clay body consist of about 20 percent sand particles of variable size and 20 percent crushed bone. The exterior grades from orange to dull yellow-orange; the core and interior are gray. Thickness ranges between 5 and 7.5 mm.

This is the only sherd in the Zone I sample that does not belong in the Rockport series. The sherd most closely resembles, in paste, color, and surface treatment bone-temperd pottery reported from the interior of southern Texas (c.f. Hester and Hill 1975, 1977). This sherd clearly is from the base of a flat-bottomed vessel, a form that is not known in the central Texas coast area, and only one example of which is reported from the interior of southern Texas (Hester and Hill 1975).

Discussion

With the exception of the single sherd in Group 9, all sherds fall within the range of variability of Rockport ware. Though most sherds are small, curvatures indicate diverse vessel forms, including open-mouthed jars, narrow-necked or bottle forms, and a very small, thin vessel (Group 5) that probably was more of a cup than a pot. These vessel forms demonstrate the possibility of a variety of functions for the Zone I ceramics. It is not demonstrable, but it is reasonable to infer that the open-mouthed, fairly large jar (Group 1) was a cooking pot, and the narrow-necked forms served as water containers.

FAUNAL REMAINS

Zone III

Bone

Unfortunately, Zone III was characterized by a complete absence of bone, almost certainly the result of decay.

Shell

The density of shell debris in Zone III was considerable and supports the identification of the deposit as a shell midden (Table 2).

The *Rangia flexuosa* count is based on whole valves and umbo fragments, so halving it accurately reflects the number of clams represented in the excavated part of the zone. The other aquatic species counts, however, are based on fragments, so

Table 2. Shell Sample From Zone III

Shell	Quantity
Rangia flexuosa	12,722
Oyster	293
Angel wing *(Crytopleura costata)*	15
Mussel *(Ischadium recurvum)*	6
Cockle *(Laevicardium robustum)*	3
Marginella	1
Marsh periwinkle *(Littorina irrorata)*	1
Land snail *(Rabdotus sp.)*	239

the number of animals represented is somewhat less than the number in Table 2. Clearly it can be concluded, however, that *Rangia flexuosa* was the significant shellfish resource exploited by the Zone III occupants of the site and that oysters played a very minor subsistence role.

The count of *Rabdotus* land snails is based on complete shells. Occasionally, the smaller *Polygyra* and *Helicina* land snails were encountered, but these shells were extremely fragile and disintegrated under the trowel. It is unclear whether the *Rabdotus* snails were gathered for food, since the species is adapted to a terrestrial habitat and the recovered specimens may represent natural deaths within the population. This seems a reasonable conclusion, since these shells were not particularly abundant in the midden. Recent *Rabdotus* shells can be seen scattered over the ground surface on, and in the vicinity of, the site.

Fish

Thirty-two marine fish otoliths were recovered from zone III (Table 3).

Table 3. Fish Otoliths Recovered From Zone III

Fish	Quantity	
Gafftop catfish *(Felicthyus felis)*	9	(28%)
Hardhead catfish *(Galeicthys milberti)*	7	(22%)
Croaker *(Micropogon undulatus)*	7	(22%)
Black drum *(Pogonias cromis)*	5	(16%)
Redfish *(Sciaenops ocellatus)*	2	(6%)
Sea trout *(Cynoscion nebulosus)*	2	(6%)

The season when marine fish died can be determined by microscopic examination of the cross sections of fish otoliths (see Casteel 1976, Smith 1983). Although the method of determination of seasonality is essentially quite simple, it can be complicated by two factors: (1) erratic growth patterns, possibly caused by abnormal fluctuations in water temperatures, can obscure annual growth bands, (2) the fish may have been too young at the time of death for the otoliths to have accumulated a sufficient number of growth bands for a reliable estimation of the width of the annuli.

So of the 32 otoliths recovered from Zone III, the season of death can be determined with a reasonable degree of confidence for only 21 (Table 4).

Table 4. Season of Death of 21 Otoliths from Zone III

Season	No.	Species	Percent of Sample
Late fall/winter	2	Gafftop catfish	
	2	Hardhead catfish	
	1	Black drum	
Total	5		23
Winter	4	Gafftop catfish	
	4	Black drum	
	2	Trout	
	2	Hardhead catfish	
	1	Redfish	
Total	13		62
Spring	1	Croaker	
Total	1		5
Summer	2	Gafftop catfish	
Total	2		10

Though the sample is not large, the distinct seasonal clustering of otoliths in the late fall-winter period strongly suggests that occupation of Zone III was primarily during that season.

Zone II

Bone

Bone in Zone II is limited to sporadic occurences of small, unidentifiable splinters, mostly in the upper part of the zone, becoming increasingly scarce with depth until they are entirely absent in the lowest part of the zone.

Shell

A scattering of land snails (*Rabdotus*, *Polygyra*, and *Helicina*) with no apparent horizontal or vertical clustering was encountered.

Both *Rangia flexuosa* and *Rangia cuneata* were present, and though these shells occurred sporadically and without the association of time-diagnostic artifacts, an interesting and probably significant pattern can be seen in the vertical distribution of the two *Rangia* species. The percentages of *Rangia flexuosa* relative to *Rangia cuneata* decrease by 10-cm levels from 100 percent in Zone III to about 27 percent in zone I (Table 5).

Table 5. Percentages of Rangia by 10–Centimeter Levels

Zone and Level		Test Trench				Unit N2E0			
		Flexuosa		Cuneata		Flexuosa		Cuneata	
		%	No.	%	No.	%	No.	%	No.
Zone I:	Level 1		9		7	28	15	72	39
Zone II:	Level 2	27	16	73	43	40	20	60	30
	Level 3	39	39	61	61	45	34	55	41
Zone III:[1]	Level 4	77	127	23	37	92	307	8	25
	Level 5	96	313	4	11	100	717	0	
	Level 6	100	257	0		100	40	0	

[1] Zone III contained only *Rangia flexuosa*. Levels 4 and 5 were primarily in Zone III, but extended slightly into Zone II.

From Table 5 it is clear that there is a shift in Zone II, where the species percentages are intermediate between Zones I and III. The apparent discrepancy in percentages per level between the test trench and unit N2E0 is due to the downsloping of the zones toward the south of the test trench (see profile, Figure 4) where the arbitrary levels were horizontal. Percentages have not been calculated for level 1 in the test trench due to the small sample size. The percentages for unit N2E0, level 1, can be regarded as reliable, since the relative percentages for the two species in the entire southern part of the area A, zone I (level 1) excavation (16 1-meter squares) are virtually identical: *flexuosa* 27.3 percent; *cuneata* 72.7 percent. The significance of these figures in a reconstruction of environmental change in the lower Nueces estuary will be discussed below.

Zone I

Bone

Bone preservation in Zone I was good, presumably due to the recentness of the occupation. In the list of fragments below, only one individual of each species is definitely represented: nineteen bison (*Bison bison*) fragments (1 radius, 9 ribs, 9 long bones); two white-tailed deer (*Odocoileus virginianus*); 22 carapace fragments from an unidentified turtle; one radio-ulna fragment from an unidentified frog; 4 long bone splinters from an unidentified bird; and 51 small unidentified bone fragments.

A tibia fragment of domestic pig, also recovered from Zone I, is in a markedly better state of preservation than the other mammal bones and is presumed to come from the historic occupation of the site.

Shell

The shells recovered from Zone I were *Rangia cuneata* (879 valves and umbos), *Rangia flexuosa* (456 valves and umbos), Oyster (*Crassostrea virginica*) (45 fragments), and Sunray venus (*Macrocallista*) (2 fragments).

It is believed that the overall representation of *Rangia flexuosa* in Zone I is somewhat greater than its actual usage by the Zone I occupants implies. Much

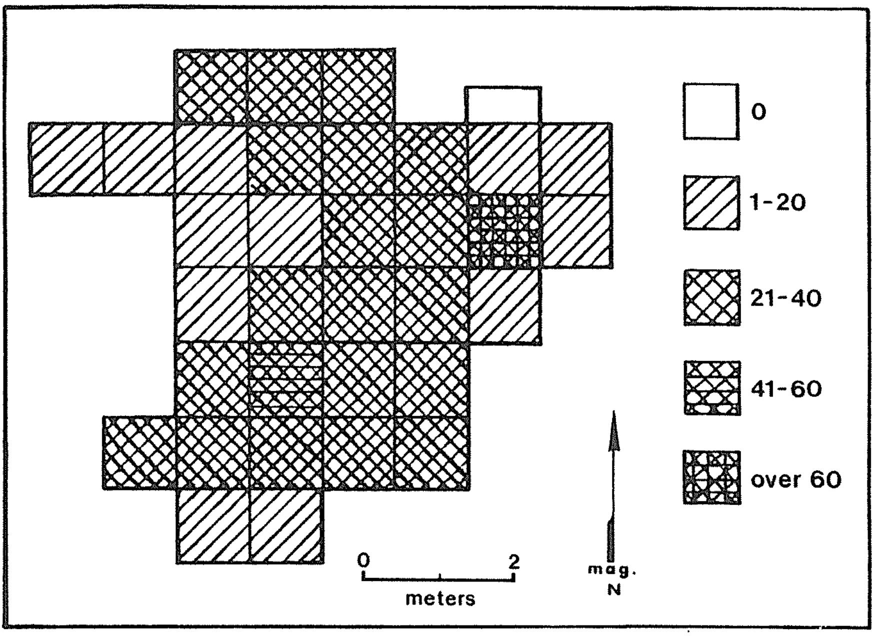

Figure 20. Plan showing occurrences of *Rangia cuneata* valves/umbos in Zone I, excavation area A.

higher numbers of this species came from the northernmost units in the Area A excavation than from elsewhere in the site. From examination of the area just to the north of the excavation it was clear that at some time soil there had been disturbed well into Zone III and that some of the Zone III soil had been redeposited onto the original surface of Zone I during the historic occupation of the site. This was most apparent in N7E4, where the top 5 to 7 cm produced more than 50 valves of *Rangia flexuosa*, but no *Rangia cuneata* and no Late Prehistoric material. Beneath the 5- to 7-cm level, however, the Zone I deposit was intact and produced the characteristic association of sandy paste potsherds with unpatinated chert debitage.

Due to this bias in the quantities of *Rangia flexuosa*, only the densities per 1–meter–square unit of *Rangia cuneata* are considered reliable. In general, the highest densities of *Rangia cuneata* occur in a roughly U-shaped band in the area A, Zone I excavation (Figure 20). The significance of this will be discussed below.

One hundred seventy-one *Rabdotus* and 67 smaller land snail shells (*Polygyra* and *Helicina*) were recorded for Zone I. As in Zones II and III, the significance of these shells is problematical, though it can be stated again that no patterning or clustering was observable in their distribution.

A sample of 77 complete *Rangia cuneata* valves was subjected to seasonality analysis, using the method developed by Lawrence Aten (1981). The McKinzie sample broke down into Aten's analytical categories as follows: Early, 27 (35 percent); Middle, 17 (22 percent); Late, 5 (6 percent); Interrupted, 17 (22 percent);

Indeterminate, 11 (15 percent).

Aten has presented a series of two-week histograms based on patterns of proportional representation of the above categories in modern *Rangia* samples from the upper and central Texas coast. So ideally, for example, a site producing *Rangia cuneata* and occupied in early April should yield a shell sample that, when broken down into the Aten's analytical categories, will conform to the two-week histogram for the period between the end of March and the middle of April.

The McKinzie sample would fit best the period from the end of April to mid-May (although this must be extrapolated from the two adjacent histograms in the sequence because this interval is one for which Aten had no sample and, therefore, no histogram. See Aten 1981:187), except for the fact that the interrupted category is much too well represented. Aten's samples show the representation of the interrupted category to be 8 percent for end of April and 4 percent for end of May, so to infer deposition of the McKinzie sample during that period would require that the interrrupted category fall around 4 to 8 percent.

Clearly the Zone I sample indicates a spring occupation in the light of Aten's histograms. But at what time during the spring, and for how long, is not clear from a glance at the histograms. Two possible explanations can be offered for the discrepancy between the McKinzie sample and Aten's histogram sequence: (1) The sample shows an overrepresentation of interrupted shells due to admixture with shells deposited during another occupation that was earlier in the year, or (2) the sample represents a single occupational episode spanning more than the two-week interval represented by each histogram.

As will be discussed below, there is a general spatial correspondence between the distribution of *Rangia cuneata* and artifacts and features in Zone I. So the *Rangia cuneata* shells recovered probably came from a single occupational episode. Working on this assumption, the discrepancy between the McKinzie sample and Aten's histograms is most economically explained by postulating that the Zone I occupation spanned a period of more than two weeks.

This postulate was tested by averaging the percentages of shells falling into the respective analytical categories (Early, Middle Late, and Interrupted) in Aten's spring histograms (the middle of March to the end of May). Since the indeterminate category is a more-or-less constant residual consisting of shells that could not be placed in any other category, it was eliminated in order to simplify comparisons. When the percentage figures for the six spring histograms were averaged, the results compared very closely with the McKinzie sample (Table 6).

These figures strongly support the inference that the McKinzie *Rangia cuneata* sample indicates an occupational episode spanning all or the better part of the period between the middle of March and the end of May. So apparently we are dealing here with something approaching a full seasonal occupation. Since Aten's histograms cannot account for possible minor differences in samples due to location or seasonal variation in any given year, attempts to make more precise estimates of the time of occupation would be of little value. In any case, for the purposes of this report, the inference of a single episode of occupation, the duration of which approximated the spring season, is adequate.

Table 6. Comparison of Aten's Spring Histograms With the McKinzie Sample

Analytical Category	Aten's Spring Histograms: Averaged Category Percentages	McKinzie Sample: Category[1] Percentages
Interrupted	27	26
Early	45	40
Middle	23	26
Late	7	8

[1] Does not include shells in the indeterminate category.

Fish

Despite reasonably good preservation of bone in zone I, only two marine fish otoliths were found—one hardhead catfish and one trout. They were found in the northern part of the excavation and may come from the thinly redeposited Zone III soil in that part of excavation area A.

FEATURES

Zone III

No cultural features were encountered in Zone III.

Zone II

Feature 6-A

A single distinct feature found in Zone II was designated Feature 6-A. The feature was in the western part of unit N5E0 in excavation area A, and, because of mottling of ashy and burned soil caused by animal burrowing between the two features, was first believed to be a downward extension of Feature 6, which was clearly a hearth associated with Zone I. Horizontal exposure of the feature surface and a cross section, however, demonstrated that Feature 6-A actually originated at about 20 to 25 cm below the modern ground surface and extended to as much as 55 cm below ground surface.

The exposed surface of the feature was roughly semicircular, and the profile was roughly U-shaped. Fill was predominantly orange burned loam soil mixed with a great deal of gray-white ash that contained only a few minute flecks of charcoal. A 5-gallon bucket of fill was water-screened through fine mesh window screening in a search for minute carbonized organic matter, but there was none. In the fill were 72 whole and fragmentary *Rangia* shells and three pieces of chert debitage.

Zone I

Hearths

Feature 4

This feature, located in units N4E0 and N4E1, originated between 7 and 10 cm below the modern ground surface. The hearth was oblong and merged with an adjacent hearth, Feature 6, in unit N5E0 to the north. It measured 37 cm east-west by about 100 cm north-south.

The fill of Feature 4 was predominantly reddish-orange burned loam with scattered ash, but no charcoal. Excavation of the fill revealed a shallow basinlike depression with a maximum depth of 16 cm.

Feature 5

This hearth originated at 7 to 9 cm below modern ground surface. It is elongated and irregular, measuring 218 cm north-south by 92 cm east-west. The fill was reddish orange burned soil mixed sporadically with brown ashy loam and gray-white ash. The fill contained no charcoal.

Removal of the fill revealed a shallow basin with a maximum depth of 11 cm. A single fragment of a large mammal long bone, probably bison, was recovered from the surface of the feature.

Feature 6

This hearth (Figure 21) originated at 8 to 10 cm below the modern ground surface in units N5E0, N5E1, N6E0 and N6E1. In plan it was an irregular oval measuring 155 by 107 cm. The fill consisted of sizeable patches of reddish-orange loam soil, gray-white ash, and dark brown ashy loam.

In the fill were several matching fragments of bison radius and three chert flakes, all in the southeastern part of the feature. A fill sample was fine water-screened for possible carbonized plant remains, but the results were negative. The screening did yield 11 minute chert flakes and a handful of very small *Rangia* fragments. Except for an occasional minute fleck, no charcoal was associated with this feature.

Feature 7

This hearth (Figure 22) was exposed at a depth of 9 to 10 cm in the northern part of unit N6W2. Only the southern part was excavated, since the feature extended into unexcavated unit N7W2. Its maximum observable dimension was 51 cm. The fill was a patchy mixture of reddish-orange burned loam, gray-white ash, and ashy brown loam, but no charcoal. The basin-shaped profile had a maximum depth of 23 cm.

Burned Loam Patches

In addition to these distinct hearths, three patches of reddish orange burned loam were noted at 7 to 10 cm below ground surface. Two were located to the east of Feature 5; the third was to the south of Feature 4 in unit N1E0 (designated Feature 2 in the field). Though these may be small, short-term hearths, their small size and shallow (1-3 cm) depth suggest scatters of burned soil, perhaps displaced from Features 4 and 5 during the Zone 1 occupation.

Ash Patches

Several patches of gray-white ash, not assigned feature numbers, were exposed

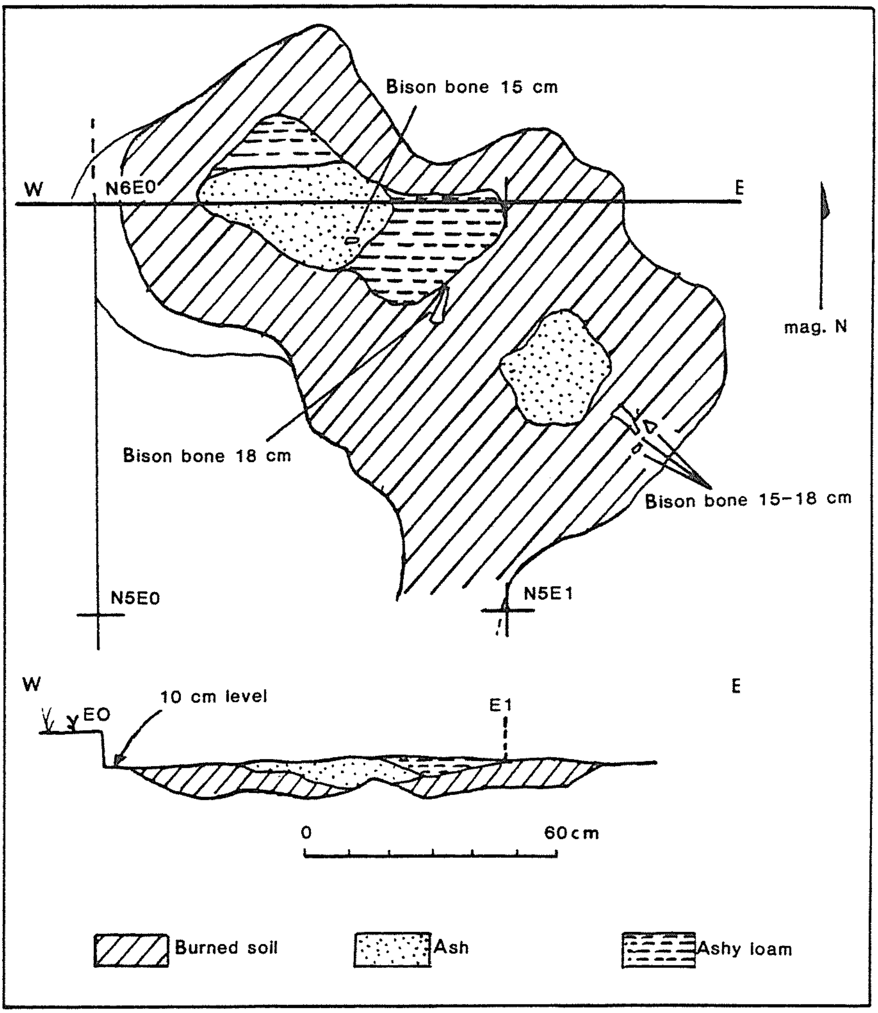

Figure 21. Plan of Feature 6, hearth in Zone I, excavation area A and west-east profile along grid line N6.

in Zone I. These are indicated on the map of the Zone I excavation (Figure 12). All were encountered between 7 and 10 cm below ground surface and ranged between 2 and 4 cm in thickness. In two instances the ash patches were adjacent to hearths (Features 6 and 7). As indicated in Figure 12, all, except for the patch next to Feature 7, were within 2 meters of Features 4, 5, and 6, and presumably are scatter from those hearths.

Pit

A small pit (Figure 23), designated Feature 8, was found in the southwestern part of unit N7E2, when, as the unit floor was brushed down at the 10-cm level, a

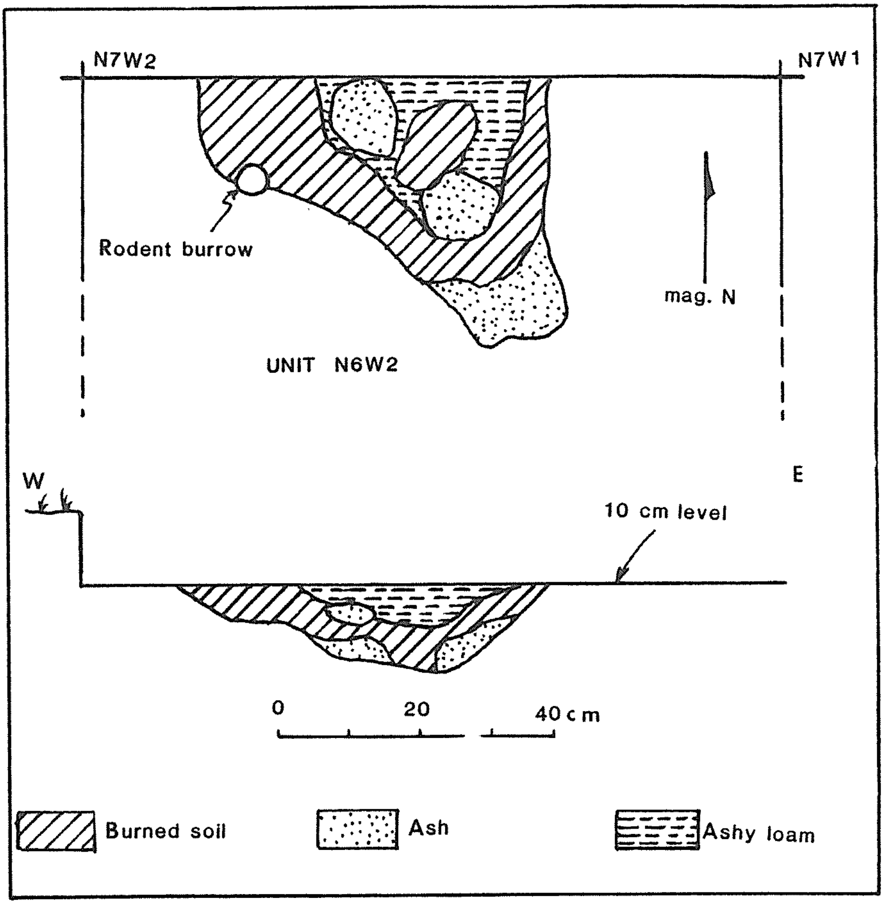

Figure 22. Plan of southern part of Feature 7 hearth in Zone I, excavation area A, and west-east profile along grid line N7.

distinctly soft, oval spot was noted in about the center of a thin patch of ash. Though first believed to be a rodent burrow, careful removal of the fill revealed a clearly oval, 32-by-21-cm U-shaped pit, as much as 18 cm deep. The soft, ashy fill contrasted markedly in texture with the compact loam matrix. No burned soil or fire-staining, which would indicate in situ burning, were seen.

In the fill were a single sandy paste potsherd (sherd Group 1) three chert flakes, and 23 small *Rangia* fragments.

Possible Pits

At the time of the excavation of the northern part of excavation area A, Zone I, infrared photographs were made of the floors of the 1-meter units at the 10-cm level. The photographs were taken from directly overhead by using a lift bucket, so it was possible to make each one cover a single excavation unit. Four dark

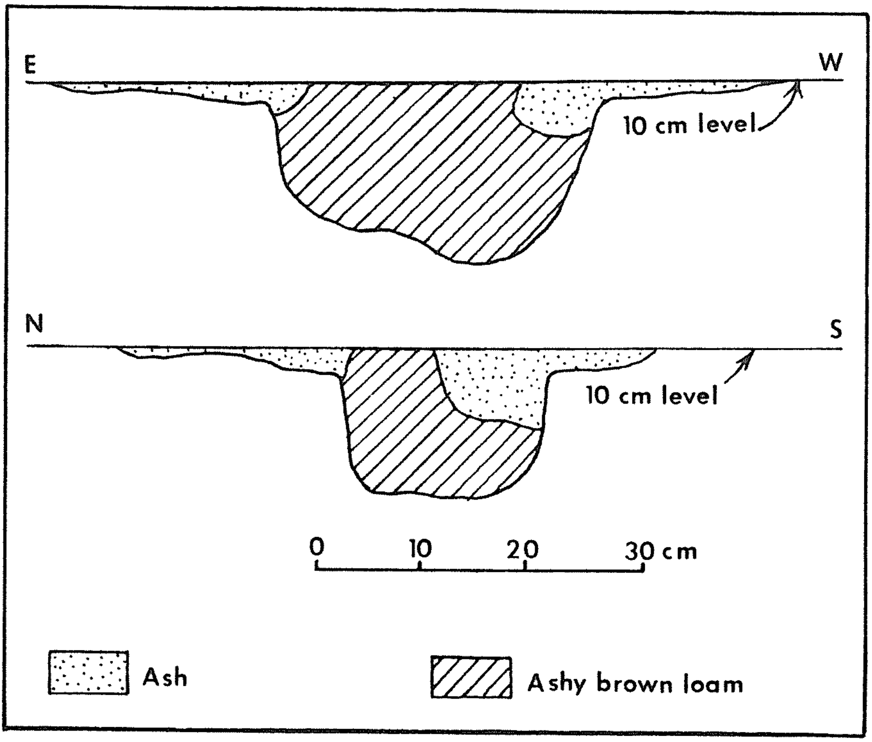

Figure 23. Cross sections through pit, Feature 8, Zone I, excavation area A.

circular spots that could not be seen from the ground were detected on the photographs (Figure 12). These spots, all about 30-35 cm in diameter, were rather evenly spaced in an arc around the hearths, Features 4, 5, and 6. It is interesting, and probably significant, that the definable pit, Feature 8, is about the same size as the spots, and its location fits into the arclike pattern. Apparently a series of small pits, including the pit, Feature 8, was arranged around the hearth area delineated by Features 4, 5, and 6.

It must be stated, however, that, after the locations of these possible pits were plotted on the field map, it was not possible, despite meticulous brushing, scraping, and probing, to find any trace of pits. During the excavation at the site, however, it was noticed that the excavated sandy clay loam, when backfilled and exposed to a few rains, returned to its original compact state.Therefore, pits that existed during the Late Prehistoric occupation had been filled with loam (without the admixture of the ash that permitted the recognition of Feature 8), it is possible that no evidence of pits could be found by ordinary field techniques.

Possible Post Molds

Four possible small post molds (Figures 24, 25, and 12) were exposed at the 10-cm level. These features could not be seen, but were felt as distinct soft spots during

Figure 24. Possible post mold, Feature 3, exposed (with fill removed) at 10-cm level, Zone I, excavation area A.

brushing of exposed, dry unit floors. More than two dozen small soft spots were recognized in this way, and all were carefully scooped out from the dried, hardened loam matrix. A few were also cross-sectioned. All but four were clearly small animal burrows, but the four possible post molds were circular in plan and bluntly conical in cross section (Figure 25).

The fill of these post molds was sandy, with little clay content, and the texture was easily distinguishable from that of the surrounding sandy clay loam. It is possible that they were the filled-in impressions of small posts that had been removed from the ground (Table 7).

Table 7. Dimensions and Depths of Possible Post Molds, Features 1, 3, 9, and 10

Feature No.	Diameter cm	Depth Below 10-cm Level cm
1	8	11
3	7.5	8
9	7.5	9
10	7	9

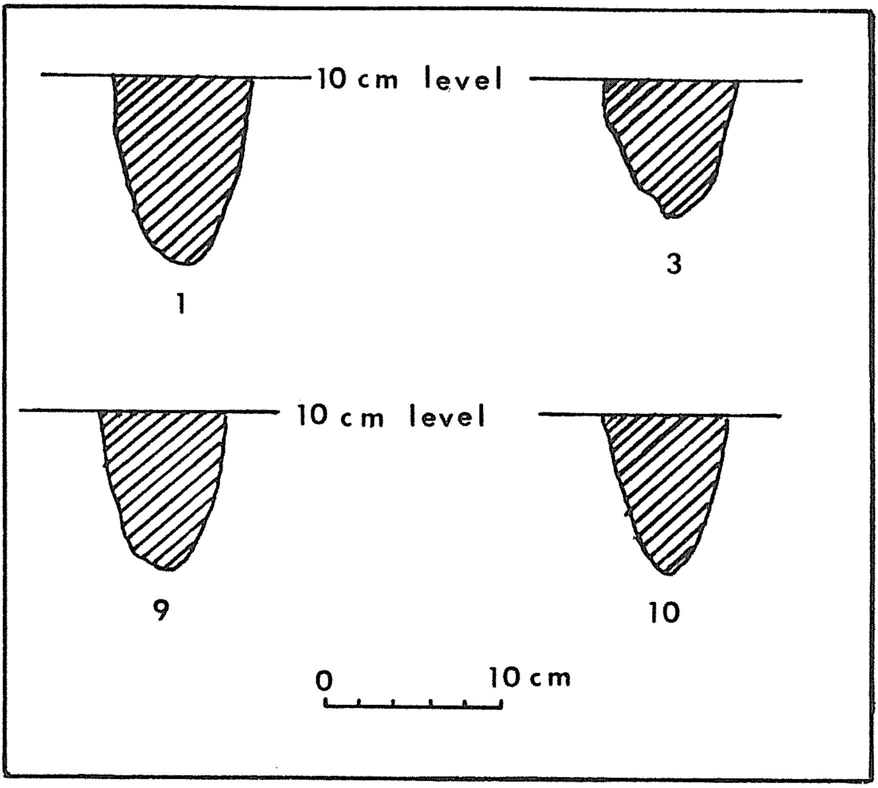

Figure 25. Cross sections of possible post molds, Features 1, 3, 9 and 10, in Zone I, excavation area A.

DATING THE SITE COMPONENTS

Zone III

Three samples of *Rangia flexuosa* shell from three different parts of the zone were submitted to the Radiocarbon Laboratory at the Balcones Research Center at The University of Texas at Austin (Table 8).

Table 8. Radiocarbon Dates From Zone III

Sample No.	Raw Date[1]	Calibrated Date[2]
Tx-5263	4450±90 B.P	5220±90 B.P.=3270 B.C.
Tx-5264	4630±90 B.P.	5310±90 B.P.=3360 B.C.
Tx-5265	4410±90 B.P.	5130±90 B.P.=3180 B.C.

[1] S. Valastro, personal communication.

[2] Calibrated by dendrochronology (Klein et al. 1982).

Aten (1983a, Appendix 1) has reported considerable success in obtaining reliable radiocarbon dates from *Rangia cuneata* shells on the Upper Gulf Coast of Texas. Salvatore Valastro (personal communication), of the Radiocarbon Laboratory of The University of Texas at Austin, states that *Rangia flexuosa* should produce similar results.

Aten has suggested, on the basis of comparisons of dates obtained on charcoal and on *Rangia cuneata* from the same archeological contexts, that dates obtained from *Rangia* are generally slightly older than dates from charcoal (Aten 1983a:330-341). In the Trinity River delta area on the Upper Texas Coast, *Rangia cuneata* samples yield dates that are about 225 years earlier than those produced by charcoal. Aten had postulated that the discrepancy is due to the absorption of carbon ions by living clams and that the higher the levels of bicarbonate in the aquatic environment, the greater the resultant discrepancy in radiocarbon dates. The amount of bicarbonate in turn correlates with the proximity of the estuary system where the clams lived to the limestone formations of Central Texas. So *Rangia* samples from the mouth of the Sabine River, for example, should produce dates very nearly the same as those from charcoal in the same context, since the Sabine drainage is largely free of dissolved carbonates from Central Texas limestone. In contrast, samples of *Rangia* from the Lavaca River estuary are predicted to produce age determinations that are some 800 to 1000 years too old, since much of the Lavaca drainage is in the Central Texas limestone region.

Aten has summarized his correlations of the recorded bicarbonate counts (mg/liter) in the waters of various Upper Coast estuaries and predicted age deviations of shell samples as a logarithmic regression. The average bicarbonate count from test locations in Nueces and Corpus Christi bays for the mid-1970s is 183 mg/liter (Lind 1980). Accordng to Aten's regression model (Aten 1983a:340), this amount of bicarbonate should produce a date on *Rangia* shell that is about 300 years too old. Based on this prediction, the *Rangia* radiocarbon dates at McKinzie would indicate a Zone III occupation at about 4900 B.P. However, it is probably unrealistic to be so precise, since Aten's regression model is, as he himself states (1983a:339), preliminary. Furthermore, modern bicarbonate counts from Nueces and Corpus Christi bays may be significantly different from those in the vicinity of the site during the Zone III occupation due to differences in the bay environment over the millenia. Bicarbonate counts are affected by the degree of interchange between estuarine and sea waters; counts for estuary and bay waters become increasingly uniform and, in the case of the Nueces/Corpus Christi Bay system, increasingly lower from the heads of the bays toward the Gulf of Mexico (see Lind 1980). So before the barrier islands were formed the bicarbonate count in the waters near the McKinzie site probably was lower than at present. Only the recovery and testing of paired charcoal/*Rangia* samples from the area will permit more accurate assessment of the degree of age deviation possible in *Rangia* samples from the charcoal norm.

The consistency of results in dating the Zone III samples and the general reliability of *Rangia* suggests that the Zone III dates are reasonably reliable approximations of the age of the occupations. Although it must be kept in mind that the dates may be too early, such deviation does not create serious interpretive problems in the light of the roughly 5,000-year time frame involved.

Zone II

No samples were submitted for dating from Zone II, since, without associated diagnostic artifacts, radiocarbon determinations would have been valueless for cultural chronology.

Zone I

The tiny bits of charcoal that occurred sporadically in Zone I could have been gathered for radiocarbon dating, but it was deemed that such dates would be unreliable because of the strong possibility that, at their shallow depth, they had been contaminated by charcoal of more recent origin and because *Rangia* shell tends to yield dates that are several centuries too early. Therefore no samples were submitted from Zone I for radiocarbon dating. However, it can be inferred that the Late Prehistoric occupation at McKinzie dates between about A.D. 1300/1400 and the eighteenth century. Though to date no radiocarbon dates have been published for the Late Prehistoric Rockport complex, the predominance of Perdiz arrowpoints in the Rockport assemblage (see Corbin 1974) suggests a post-A.D.-1300/1400 time, since this point type has been so dated in adjacent interior southern and south-central Texas (see Prewitt 1985; Black 1986). The presence on Rockport sites of European trade material and arrowpoints made from bottle glass (Campbell 1958b; Corbin 1963, 1974) indicates that the Rockport complex persisted into the period of European contact.

SITE-SPECIFIC INTERPRETATIONS

Zone III

On the basis of dart points and an average date of 5220±90 B.P. for the three radiocarbon dates (Table 8), Zone III can be assigned to a fairly early period in the Archaic stage. The radiocarbon dates are supported by the occurrence in Zone III of a Bell dart point. Prewitt has estimated the time range for Bell points in Central Texas as about 4100 to 3100 B.C. (Prewitt 1981, 1985). So the average of the McKinzie Zone III dates appears to fit the Central Texas chronology suggested by Prewitt.

The Tortugas point from Zone III is also probably at home within the time frame suggested by the radiocarbon dates, since this point type has been estimated to date to the Early and Middle Archaic in southern Texas (Turner and Hester 1985:152).

The presence of the small Catan and Catan-like points at about 5000 B.P., however, is at variance with the previously suggested time range for such points in southern Texas. It has been suggested that the Catan point is a Late Archaic type (see Hester 1980b:98; Turner and Hester 1985:78), and Hester has postulated that the type may represent the later end of a continuum involving progressive diminuition from the larger but morphologically similar Abasolo type.

Data from Nuevo Leon in northeastern Mexico, however, are not inconsistent with a relatively early occurrence of Catan and Catan-like points and may have more relevance for the southern Texas region than has been apparent. As indicated by a series of radiocarbon dates, Catan and Catan-like points are found at the Cueva de la Zona de Derrumbes site by about 3000 B.C. (Epstein 1972, 1980; McClurkan 1980:61). The type is also found in unit 32, a level dated by uncorrected radiocarbon determinations to between 3450 and 2450 B.C. (Nance 1980:43-44), at the La Calsada site.

Although the McKinzie Zone III sample is small, the association of all four dart points with the dated shell samples is excellent. Vertical displacement of materials can be ruled out confidently since all of the nearly 13,000 *Rangia* specimens recovered and identified as to species were *Rangia flexuosa*. Despite the occurrence of *Rangia cuneata* at the base of Zone II, no specimens were found in Zone III, indicating that there was no downward displacement of material. Too, all chert debitage in Zone III had slight-to-moderate patination that was not characteristic of higher zones. The dart points were similarly patinated, suggesting undisturbed association with the Zone III debris.

On the basis of the Catan and Catan-like points in Zone III, dated to about 5000 B.P., and the well-established assignment of these points to a similar date in Nuevo Leon, it appears that Catan points do not come only from a relatively late time period in South Texas. The type may have a much longer time span than has been previously thought or, alternatively, we may be dealing with two or more temporally and/or culturally distinct types, which are, at least by current analytical standards, morphologically indistinguishable. In either case, more information about the chronological position(s) of the small, unstemmed, round-based dart point form in southern Texas apparently is needed before the Catan type can be accepted as chronologically diagnostic.

Environmental and Ecological Inferences

Both *Rangia cuneata* and *Rangia flexuosa* are brackish water clams, but *Rangia flexuosa* is known to prefer a higher salinity level than does *Rangia cuneata* (Andrews 1977;220-221). Therefore the shift from 100 percent *Rangia flexuosa* in Zone III to a predominance of *Rangia cuneata* in Zone I suggests that a decrease in salinity occurred in the estuarine waters near the site during the several millenia between the occupations of the two zones. That this shift was gradual, reflecting fundamental change in the estuary environment rather than relativly short term oscillations in salinity levels, is suggested by the progressive shift in the proportional representation of the two species between successive 10-cm levels in the excavations (Table 5). The percentages by level suggest that light and sporadic occupations deposited *Rangia* shell in the gradually accumulating loam soil of Zone II, and that *Rangia cuneata* became increasingly well represented as aquatic conditions became more suited to its requirements.

That such changes were not restricted to the area around the McKinzie site is indicated by the following data from other sites along the southern margin of the Nueces estuary.

1) The Means site (41NU184), several kilometers upstream from McKinzie, can be described as a dense *Rangia flexuosa* midden similar to McKinzie, Zone III.

All of the more-than-two-dozen projectile points recovered from the site, except for a single Fresno arrowpoint, were Archaic dart points. There were no other Late Prehistoric artifacts, such as potsherds. Excavations at this site revealed an apparent aboriginal living surface that produced a crescentic post mold pattern in probable association with a thin scatter of camp debris (Ricklis and Gunter 1986). At the same level a cluster of *Rangia flexuosa* shells was uncovered. These shells were submitted to the Radiocarbon Laboratory, Balcones Research Center, The University of Texas at Austin, and yielded a date of 5080±70 B.P. (Tx-5303-4390±70 B.P. Callibration by dendrochronology, Klein 1984) (ibid.:25). So the profusion of *Rangia flexuosa* at this site suggests an aquatic estuarine environment similar to and at about the same time as that indicated at Zone III at McKinzie.

2) A shell stratum containing *Rangia flexuosa* exclusively was seen in an exposed soil profile at the edge of an eroded wash at the Jackson Woods site (42NU240), about 1 km upstream from McKinzie (R. Ricklis, field notes). The stratum, 1 meter beneath the modern surface of a dark brown sandy clay-loam topsoil, was about 10 cm thick. Eroding out of this stratum, together with several chert flakes, was the medial section of a dart point, suggesting an Archaic occupation. On the other hand, an exposed deposit of Late Prehistoric debris at this site, which yielded chert flakes and Rockport ware pottery, had a scatter of *Rangia cuneata* but no *Rangia flexuosa*.

3) At the Allison site (41NU185), half a kilometer upstream from McKinzie, test excavations yielded Late Prehistoric Rockport ware sherds in association with *Rangia cuneata* (Carlson et al. 1983, Figures 15, 16).

So, though the data base ought to be expanded for greater certainty, *Rangia flexuosa* deposits appear to correlate with relatively early occupations, whereas *Rangia cuneata* is exclusively or predominantly in association with Late Prehistoric material remains. The inference to be drawn from these data is that the changing salinity in the Nueces estuary indicated by findings at the McKinzie excavation happened throughout the area. This may appear to contradict the general paleoclimatic evidence that Texas (see Bryant and Halloway 1985) had increasingly dry conditions during the Holocene, which would have resulted in progressively reduced discharge of fresh water into coastal estuaries and a concomitant increase in salinity levels. If the geological evidence is considered, however, a coherent picture emerges that agrees with the archeological data. As already noted, geological evidence indicates that by about 4500 B.P. the Nueces Valley was inundated by Gulf waters at least as far inland as Calallen (Figure 1), about 8 km west of the McKinzie site, creating a long embayment. At that time the high ground on which the McKinzie site was situated would have been directly on the shore. Since the present barrier islands had not formed, this embayment was susceptible to tidal influence from the open Gulf, so general salinity levels would have been high, decreasing toward more river-influenced areas near the head of the bay. With the gradual formation of the barrier islands after about 2800 B.P. (Brown et al. 1976), the estuary would have become gradually less saline, until a habitat more suited to the requirements of *Rangia cuneata* populations was established.

For these reasons it is postulated here that Zone III at McKinzie represents the adaptation to an estuarine bayshore environment of aboriginal people by about 5000 B.P., with a varied subsistence base relying significantly on shellfish, primarily *Rangia flexuosa* clams, but also, to a minor extent, on oysters. The marine fish otoliths in Zone III indicate that fall-winter fishing also played a role in their subsistence economy. The importance of hunting is suggested by the fact that, excluding debitage, dart points account for more than half of the lithic artifacts recoverd. The complete absence of preserved bone in Zone III makes it impossible to determine what species were hunted.

Zone II

Little can be said about Zone II. The sporadic and apparently random occurrence of *Rangia* shell and occasional bits of unidentifiable bone suggests very short term camping episodes that involved shellfish gathering and hunting activities. The sizeable and rather deep Feature 6-A, which had large amounts of ash and burned soil, may have served as a roasting pit, but the absence of associated faunal or floral remains makes further interpretation impossible.

Zone I

The artifact assemblage recovered from Zone I—Rockport ware pottery, Perdiz arrowpoints, prismatic blades, and the small unifacial end scraper—is characteristic of the Late Prehistoric Rockport complex. These materials differ in no significant way from those at many other sites in the Coastal Bend (cf. Campbell 1958b, Corbin 1963, Story 1968). Because of the controlled conditions of their recovery, the findings from Zone I have the potential to reveal the nature of a single Late Prehistoric occupation assignable to the Rockport complex.

Distributional Patterns

Though Zone I materials were found between 5 and 12 cm below the modern ground surface, most specimens were found between 7 and 10 cm. All features—hearths, possible post molds, and the small pit—also came from the narrow range of 7 to 10 cm. The contemporaneity of artifacts and features so implied is also strongly supported by the horizontal distributions of features and debris.

Except for a dense cluster of debris in the northeastern part of the area A excavation, most of the artifacts and bone fragments are clustered rather tightly around the hearths, Features 4, 5, and 6 (Figure 12). In order to interpret this distribution pattern, the densities of debris clusters in the excavated area were examined. Three areas of debris clustering are suggested: (1) an area of moderate density partially encircling the group of hearths, Features 4, 5, and 6, and contained within a radius of about 1.5 to 2 meters to the northeast, east, and south of the hearths where the average density of debris (sherds, chert debitage, and bone fragments) is 27.1/square meter, (2) an area of high density in the northeastern part of the excavation area where, except for very small splinters, there were no bone fragments, and the density of sherds and debitage averages 48/square meter, and (3) an area defined as all of the Zone I excavation outside of areas 1 and 2, where debris is extremely sparse, averaging 5.3 specimens per square meter.

The presence of the moderately dense cluster around Features 4, 5, and 6 (Figure 26) is not believed to be fortuitous; it is probably debris accumulated during daily activites around a central hearth complex. The location of the cluster to the northeast, east, and south of the hearths is logical in the light of the fact that prevailing winds during the spring, when the site was occupied, come from the east-southeast (Brown et al. 1976:29). Activities would have been concentrated on the windward side of hearths.

In this light the area in the northeastern part of the excavation, which had the highest density of debris, probably represents an episode of trash deposition. The association of this debris with that around the hearths is certain, since the sherds in both areas fall into the same groups—mostly Group 1—and all of the sherds in Group 1 are from the same vessel.

This interpretation is further strengthened by the close correspondence in the distribution of artifactual debris and *Rangia cuneata* fragments (Figures 20, 26). The distribution pattern of *Rangia* (density per 1-meter unit) is a circle that approximately duplicates, in both shape and location, the first of the artifactual debris clusters described above. The 1-meter unit with the greatest density of *Rangia cuneata* is also the unit with most sherds and debitage, a fact that further supports the inference that the debris cluster in the northeast part of the excavation is trash resulting from activites around the hearths.

Since the area around the hearths probably was a focal point of camp activity, the area probably would have had a maintained surface, i.e., debris resulting from various activities would have been deposited elsewhere. One area of deposition of debris has been inferred; presumably there were others, since recovered potsherds account for only small parts of the vessels from which they came. Also, the few hundred pieces of chert debitage and the few bone fragments recovered probably are only a fraction of the quantities of such debris that would be generated by an occupation spanning all, or the better part, of a full season.

The inference that the debris that surrounds the hearths came from activities that were performed inside a circular or semicircular structure is supported by several findings:

1) Except for the cluster of relatively high density believed to result from trash disposal, debris is distributed around the hearths in a circular pattern (Figure 26). It will be noted that nearly all sherds, debitage, and bone fragments fall inside the dashed circle, suggesting containment by a structure that minimized the natural tendency for debris to be scattered by daily traffic.

2) Features 1, 3, 9, and 10 (Figure 26), possible post molds, are on or very near the circle that marks the extent of debris around the hearths. Though every effort was made during excavation to locate post molds, only these four seemed actually to be post molds.

3) The small pit, Feature 8 (Figure 26), is just inside the circle. So, in accordance with the postulation of structural containment, this feature represents a pit located inside and near the wall of a structure. This placement of pits that served as storage facilities in domiciles is well documented in a wide range of perhistoric cultural contexts in North America.

4) The possible pits indicated by infrared photography form an alignment that includes Feature 8 and closely follows the circular pattern (Figure 26). Also, the consistent spacing of these possible pits and Feature 8 strongly suggests that the spots visible in the photographs do indeed delineate a series of small pits just inside a circular structural wall.

Taken together, these data strongly support the postulation of a circular or semicircular hut about 5.5 meters in diameter with a central hearth complex. Such a structure would be similar to the huts described for the historic aboriginal inhabitants of the central Gulf Coast of Texas. Newcomb (1983:363) has described the dwellings of the Karankawa as

> constructed of a dozen or so slender willow poles approximately 18 feet long and pointed at one or both ends. The sharpened ends were forced into the ground in a circle, the upper ends interlaced and tied with thongs to form an oval framework over which skins and woven rush mats were thrown. Often only the windward side was covered, so it could as well be called a windbreak as a hut. The size of the huts varied, but normally they were 10 or 12 feet in diameter and accommodated seven or eight people. They could be dismantled quickly...Fires for cooking and for heat were built in the center of the huts, the smoke easily finding its way out.

Functional Variability

Due to the temporary nature of the occupation and the apparent disposal of debris outside the activity area on which the excavation was focused, the artifact sample is small. Nevertheless, the material covers the range of daily activities predictable for a seasonal multifunctional and residential occupation, as the following list indicates.

1) Lithic tool production. The range of flake types covers all phases of tool production, from primary cobble reduction to biface thinning. The most likely source for lithic raw material is the gravel bed some 20 km up the Nueces River (Chandler 1984). The presence of primary cortex flakes and the core indicates that whole cobbles were brought to the site before initial reduction.

2) Plant processing. Two milling stone fragments (one from the Zone I excavation) suggest that plants were being processed.

3) Storage. The one or more small pits that probably were inside a structure, strongly suggests short-term storage, perhaps of gathered plants.

4) Various cutting and scraping tasks. The chert end scraper, two *Rangia* shell scrapers, and several utilized flakes, all found in the debris cluster around the hearths, indicate a variety of scraping and cutting activities.

5) Cooking. The distribution of nearly all of the larger bone fragments and sherds from what was probably a fairly large open-mouthed cooking pot (sherd Group 1) around the hearths indicates that this area was a focal point for cooking and eating.

Seasonality

As already discussed, analysis of *Rangia cuneata* valves indicates occupation from about the middle of March through May. The close correspondence between the distributions of *Rangia cuneata* shells and other debris, together with the

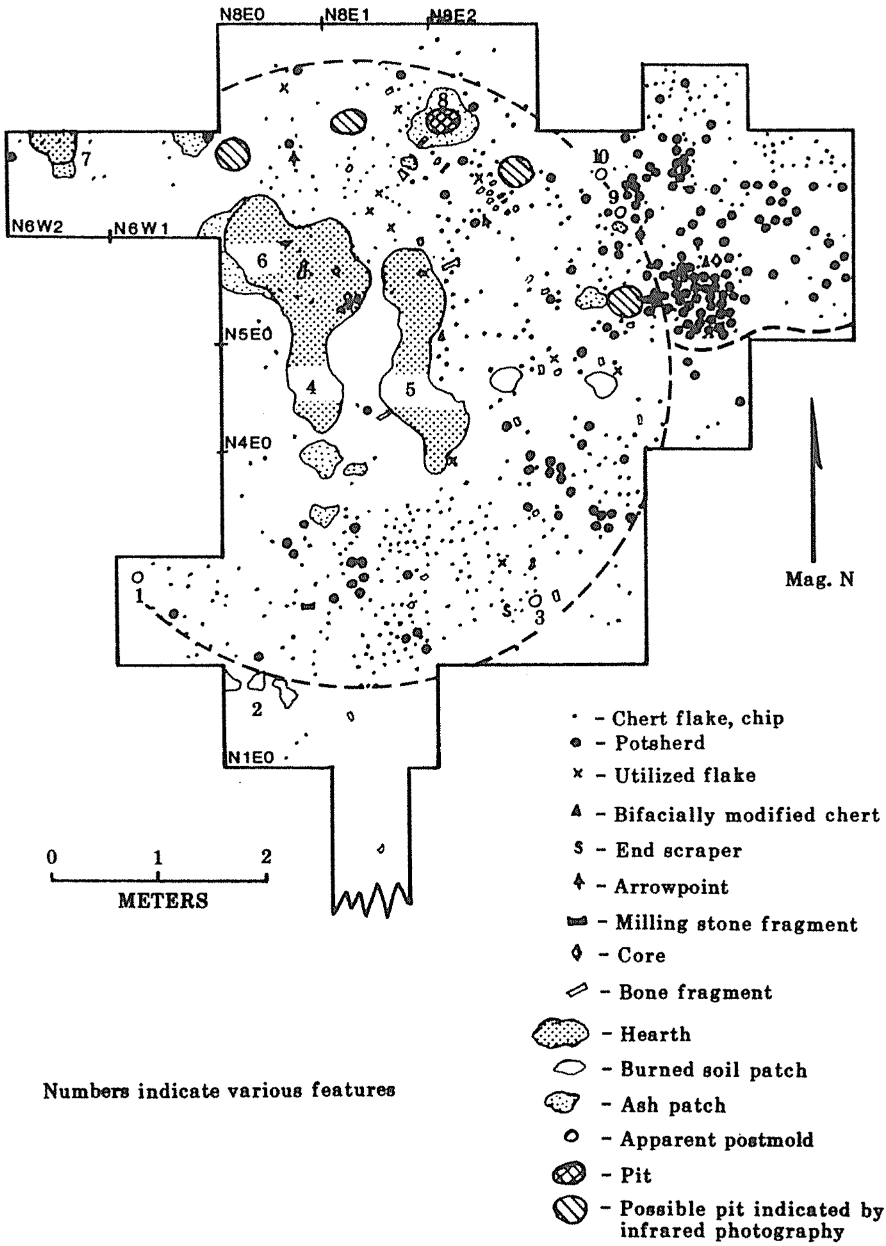

Figure 26. Plan of area A, Zone I excavation, showing suggested debris clusters outlined by dashed lines.

reasonably inferred association of these distributions with the features, strongly suggests that the Zone I findings are the result of a single episode of occupation during these months.

Ecological Considerations

The location of the McKinzie site is ecotonal, situated as it is between the ecologically different zones of the Nueces estuary and the grassland prairie of the higher ground to the south of the floodplain. Nevertheless, all indications are that subsistence was oriented primarily to the terrestrial prairie environment. Relatively little use seems to have been made of the aquatic food resources that must have been available in the nearby estuary. In spite of reasonably good bone preservation in Zone I, no fish bones were recovered, and, although it is recognized that fish bone in general is susceptible to rapid decay, it would be reasonable to expect preservation of at least some vertebrae. Fish otoliths, on the other hand, resist decomposition very well, yet only two otoliths were recovered from Zone I, and both may have been redeposited from the disturbance that intruded into Zone III to the north of the excavation. Meticulous examination of the surfaces on the site that produced Late Prehistoric artifacts also failed to yield any signs of fish bones or otoliths. So it can be stated with confidence that fishing was, at most, an insignificant subsistence activity during the Late Prehistoric occupation of the site. It is possible that procurement and consumption of fish was taking place at a fishing station away from the site, which would account for the absence of fish remains, but this is only a weak possibility because (1) the site itself is adjacent to the Nueces River, (2) *Rangia cuneata* obviously were being gathered in the estuary and brought back to the site for consumption, and (3) the excavated area was the focal point of various daily activities and, as indicated by the mammal bone and inferred plant processing, was an area to which food resources were brought to be processed and consumed.

Rangia clams in Zone I are in what can be described best as a scatter. The excavation yielded 1235 identifiable umbo fragments and whole valves, which would account for half as many clams—not an impressive amount of food. Granting that much of the *Rangia* debris generated by the occupation presumably was deposited beyond the limits of the excavation, the scattering of *Rangia* seen in the parts of the site that yielded Late Prehistoric material supports the inference that *Rangia* was an occasional rather than a primary food resource.

The data indicate that the most significant subsistence pursuit was hunting. The faunal remains indicate that small animals—turtles, birds, and frogs—were eaten, but the greatest source of meat apparently was large game, specifically white-tailed deer and bison. Though these two species are represented by only one individual each, they account for several hundred pounds of meat, far more than the meat in all other species in the faunal sample combined. The small number of bones in the excavated area, though, suggests that (a) food was shared with people occupying other parts of the site, (b) bones were left at kill sites or butchering areas, or (c) bones were deposited in so-far-unexcavated trash areas.

Synthesis

The points made above regarding the Zone I occupation can be synthesized as follows. The cultural remains were left by a small group of people; perhaps the group stayed at this location for all or for the better part of the spring season, subsisting largely on hunted mammals, together with plants and small animals. Plant processing may have been of some significance; the evidence at least suggests that plant foods were being stored on a short-term basis for ongoing use. Despite their proximity to estuarine resources, these people appear to have made little use of aquatic species.

Daily activity was centered around a small hearth complex, probably in a circular or semicircular shelter that was the focal point to which foods were brought, processed, and eaten. Tools were made here and used in a variety of daily tasks. The length of residence at this encampment, combined with the varied tasks performed and the variety of resources procured and brought back to camp, indicate a residential, multifunctional occupation. The people who abandoned the Zone I remains followed a variety of subsistence pursuits and do not appear to have concentrated their efforts on any single resource.

Parts of the site where disturbances have exposed Late Prehistoric deposits apparently are similar to the excavated part of Zone I; light scatters of sandy paste sherds, lithic debitage, *Rangia* shell, and occasional mammal bone are the rule. Therefore, the kind of temporary focused activity area defined for the excavated area probably characterized the Late Prehistoric occupation in other parts of the site. Whether the unexcavated areas represent recurrent occupations at different times or concurrent activities of other small groups within a single band cannot be determined from the available data.

How a seasonal occupation of the kind defined here might fit into the broader pattern of settlement and subsistence in the Coastal Bend area during the Late Prehistoric is examined below.

AN ECOLOGICAL MODEL OF LATE PREHISTORIC SETTLEMENT AND SUBSISTENCE PATTERNS IN THE CORPUS CHRISTI BAY AREA

Based on the data and analyses presented above, it is concluded that the Zone I occupation at the McKinzie site was a seasonal residential and multifunctional encampment in which subsistence was based primarily on the terrestrial grassland environment. A study of settlement and subsistence patterns for the Late Prehistoric Rockport complex in the Corpus Christi Bay area establishes a cultural context for the Zone I occupation. There are two basic questions: (1) is there any discernable variability in the nature of Rockport complex sites that can be correlated with a pattern of spatial distribution and, if so, (2) what implications might this have for understanding the relationships among settlement pattern, subsistence strategy, and social organization within the cultural system?

Examination of the existing information on 26 sites in the Corpus Christi area (Figure 27) in the light of these questions raises further questions:

1) What are the relative densities of occupational debris on Rockport complex

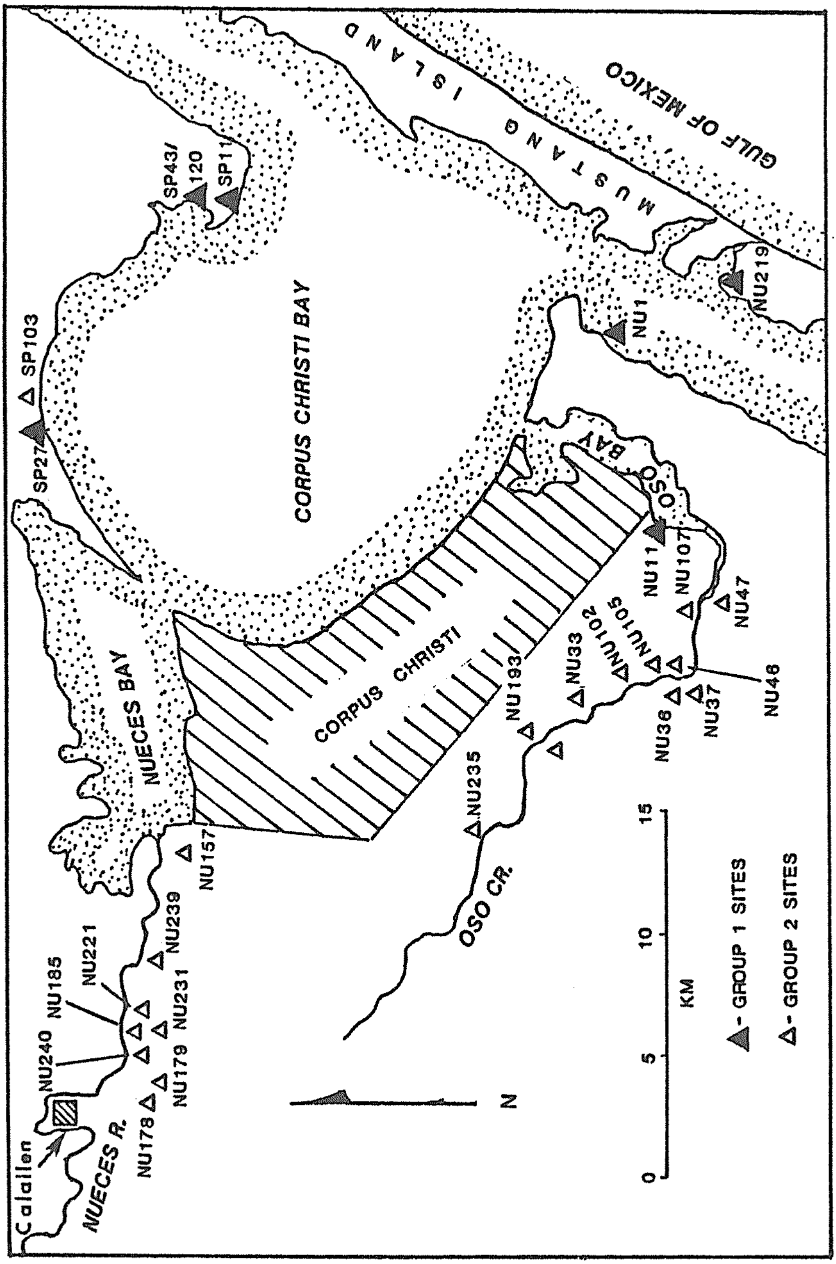

Figure 27. Plan of the Corpus Christi Bay area showing Group 1 (solid triangles) and Group 2 (outline triangles) sites.

sites, and, by inference, what was the intensity of occupation at each site?

2) What kinds of faunal remains predominate at each site?

3) Is there spatial patterning of sites with different densities of debris and different kinds of faunal remains from which variation in settlement and subsistence can be inferred?

From the data presented below, the following conclusions are suggested.

1) The most intensively occupied sites in the area, i.e., the sites with the highest densities of cultural debris, are directly adjacent to the shores of bays and lagoons.

2) These intensively occupied sites are relatively few in number.

3) Marine faunal remains (fish and shellfish) are abundant in these shoreline sites.

4) Sites with markedly lower densities of cultural debris are away from the shorelines, along the streams feeding the Corpus Christi Bay system.

5) There are many more low-density sites than high-density shoreline sites.

6) The low-density sites yield relatively few marine faunal remains.

The Sites

Many of the more-than-350 sites in the area have yielded Late Prehistoric materials, but useful information has come only from the sites described below. Unless otherwise stated, the data are taken from site records on file at the Balcones Research Center (TARL), The University of Texas at Austin.

For convenience and clarity, the sites have been divided into two groups, based on the density of cultural debris. Group 1 sites , according to the files at TARL or other sources (including the author's field observations), have yielded large quantities of cultural debris. Group 2 sites are sites for which the available information indicates thin, low-density deposits. On these sites, artifactual finds are few, and cultural debris in general (chert debitage, faunal remains) is thin and scattered. Sites for which records were inconclusive on this point, and for which the quantities of cultural remains could not be determined by field observations, were not considered, even though they were known to contain Late Prehistoric material. Therefore, although there may be sites of intermediate density—neither very high nor clearly low—in the area, they are not included here because their density status could not be determined.

Ideally, density of cultural debris should be quantified in terms of numbers of artifacts and faunal specimens per unit volume of depositional matrix for each site. This is possible in a few cases, but, since controlled excavations have not been made at most sites, density must be evaluated by surface observation. Unless otherwise stated, data have been obtained in this manner, but it is not as unreliable a procedure as it might seem. Due to the semiarid climate, erosion has exposed significant parts of many sites near streams and bays to such an extent that fairly useful observations often can be made regarding the nature of cultural deposits. Clearly there is some error inherent in this approach, but the differential distribution of high and low density sites across the landscape that emerges from this inquiry indicates that we are on the right track (Appendix Tables 3, 4).

Group 1 Sites

41NU1 (Webb Island Site)

This site was on an island (now destroyed) in Laguna Madre, very near the mainland shore. The site has been known as a rich collecting ground for arrowpoints since early in this century and has been referred to often as Arrowhead Island. The site was tested in 1933 by A. T. Jackson, under the auspices of The University of Texas. Jackson did not publish the results of his work, but the findings were summarized by Campbell (1956). Jackson's notes, on file at TARL, are cursory but indicate that much of the island was capped with a midden containing abundant artifacts in association with conch (probably whelk) and oyster shell and abundant fish bones. The site is described (Texas Archeological Research Laboratory files) by a local collector as one of the densest kitchen middens in the area. Campbell (1956), in his review of materials collected from the site, noted the presence of mammal bone, including some specimens of what appeared to be bison bone.

The collection from the site, stored at TARL, includes several thousand sherds of Rockport Plain and Rockport Black on Gray pottery, and in the lithic material attributable to the Late Prehistoric are Perdiz (109), Bulbar Stemmed (13), Starr (11), Fresno (10), Cliffton (5), Cameron (2), and McGloin (1) arrowpoints and 45 small unifacial end scrapers.

41NU11 (Kirchmeyer Site)

This site is on a clay dune overlooking Oso Bay. Testing by T. R. Hester and J. E. Corbin in 1969 revealed only a patchy distribution of concentrated debris (field notes on file at TARL), but the site has yielded large quantities of surface-collected Late Prehistoric artifacts that indicate fairly intensive use.

A sizeable collection from this site, housed at TARL, includes several thousand sherds of Rockport Plain and Rockport Black on Gray pottery, 56 Perdiz, 28 Fresno, 8 Bulbar Stemmed, 7 Starr, 5 Guerrero, 4 Lozenge and 1 McGloin arrowpoint; and 18 small, unifacial end scrapers.

The testing by Hester and Corbin documented a rather wide range of faunal remains, including marine species (whelk, oyster, sunray venus clam, and black drum fish) as well as terrestrial mammals (deer, bison).

41NU219

This recently discovered site is adjacent to Laguna Madre at the north end of Padre Island on the edge of Packery Channel, a tidal pass that probably connected the Gulf of Mexico and Laguna Madre when the site was occupied. The site was discovered during an archeological reconnaissance of the area by James E. Warren (Texas Archeological Research Laboratory files).

Late Prehistoric cultural debris is found on the surface of the sandy soil for at least 240 meters parallel to Packery Channel. A 1-meter test unit excavated under Warren's direction yielded a large quantity of cultural debris, including several hundred sherds of Rockport ware pottery, several hundred pieces of chert debitage, a Perdiz arrowpoint, and abundant marine faunal material in the form of shell debris and fish bones.

The author visited the site in the spring of 1985 and saw that the soil in the site area was markedly darker than that beyond the apparent limits of the site. Presumably this is the result of organic staining due to intensive aboriginal use of the location.

41SP27

This site was on the top of the clay bluff overlooking the north shore of Corpus Christi Bay. The site, now destroyed by recent residential expansion of the city of Portland, was tested by Don Kindler, of Corpus Christi, shortly before its destruction (Kindler, personal communication). Kindler opened five 1-meter–square units and found abundant Late Prehistoric material to a depth of at least 30 cm in an area characterized by dense accumulations of oyster shell. Shell debris other than oyster was notably scarce and consisted of only four whelk fragments and a single scallop shell.

The author briefly examined the material recovered by Kindler and noted more than 800 sherds of Rockport ware pottery, 448 pieces of chert debitage, 4 arrowpoints (3 Perdiz, 1 Fresno), 2 small unifacial end scrapers, several utilized flakes, and 2 artificially perforated fish vertebrae that probably were beads.

Faunal remains collected by Kindler were 42 fragments of deer or deer-sized bone, 6 turtle carapace fragments, and 15 rather large pieces of fish bone, including 2 black drum mandibles. The large size of the fish bones suggests that smaller bones were present but not recovered.

41SP11 (McGloin Bluff Site)

This site has been reported briefly by Corbin, who made surface examinations there (Corbin 1963) and reported 3,381 sherds of Rockport ware pottery and several stone artifacts. Among these artifacts are 18 arrowpoints (Perdiz, Bulbar Stemmed, Starr, Young, and several untyped specimens), a small end scraper, 4 side scrapers and a graver.

On visits in 1985, the author found an extensive site spread along the top of a sand dune formation that parallels the Corpus Christi Bay shoreline for at least 400 meters. A borrow pit has intruded into the dune near the west end of the site, and many potsherds were eroding out of the walls of this disturbance. Close examination of these walls, however, revealed no visible occupational midden, probably because the dune had shifted since, and perhaps even during, the Late Prehistoric occupation. On the other hand, recent erosion at the east end of the site has revealed—buried under several feet of windblown, culturally sterile sand—a zone at least 50 cm thick of dark-stained sand from which many artifacts have been eroded and collected by LeAnne Weaver, of Corpus Christi (personal communication). The author examined this material briefly and noted, in addition to several hundred sherds of Rockport ware, one Perdiz and one Starr arrowpoint, a small flaked drill, and many small flakes of chert.

The density of material at this site is difficult to evaluate with complete confidence. Although artifacts, particularly potsherds, abound, much of the material seems to have been displaced by the shifting of the sand dune on which the site is located. Faunal materials are scarce, but there is some bone, as well as many fragments of poorly preserved whelk, oyster, scallop, and sunray venus shell. The site is assigned to Group 1 on the basis of the abundance of artifacts recovered from the surface.

41SP43/120

These sites, though assigned separate registration numbers, abut each other and apparently are two parts of a continuous Late Prehistoric deposit along the sandy loam bluff that borders Ingleside Cove, off Corpus Christi Bay. The exact extent of these remains cannot be determined due to disturbances associated with modern residential construction. The site is clearly extensive, however, as is indicated by the sherds and other artifacts that are eroding out of several hundred meters of the shoreline bluff. Site 41SP43 was tested by Dee Ann Story in 1967 (Story 1968). Story's findings will not be reiterated here, except to emphasize that the excavations revealed a Late Prehistoric Rockport complex component overlying earlier Archaic material, and that characteristic Rockport material was associated with both terrestrial mammal and large quantities of fish and shellfish remains (ibid.).

Some 100 meters south of 41SP43 is 41SP120, on a particularly intensively occupied part of the Cove shoreline. This site was discovered in the fall of 1984 by LeAnne Weaver and Skip Kennedy, of the Coastal Bend Archeological Society. The site was first recognized as a discrete, densely packed shell midden directly adjacent to the shoreline bluff. Testing revealed a seemingly fairly discrete, largely nonshell midden area, some 15 meters south of the shell midden.

In order to determine the density, depth, and nature of the Late Prehistoric remains at this site, a 1-meter test unit was excavated in the nonshell midden, under the author's direction in December, 1985. Trowels were used, and control was in arbitrary 5-cm levels. Due to time restrictions, this test unit was excavated only to a depth of 55 cm. Late Prehistoric artifacts and a profusion of faunal remains, mostly fish bone and small shell fragments, were found throughout the deposit (Figure 28).

Except for a single Rockport Incised rim sherd (Suhm and Jelks 1962:134), all of the 293 sherds from this test unit can be assigned to either the Rockport Plain or Rockport Black on Gray types. Judging from the differences in thickness, color, paste, and surface treatment, at least 20 vessels are represented.

Lithic artifacts consist of one Fresno arrowpoint and two narrow-stemmed (probably Perdiz) arrowpoints with stems missing, together with a small end scraper, two small bipointed chert drills, a trimmed prismatic blade, two utilized flakes and 98 pieces of debitage.

Bone artifacts recovered are two tubular bird bone beads, an antler tine ground to a point, and a modified deer ulna similar to others from south Texas referred to as flaking tools (Corbin 1963:16, Hester 1980b:120).

Shell artifacts consist of a perforated oyster shell and six edge-flaked sunray venus clamshells.

More than 2,000 fragments of marine shell recovered represented, in order of decreasing abundance, oyster, scallop, whelk, sunray venus, quahog, and cross-barred venus. Shell was far less abundant in this midden than in the nearby dense shell midden mentioned above.

Figure 28. Test unit excavation in nonshell midden, 41SP120. Late Prehistoric materials were found throughout this unit. Note scattering of shell debris.

Since all excavated soil was put through an 1/8-inch mesh in a water-screening process, several thousand, mostly very small, fish bones were recovered. In addition, 212 marine fish otoliths from black drum (23 %), croaker (28 percent), sea trout (22 percent), redfish (19 percent), and catfish (8 percent) were collected.

Mammal remains were relatively few and comprised 31 fragments of deer and deer-sized bone and 3 bovid bone fragemnts, presumably bison. Eleven fragments of bird bone were found.

Microscopic examination of fish otolith cross sections for determination of season of death showed that the annuli in only 79 of the 212 specimens were clear enough to be useful indicators of seasonality. Many of the otoliths were too small to have clear annual ring patterns, and it was found that croaker otoliths generally did not have clear patterns (Table 9).

Table 9. Seasons of Death for the 79 Usable Fish Otoliths From 41SP120

	Season				
Species	Winter	Spring	Summer	Fall	Total
Black drum	24	1	3	6	34
Trout	14	1	5	5	25
Catfish	6	0	1	3	10
Redfish	5	1	1	0	7
Croaker	1	1	0	1	3
Total	50 (63%)	4 (5%)	10 (13%)	15 (19%)	79 (100%)

Since it is assumed that fish were caught as required during the site's occupancy, these data suggest a predominantly winter, or perhaps fall-winter occupation. Spring is very poorly represented. It is probably significant that drum enter the shallower parts of coastal bays in large numbers during the winter (Simmons and Breuer 1962). The predictable presence of large aggregates of black drum may have been a major factor in the choice of this location. At the same time, the preponderance of winter death otoliths among the other species shows that these numbers indicate the season of occupation, rather than simply the seasonal abundance of drum.

It is significant that this seasonal representation persists throughout the sampled deposit. Calculation of seasonality of the otoliths according to occurrence by 10-cm depth increments produced the same results. Assuming that the deep, dense deposit represents occupation over a considerable (though undefined) time span, recurrent emphasis on winter or fall-winter occupation apparently continued throughout that period.

Group 2 Sites

41NU33.

On the northeast bank of Oso Creek, about 9.5 km upstream from the head of Oso Bay (Figure 27), scattered cultural debris includes small quantities of pottery, as well as Perdiz and Fresno arrowpoints (numbers not specified in files of TARL).

41NU36.

Near the crest of a clay dune on the west bank of Oso Creek (Figure 27). A small intermittent stream flows just south of the site. During the summer and fall of 1980 a very thin scatter of cultural debris exposed by sheet erosion was seen. Scattered burned clay nodules and scant marine shell debris (sunray venus and whelk) were seen in an area about 20 meters in diameter. Twenty-three pieces of chert debitage, four sherds of Rockport ware pottery, and a reworked dart point were collected. It is possible that this site has an Archaic component.

41NU37.

On the west bank of Oso Creek on a clay dune just south of 41NU36 (Figure 27). In 1980 and 1981, Late Prehistoric material was thinly scattered along the eroded edge of the sandy loam topsoil capping the dune's tan clay subsoil. This material was found along a stretch of about 50 meters at the crest of the dune, where it was clustered in two areas, each about 15 meters long. A similar scatter was observed at the base of the dune, toward Oso Creek.

About five hours of meticulous surface collection resulted in the recovery of 107 small sherds of Rockport ware pottery, 2 Fresno arrowpoints, 1 small bipointed chert drill, 1 small unifacial end scraper, 2 prismatic blades, 2 utilized flakes, 23 pieces of chert debitage, and 1 sandstone mano fragment.

During a survey by the Texas Archeological Survey (Patterson and Ford 1974:35), a Perdiz arrowpoint, a fractured mano fragment, and an unspecified number of potsherds and chert flakes were found. Notes in files of TARL describe this material as scanty.

Faunal remains recovered from 41NU37 are five long bone fragments and one rib fragment of bovid bone (almost certainly bison, judging from the green fractures and apparent association with Late Prehistoric material) and six pieces of deer bone. Except for a few small fragments of sunray venus clamshell, no aquatic faunal remains were noted.

41NU46.

On a clay dune on the east bank of Oso Creek (Figure 27), this site is primarily a large Archaic midden. Late Prehistoric material is relatively sparse. According to Jerry L. Bauman, of Corpus Christi, who has carefully documented a large collection of Archaic material from the surface of eroded parts of the site, Late Prehistoric material is found only sparsely and in only a small part of the east end of the site (Jerry L.Bauman, personal communication). Over several years Bauman recovered a few small sherds of Rockport ware pottery and Perdiz, Fresno, and Starr arrowpoints from this area.

41NU47.

Adjacent to the south bank of Oso Creek, about 4 km upstream from the head of Oso Bay (Figure 27). Cultural material is sparse; the only diagnostic artifacts reported are four sherds of Rockport ware. No information on faunal remains is available.

41NU99.

In a cultivated field on the west bank of Oso Creek, about 11 km upstream from the head of Oso Bay (Figure 27), reported by Patterson and Ford (1974:38). Surface material was shallow and scattered. An unspecified number of chert flakes, one sherd, and a fragmentary Perdiz arrowpoint were recovered. Faunal material consisted of scattered unidentified marine shell and mammal bone fragments.

41NU105.

On the east bank of Oso Creek, about 7 km upstream from the head of Oso Bay (Figure 27). The site was surveyed by Patterson, who describes debris as scattered (Patterson and Ford 1974:40), consisting of chert debitage, two sherds, and a scattering of marine shell and mammal bone.

41NU107.

On the north bank of Oso Creek some 3.5 km upstream from the head of Oso Bay (Figure 27). The files at TARL indicate that cultural debris is sparse, consisting of three sherds of Rockport ware pottery, a light scatter of mammal bone, chert debitage, and unidentified marine shell.

41NU157.

On a low rise at the west end of a small, shallow pond called Tule Lake, 2 km south of the present mouth of the Nueces River (Figure 27). In 1979, a thin scatter of *Rangia* shell and chert debitage covered an area about 50 by 15 meters. In the files of TARL, fragments of burned mammal bone and several sherds of Rockport ware are recorded for this site.

41NU178.

On elevated ground next to a small intermittent stream that flows into the Nueces River 10 km upstream from the head of Nueces Bay (Figure 27). As reported in the files of TARL, artifacts consist of chert debitage, utilized flakes, a Perdiz arrowpoint, and 20 sherds. Faunal remains consist of *Rangia* shell and a small amount of oyster, whelk, sunray venus, and mammal bone (species not stated).

41NU179.

Reported in TARL files as a thin *Rangia* shell accumulation on the same small stream as 41NU178 (Figure 27). The recovery of dart points shows that the site has an Archaic component, and a very light Late Prehistoric occupation is suggested by the recovery of a single sherd and a possible Perdiz arrowpoint.

41NU185 (Allison Site).

On a hilltop adjacent to the Nueces floodplain, about 0.5 km upstream from the McKinzie site, this site has been reported by Carlson, Steele, and Bruno (1983), who describe tests carried out at the site by a crew from Texas A&M University.

Three 1-meter test squares were opened to depths of as much as 150 cm. Units 2 and 3, near the crest of the hill, yielded 39 small sherds of Rockport ware, mostly within the upper 20 to 40 cm of the deposits. Also in the levels producing pottery were 18 pieces of lithic debitage, a graver, and a biface fragment (Carlson, Steele, and Bruno 1983:Tables 2, 3, and 4). *Rangia cuneata* valves and fragments also were scattered throughout these levels, and faunal materials from these levels consist of the bones of a juvenile deer (believed to have been from a spring-summer kill), a probably juvenile bison humerus shaft, and the left scapula of a cottontail. Also recovered in one of these units was a drum fish otolith, though it is not specified whether this was found in the pottery-bearing levels (Carlson, Steele, and Bruno 1983:63-67).

41NU193.

On the east bank of Oso Creek (Figure 27),this is a very low density scatter of unidentified shell and burned clay nodules. Late Prehistoric artifacts are six Perdiz arrowpoints, two Fresno arrowpoints, a small end scraper, and one sherd.

41NU221. (McKinzie Site)

All indications, already discussed in detail, are that the Late Prehistoric occupation at the McKinzie site was light and temporary. Surface observations of both the site and the excavations, revealed only thinly scattered Late Prehistoric materials.

41NU231.

On a low rise next to a small intermittent stream that flows into the Nueces River some 7 km upstream from the head of Nueces Bay (Figure 27), the site is in a cultivated field and has been intensively surface-collected by Don Kindler, of Corpus Christi (Kindler, personal communication). Most artifacts recovered are Archaic forms. A very light Late Prehistoric occupation is indicated by two Perdiz arrowpoints and three sherds of Rockport ware. While working at the McKinzie site, the author visited this site briefly and noted a scatter of *Rangia* shell on the surface of the plowed field. Most of the shell was *Rangia flexuosa*, probably associated with the Archaic artifacts (see "Site-specific Interpretations," above). A scatter of *Rangia cuneata*, however, may have been deposited by the Late Prehistoric occupants of the site. No other information on faunal remains is available.

41NU235

This site, discovered by the author during a surface reconnaissance in 1979, is on a narrow elevated point between two old erosional cuts on the east bank of Oso Creek (Figure 27). Extensive sheet erosion had exposed a scatter of burned clay nodules and scanty lithic debitage in an area no more than 8 meters in diameter. Two Fresno arrowpoints and a few small splinters of deer bone were found in this area.

41NU239

This site, now destroyed by sand–quarrying operations, was on the crest of a hill overlooking the Nueces floodplain, near a small intermittent stream. In 1978, shallow (10 to 15 cm deep) bulldozer blading had exposed a sparse but discrete scatter of occupational debris about 10 meters in diameter. Careful examination of the surface resulted in the recovery of two sherds of Rockport Plain pottery, a fragmentary Perdiz arrowpoint, and 41 pieces of lithic debitage. A thin scatter of *Rangia* shell was noted, and six small fragments of deer or deer-sized bone were recovered.

41NU240 (Jackson Woods Site).

On a hill adjacent to the Nueces floodplain, 1 km upstream from the McKinzie site. Patches of *Rangia* shell scatter can be seen in exposed areas over several acres along the crest and north slope of the hill. At the crest of the hill, the convergence of several shallow (10 cm deep) roadcuts has exposed what appears to be a discrete scatter of *Rangia cuneata* shell some 25 meters long by about 8 to 10 meters wide. Careful surface inspection of this part of the site in 1984 resulted in the recovery of 81 pieces of lithic debitage and 5 small Rockport Plain sherds from at least 3 vessels. Besides *Rangia cuneata*, the only faunal remains noted were one bovid (bison?) rib fragment and a splinter of bird bone. A careful search was made for fish remains, but none were found.

A sample of 37 *Rangia cuneata* was gathered for seasonality analysis according to the method developed by Aten (1981). The shells fell into the five analytical categories (see discussion under "Faunal Remains, Zone I") as follows: interrupted 8 (22 percent), early 8 (22 percent), middle 12 (32 percent), late 4 (11 percent), and indeterminate 5 (13 percent).

As with the McKinzie sample, these results do not fit well into any of the single two-week growth histograms presented by Aten (see Aten 1981:187), suggesting that the occupation at this site (which appears to be a discrete episode, judging by the low density and spatial restriction of the debris) spanned several of the two-week periods. The procedure described above of averaging the category percentages (less the indeterminate category) for several two-week periods was applied, but with less clear-cut results than were yielded by the McKinzie sample. The McKinzie sample fell into category percentages for mid-March through end-May presented by Aten, but the Jackson Woods category percentages did not conform closely with any of the several averagings of two-week percentages. The closest fit that could be obtained was with the average of the category percentages for the period from end-March through end-June (Table 10).

Table 10. Comparison of Aten's Category Percentages With Those From the Jackson Woods Sample

Category	Aten's Sample End of March to End of June Percent	JacksonWoods Sample Percent
Interrupted	16	25
Early	36	25
Middle	38	38
Late	10	12

These data indicate a spring-early summer occupation. Why the results do not conform better to Aten's percentages cannot be determined, though several explanations are possible: 1) The Jackson Woods sample may be biased by (a) the presence of shells from more than one occupational episode or by (b) emphasis on *Rangia* gathering during a particular period within an occupational episode; 2) Unusual temperature patterns during the time of site occupation may have skewed the growth ring patterns on the *Rangia* shells, or 3) The sample may be too small for a high degree of analytical accuracy.

41SP103.

A small site on the clay bluff that overlooks the north shore of Corpus Christi Bay, close to a small stream that flows into the Bay. When the site was visited in 1979, it had already been partially lost to landward erosion of the bluff, and it was recently destroyed by residential development. Examination of the naturally created soil profile along the bluff indicated that Late Prehistoric material was eroding out of a thin (2 to 5 cm) zone of soil 5 to 10 cm below modern ground surface. This occupational zone could be traced along the bluff for about 10 meters.

Material recovered during several visits to the site includes 103 sherds (mostly very small) of Rockport pottery, 384 pieces of chert debitage, 2 Perdiz arrowpoints, 4 small unifacial end scrapers, and 3 utilized flakes.

Marine faunal material was surprisingly scarce (considering the site's shoreline location) and consisted of a few small fragments of whelk and oyster, as well as a single stingray spine. Bone material includes three bovid (presumably bison) long bone fragments, eighteen deer and deer-sized fragments, and five splinters of bird long bone.

Discussion

The information from the sites described above (Appendix, Table 3) indicates that intensively occupied locations are found only in marine shore environments: All sites with large samples of artifacts and relatively deep midden deposits are on bay or lagoon shores. The information also indicates that all sites away from the shorelines in riverine environments have only scattered cultural material, a conclusion that agrees with an observation by Steele and Mokry (1985:305) on the scattered nature of site deposits along Oso Creek. Artifacts are few from these slightly inland sites; even the sites in Group 2 that have yielded more than a few Late Prehistoric artifacts have done so only because of rather intensive surface inspection (such as 41NU37 and 41SP103) or excavation involving more than very limited testing, as at McKinzie. On the other hand, the very limited testings at Group 1 sites, as at 41NU219, 41SP27, and 41SP120, have yielded hundreds of diagnostic Late Prehistoric, mainly ceramic, artifacts.

The data surveyed here also indicate that Group 1 sites are few, and Group 2 sites are relatively numerous.

Intensively occupied shoreline sites, according to the available information, tend to yield large quantities of marine faunal remains, however, there does appear to be variability in the density and nature of such remains. It is apparent, for example, that fish and shellfish remains are not as abundant at sites 41NU11 and 41SP11 as they are at 41SP43/120, 41NU1, and 41NU219. At 41SP11, this may be a factor of the general dispersal of remains in a shifting sand dune, whereas 41NU11, which yielded a patchy concentration of debris, probably was not occupied as intensively as were the other sites in Group 1.

Nevertheless, as a group, these sites can be distinguished readily from Group 2 sites, on which neither artifacts nor marine and/or estuarine faunal remains are abundant. Many of the sites have shellfish scatters, which probably reflect minor contributions of molluscs to the diets of their occupants. Recent studies have suggested that even large quantities of shellfish were only of supplementary significance in hunter-gatherer diets (e.g. Bailey 1978; Parmalee and Klippel 1974). Bailey, for example, has estimated that more than 57,000 oysters would be required to provide the caloric and protein equivalent of a single European red deer (Bailey 1978:39), and Aten has estimated that the 680 *Rangia cuneata* clams at site 41CH170 on the Upper Texas Coast represent sufficient food for only one or two meals for a group of four to six adults (see discussion in Aten 1983b:13-16).

Group 2 sites appear to yield few if any fish remains. Many of the sites have yielded inadequate data on this point, but the Group 2 sites examined by the author (41NU36, 41NU37, 41NU221, 41NU239, 41NU240, and 41SP103) have yielded few or no fish remains. Much the same can be said for the Allison site (41NU185), where only a single fish otolith was reported from test units bearing Late Prehistoric artifacts (Carlson et al. 1983).

Since all of the sites, except for a few from which no faunal information is available, have yielded at least some mammal remains, it is apparent that land species were hunted regardless of location or intensity of occupation. The poor representation of aquatic species on Group 2 sites suggests, however, that, proportionately, terrestrial mammals were of considerably greater significance at these sites than at the shoreline Group 1 sites. This is in accord with the conclusions already stated for the McKinzie site, the only Group 2 site from which there is a substantial body of excavated data.

So the differential distribution of intensively occupied shoreline sites as opposed to much less intensively occupied riverine sites can be correlated with differences in relative quantities of marine as opposed to land faunal remains. This has significance for the generation of a model of settlement and subsistence patterns, which is discussed from a cultural-ecological perspective below.

The Model

It should come as no surprise that shoreline locations in this study area have yielded evidence of intensive aboriginal occupation. The shallow bays and lagoons between the mainland and the barrier islands of Texas produce a variety of fish and shellfish that are obtained easily with the simple technology of the inhabitants of the area.

We have seen, however, that Late Prehistoric sites in the area vary considerably both in the intensity of occupation and in the kinds of faunal species present. A correlated spatial pattern appears to be involved, with the relativity few intensively occupied sites only on marine shorelines, and the many lightly occupied sites inland along stream courses.

What significance does this distributional pattern have for Late Prehistoric settlement and subsistence patterns? Emerging clearly is the fact that certain shoreline locations were focal points of settlement and subsistence activities and that inland locations saw less intensive, more dispersed occupation. This is ecologically significant, since all of the Group 1 sites are along shallow marine waters containing concentrated and predictable marine resources. These resources were not evenly available to the inhabitants at their respective levels of technological development. Shellfish would have been obtainable only in shallow and generally quiet waters. Fish could have been taken in large quantities with nets and fish traps, but, again, only in the shallower parts of the bays and lagoons. So the Group 1 sites were ideally located in relation to these limitations.

It has been postulated by various authors that hunter-gatherer settlement will generally increase in both intensity and size with a corresponding increase in the concentration and predictability of food resources in a heterogeneous resource mosaic (Butzer 1982:230-43, Hassan 1981:180, Jochim 1981:148-63). This point has been discussed at some length, specifically for hunter-gatherer adaptation in highly productive coastal environments. The high level of concentration and predictability of marine resources at favorable locations is suggested to have been conducive to a corresponding focus and intensity of human settlement (Pearlman 1980, Yesner 1980, Rowley-Conwy 1983), and, for this reason, population aggregations such as Group 1 sites may have occurred at optimal coastal locations. This may be viewed as both an opportunistic response and as a necessary precondition for the successful extraction of large quantities of small-sized species.

The Group 1 sites are, then, ecologically predictable. The socio-cultural implications here offer a potentially fruitful line of inquiry. If Group 1 sites do in fact represent population aggregations, they probably were focal points for social interaction beyond the minimal band level (The term minimum band is used here to refer to the smallest population group thought to have been necessary for the effective functioning of a hunter-gather adaptive system; see Hassan 1981:180-186, Lee and DeVore 1968, Wobst 1974:170). A systemic linkage among subsistence, settlement, and social organization strategies is likely. As favorable resource availability enables minimal band groups to coalesce periodically into larger groups, the opportunities for exchange of information, establishment and maintenance of mating networks, and the performance of rituals and ceremonies that affirm social and ideological ties beyond the minimal band level are both possible and necessary (Wobst 1974, Hassan 1981:180-186).

Therefore it is postulated here that, within the Late Prehistoric settlement patterns, Group 1 sites were base camps that served as focal points for relatively large group aggregates and concomitant socio-cultural elaboration beyond the minimal band level. However, although there can be no doubt that these locations saw relatively intensive occupation, there are no archeological data available for relatively large resident populations, so they simply could have seen more frequent use by small bands than did locations less rich in resources. However, some ethnohistorical and human biological evidences support the inference of population aggregates.

Newcomb (1983:364) has suggested sizeable group aggregates, perhaps as many as 350 to 500 people, among the early historic Karankawans of the region, based on extrapolations from accounts of contemporary observers who reported large groups of warriors. The 1720 account of the French navigator Jean Beranger describes a shoreline encampment of some 500 people near Aransas Pass on the northern edge of this study area (Beranger 1983). This observation, made during the fall season, also refers to circular huts used (apparently by the same group) for storage of fish, which suggests that large quantities of fish were caught and stored for the support of a sizable population.

Research completed recently by Jackson, Boone, and Henneberg (1986) suggested population aggregation during the Late Archaic. Sixty-eight skeletons from a large cemetery site on Oso Bay (41NU2, excavated by A. T. Jackson for The University of Texas in the 1930s) were studied. At least 24 percent of the individuals suffered from what may have been endemic treponematosis, a disease that is likely to be transmitted to such a high percentage of the population only under circumstances of at least part-time population aggregation. So the large groups postulated here for the Late Prehistoric probably were already in the area during the Late Archaic.

If Group 1 sites are seen to represent base camps with population aggregates made possible by concentrated and predictable resources, how can we view the role of the more numerous Group 2 sites? Two possible functions are suggested.

First, they may be short term, function specific sites that were locations for the procurement of specific resources not readily available in the shoreline base camps. Aggregate populations might easily exhaust important terrestrial resources (such as deer, for example) if, as is indicated by substantial accumulations of debris, these locations were occupied over considerable periods of time. Group 2 sites would have served as intermediate procurement stations between the resources of the interior and the consumer populations in the shoreline base camps that were more or less permanent residences for relatively large groups, from which specialized task groups made repeated forays. Smith (n.d.) has postulated such a permanent base camp function for the large Late Prehistoric component at site 41KL13 on Baffin Bay. The evidence at 41KL13, however, may preclude an interpretation of year-round permanence, since black drum otoliths comprise the "overwhelming majority" of fish otoliths collected, and, of the drum otoliths, 70 percent are from winter fish kills and only 2 percent from summer kills (see Smith 1983:499).

A second interpretation of Group 2 sites—the one favored here—is that these sites were not task-specific in function, but rather were the residences of small groups that periodically spread out from base camps that were only recurrently occupied in a seasonally oscillating settlement and subsistence strategy. The data from the McKinzie site have strongly suggested this kind of occupation—a residential, multifunctional seasonal camp. In this perspective, Group 2 sites were the encampments of small groups who practiced a range of subsistence pursuits.

So both shoreline base camps and smaller seasonal camps were focal points for the exploitation of different segments of the adaptive niche. The abundance of marine resources, augmented by the influx into shallow bay/lagoon waters of large quantities of drum fish, allowed the coalescence of significant band aggregates during the fall-winter season. With the scattering of concentrations of drum populations in the spring, the least risk response of the inhabitants of the area was population dispersal. Although some groups may have remained at the temporarily less productive shoreline locations, other groups moved into the riverine zones, presumably attracted by game and plant resources.

At this writing, we have data on seasonality from only three sites in the Corpus Christi Bay area. Clearly, much more information of this kind is needed, but it is perhaps significant that the data we have are complementary rather than contradictory. Seasonality analysis of fish otoliths indicates that at the Group 1 site 41SP120 the heaviest occupation apparently was during the fall-winter period. This is in accord with the response postulated here to particularly abundant winter fish resources. On the other hand, the analyses of the *Rangia cuneata* samples from the McKinzie and Jackson Woods sites (Group 2 sites) indicate spring and spring and early summer occupations respectively—just the times of the year most poorly represented by the otoliths from 41SP120. So the data, although limited, suggest a seasonal cycle involving winter or fall-winter marine-oriented base camps and spring-summer dispersal into smaller groups.

A relevant observation was made by Cabeza de Vaca. Though it pertains to his Capoques and Han groups, who probably lived to the north of this study area around the western end of Galveston Island (Newcomb 1983:361), the seasonal subsistence strategy is similar to the strategy suggested here.

> From October through February every year, which is the season these Indians live on the Island, they subsist on the roots I have mentioned, which the women get from under the water in November and December. Only in these two months, too, do they take fish in the cane weirs. When the fish is consumed, the roots furnish the staple. At the end of February, the islanders go to other parts to seek sustenance, for the root is beginning to grow and is not edible [Covey 1983:61].

Though Cabeza de Vaca seems to have been particularly impressed with the importance of the roots, the mention of weirs suggests that fish were being taken in sufficiently large quantities to be a significant factor in supporting a fall-winter shoreline occupation.

It can be pointed out here, incidentally, that a comparison of the seasonal breakdowns, presented above, of the fish otolith analyses from 41SP120 with those from the Zone III Archaic component at McKinzie, which dates to about 5000 B.P., shows that they have virtually identical patterns of seasonality. So it is possible that the McKinzie Zone III occupation falls into a long-lived pattern of fall-winter emphasis on bayshore resource exploitation that had been established by the mid-Holocene, a possibility that fits in with Corbin's suggestion (1976) of continuity in adaptive patterns from the Archaic through the Late Prehistoric. Future research might well focus on the question of continuity in adaptive patterns in the region from the mid-Holocene to and through the Late Prehistoric [see Prewitt and Paine, herein Editor].

Two groups of sites have been suggested here, but it is likely that there is in the archeological record a third group that represents short term procurement camps the temporal and spatial patterns of resource availability. The model posits a hierarchy of archeological sites falling into two and, predictably, three groupings, each reflecting differences in intensity of occupation, group size, and resource procurement. It is suggested that whereas the overall adaptation that characterized the Rockport complex was strongly oriented toward marine resources, settlement and subsistence activities oscillated seasonally between intensive use of shoreline zones and a more dispersed pattern of exploitation of terrestrial resources.
that served specific functions. These will be difficult to recognize in the field, since cultural debris is likely to be extremely sparse. Such sites, if found, would comprise debris from short term hunting and/or plant-gathering activities by small groups within the catchments of Group 1 and Group 2 sites. It is entirely possible that some of the sites considered here Group 2 are in fact such function-specific sites, but without excavation it would be very difficult to make such a distinction.

In summary, the model (Figure 29) proposed here is an ecological one, with settlement pattern inextricably linked to subsistence strategy and the temporal and

Testing the Model

The following lines of research should be undertaken as tests of the proposed model:

1. Quantification of site densities. Most of the site data reported here come from surface observations, so controlled testing should be undertaken to quantify the densities of artifacts and faunal remains per unit volume of deposit. Such a

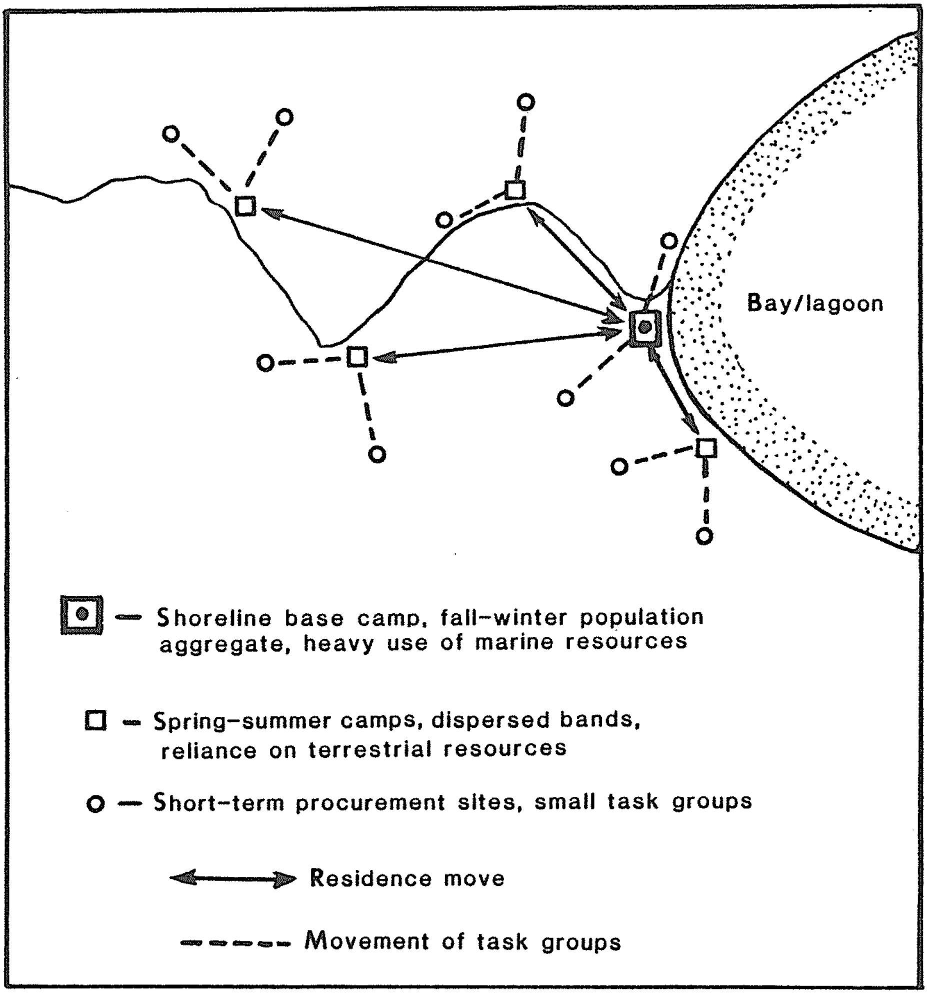

Figure 29. Schematic representation of Late Prehistoric settlement/subsistence pattern model in the Corpus Christi Bay area.

procedure would either put the present hypothesis on a firm footing or indicate the need for revision of the model.

2. Determination of site seasonality. An oscillating pattern of seasonal settlement is postulated here on the basis of data from three sites; expansion of this small data base would help in evaluating these inferences. A surge in research in recent years has opened several lines of inquiry for determination of seasonality, involving the remains of fish (Casteel 1976, Monks 1981), shellfish (Aten 1981, Quitmeyer et al. 1985), and mammals (Monks 1981). The use of as many seasonal indicators as possible from a given site would insure the determination of the season(s) of actual occupation and not simply the seasonal availability of specific kinds of resources.

3. Definition of intrasite patterns. At present the McKinzie site data provide the only details of spatial patterns in a Late Prehistoric site in the study area. In order to evaluate the postulation of both large base camps and camps occupied by small groups, data are needed on spatial arrangements at other sites in the area.

Taken together, this model and the procedures suggested for testing it can serve as a basis for a systematic approach to the Late Prehistoric stage in the central part of the Texas coast. With expansion of the data base, the model would be either strengthened or revised in accordance with the new data. Ultimately, these procedures will make it possible to pursue a productive line of inquiry into the interrelationships among patterns of settlement, economy, and social organization in an adaptation by hunter-gatherers to a resource-rich coastal environment.

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APPENDIX, Tables

Table 1. Aritfact Occurrences by Zone, McKinzie Site (41NU221)

	Zone		
Artifact	I	II	III
Lithic			
Arrowpoint			
Perdiz	1	–	–
Indeterminate	1	–	–
Dart points			
Bell	–	–	1
Catan	–	–	1
Catan-like	–	–	1
Tortugas	–	–	1
Bifaces (untyped)	2	–	1
End scrapers	1	–	2
Prismatic blades	12	–	–
Core	1	–	–
Utilized flakes	12	–	10
Quartzite chip	1	–	–
Clear fork tool (fragmentary)	–	–	1
Obsidian flake	–	–	1
Debitage (totals)	596	47	233
Flakes			
Primary	23	2	7
Secondary	51	6	15
Tertiary	97	14	47
Thinning	104	9	59
Flake fragments			
Primary	20	2	8
Secondary	49	3	16
Tertiary	224	11	71
Chunks	28	–	10
Modified sand-stone milling stone	1	–	–
Ceramic			
Rockport ware	196	–	–
Bone tempered	1	–	–
Bone			
Awl(?) fragments	3	–	–
Shell			
Conch shell adze	–	1	–
Rangia scrapers	2	–	–
Edge-flaked sunray venus	–	1	–
Perforated oyster	–	–	1
Rectangular oyster	–	–	1

Table 2. Faunal Remains by Zone, McKinzie Site (41NU221)

Animal	Zone I	Zone II	Zone III
Mammals (Number of fragments)			
Bison	19	–	–
White-tailed deer	2	–	–
Birds			
Sp. unidentified	4	–	–
Turtle			
Sp. unidentified	22	–	–
Frog			
Sp. unidentified	1	–	–
Fish (otoliths)			
Black drum	–	–	5
Trout	1*	–	2
Redfish	–	–	2
Catfish	1*	–	16
Croaker	–	–	7
Shellfish			
Rangia cuneata	879	287	–
Rangia flexuosa	456	109	12,722
Oyster	45	–	293
Angel wing	–	–	15
Mussel	–	–	6
Cockle	–	–	3
Marsh periwinkle	–	–	1
Marginella	–	–	1
Sunray venus	2	–	–
Land snails			
Rabdotus	171	112	239
Others *(Polygyra, Helicina)*	67	62	present

*-May have been redeposited from Zone III disturbance. See text.

Table 3. Relative Densities of Cultural Debris, Kinds of Faunal Remains, and Environments for Sites Summarized in Text

Site	Density of Debris		Fauna		Environment	
	Low	High	Mammal (Present)	Marine (Abundant)	Shoreline	Riverine
41NU1		x	x	x	x	
41NU11		x?	x	x?	x	
41NU219		x	x	x	x	
41SP11		x?	x	x?	x	
41SP27		x	x	x	x	
41NU120		x	x	x	x	
41NU33	x		–	–		x
41NU36	x		x			x
41NU37	x		x			x
41NU46	x		–	–		x
41NU47	x		–	–		x
41NU99	x		x			x
41NU105	x		x			x
41NU107	x		x			x
41NU157	x		x			x
41N4178	x		x			x
41NU179	x		–	–		x
41NU185	x		x			x
41NU193	x		–	–		x
41NU221	x		x			x
41NU231	x		–	–		x
41NU235	x		x			x
41NU239	x		x			x
41NU240	x		x			x
41SP103	x		x		x	

x?-Questionable categorization

– No data

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Archeological Investigations at Shy Pond, Brazoria County, Texas

D. L. Hamilton

ABSTRACT

Archeological investigation of two *Rangia* shell midden sites at Shy Pond, a small body of water on the Brazos deltaic plain on the northwest edge of the town of Lake Jackson, Brazoria County, Texas, was conducted in the summer of 1967 by the Texas Archeological Research Laboratory (TARL) of The University of Texas at Austin. The data indicate that hunting and gathering groups occupied the area from late summer to early fall. The sandy paste ceramic tradition and the cultural manifestation are most strongly affiliated with the Galveston Bay area to the east, but the artifacts have less typological variation than is found there. The Brazos deltaic plain apparently was an isolated area between Galveston Bay to the east and the Central Texas coast to the west. The data from the sites provide insight into cultural developments and adaptations to the varied coastal environments of the Gulf Coast of Texas.

INTRODUCTION

In the summer of 1967, from July 17 through August 4, archeological excavations were carried out at two sites on the northwest side of Shy Pond, a small pond in an old meander belt of the Brazos River. Situated between the present channel of the Brazos River to the west and Oyster Creek to the east, the pond is on the northwest edge of the town of Lake Jackson, in Brazoria County, Texas. It is on the Colorado/Brazos deltaic plain, and is about 20 km (12 miles) from the Gulf Coast, in an area that varies in elevation from 4.5 to 6 meters (15 to 10 feet) above mean sea level.

Until these investigations were made, no extensive controlled archeological excavations had been carried out in the area. The Archeology Club of the Brazosport Museum of Natural Science, under the direction of the late Raymond Walley, of Lake Jackson, carried out limited excavations of some of the sites, but most have not been investigated and none has been published. Since this report was started, Aten (1971) has reported on the Dow–Cleaver site, 8.8 km (5.5 miles) south of Shy Pond.

Due to the enthusiasm and concern shown by Mr. Walley, Dee Ann Story and Thomas R. Hester, of TARL, visited Lake Jackson to examine several sites near Shy Pond. They noticed many *Rangia* shell middens of various sizes on slightly elevated elongated ridges around the pond, several of which looked promising. Since the prehistory of this part of the Gulf Coast largely has been ignored to date and archeological excavations would provide significant data about local developments and possible relationships with the central and southwestern Gulf Coast, one extensive *Rangia* shell midden, site 41BO13, later named the Copperhead site, was excavated.

When rain interrupted work at the Copperhead site, time was spent testing the Cleaver site (41BO15), a small *Rangia* midden. The results of both excavations are reported here.

Since both sites were excavated using English measurements, the excavation measurements and site plans are in English units. However, metric equivalents are given for most measurements.

ENVIRONMENTAL SETTING

The Colorado/Brazos deltaic plain is a late Quaternary feature associated with the development of the Gulf Coast shoreline in the last 5,000 years (LeBlanc and

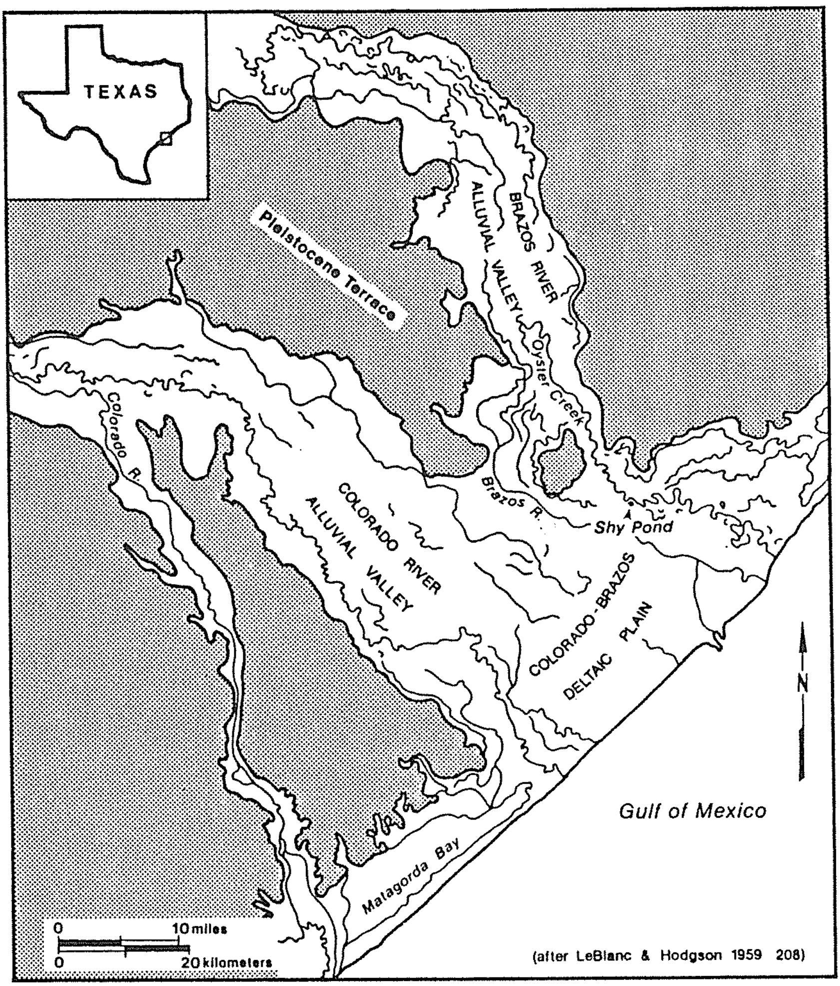


Figure 1. Map of parts of Brazoria and Matagorda counties, Texas, showing the alluvial valleys and deltaic plains of the Colorado and Brazos rivers.

left abandoned channels, meander belts, small lakes, and swamp areas. Shy Pond is in a low-lying area next to a series of point bar ridges and swales in an Hodgson 1959:204). Upon this deltaic plain the Brazos River and other streams old meander belt associated with the Oyster Creek Channel stage of the Brazos River (Figure 2). The Brazos River diverged from the Oyster Creek Channel about 1,000 years ago (Bernard et al. 1970:8), but since the Shy Pond sites postdate this divergence, the channel sequence of the Brazos River is not discussed here.

The sites around Shy Pond are on long, narrow point bar ridges slightly elevated above the surrounding terrain (Figure 2).

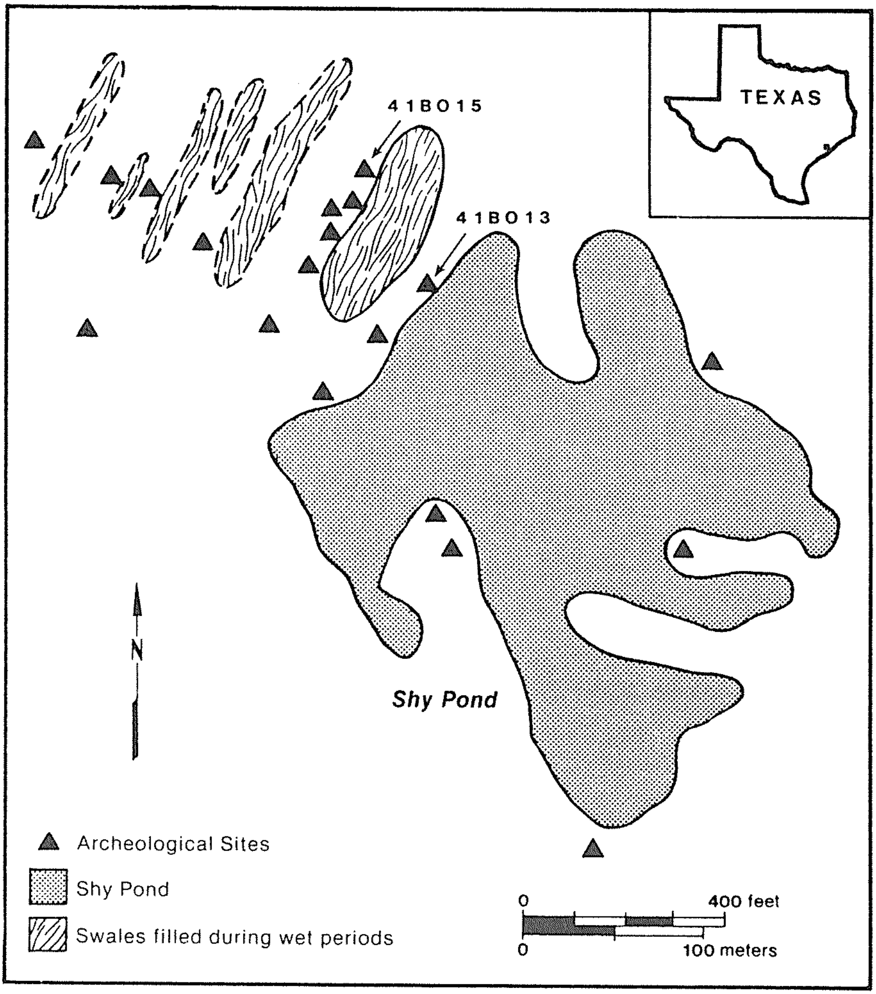


Figure 2. Sketch plan of Shy Pond showing associated sites. Swales are between the point bars.

A point bar ridge is the principal depositional environment within a meander belt. Point bars are parts of bar systems that are created when meanders cut rapidly into eroding banks while arcuate systems of alternating low ridges and swales are formed on the depositional banks (Bernard and LeBlanc 1965:171–172). They are formed over varying lengths of time, depending on the volume of the water flow and the rate at which the meanders travel, so point bar ridges—which are formed sequentially—are separated from one another by a passage of time, and each ridge in a meander belt represents a separate period in the depositional development of the meander belt.

Local informants report that there is a sequence of at least five point bar ridges along the northwest side of Shy Pond, and there are several *Rangia* middens on each of these ridges (Figure 2). It has not been demonstrated archeologically, but it is possible that the sites associated with each of the five or more point bar ridges of Shy Pond represent chronological sequences of occupation in the area. However, all of the sites investigated appear to postdate A.D. 1000.

The Shy Pond area of the Colorado/Brazos deltaic plain is in the coastal prairie subdivision of the Texas Coastal Plain physiographic region, which is a nearly flat strip of land 48 to 128 km (30 to 80 miles) wide, bordering the Texas Gulf Coast (Moore 1970:127). The Shy Pond site is in a borderline area between the Austroriparian and Texan biotic provinces (Dice 1943, Blair 1950). However, the alluvial soils along the Brazos and other rivers support a floodplain cover of oaks, blackberries, pecans, and other trees that provide environmental conditions more favorable to the Austroriparian species (Blair 1943:97, 101).

According to Blair (1943:99) there are 47 species of mammals, 29 of snakes, 10 of lizards, two of land turtles, 17 of anurans, and 18 of urodeles in the Austroriparian. In addition, alligators, various aquatic turtles, freshwater and brackish water fish, various amphibians, and various freshwater and brackish water mollusks such as *Unio* and *Rangia* live in the area. There are no species endemic to the area.

ARCHEOLOGICAL BACKGROUND

Two late prehistoric artifact assemblages (foci) have been defined for the Gulf Coast—one to the east and one to the west of the Brazos River. The Rockport focus has been described in the Central Gulf Coast area from the Brazos River to Baffin Bay, and the Galveston Bay focus has been described in the Galveston Bay area and eastward to the Brazos River (Suhm, Krieger, and Jelks 1954:132, 133). Readers are directed to Ambler (1967), Aten (1967, 1971, 1979), Campbell (1960:145–175), Corbin (1974:29–54), Dering and Ayers (1977), Story (1968), Suhm, Krieger, and Jelks (1954), and Wheat (1953) for more information on the prehistory of the Gulf Coast of Texas.

The artifact assemblages of the Rockport and Galveston Bay foci are differentiated primarily on the basis of the associated pottery. The diagnostic ceramics of the Rockport focus are the Rockport ware consisting of Rockport Plain, Rockport Black–on–gray, and Rockport Incised. Rockport ware can be described generally as having a fine–textured sandy paste (with or without white inclusions believed to be bone), smoothed surfaces, geometric incised designs on the rims, and, frequently, asphaltum used for decoration or for mending cracks in vessel walls (Campbell 1962:331, 332).

In the Galveston Bay focus, two pottery types—Goose Creek Plain and Goose Creek Incised—were identified (Suhm, Krieger, and Jelks 1954:129). As originally defined, the Goose Creek types had sandy paste that sometimes contained grog and, rarely, pulverized bone, as additional temper, with a red wash applied to the exterior surface in rare cases (Suhm and Jelks 1962:55–57). It soon became evident that the Goose Creek types could be broken usefully into additional types that have definite chronological and perhaps, regional, significance. Aten (1967), in the Jamison site report, redefined Goose Creek Plain and Goose Creek Incised as having exclusively sandy paste with no additional aplastics. Aten then established the Goose Creek Red Filmed type for the red washed sandy paste pottery, the San Jacinto Plain and San Jacinto Incised types for the sandy paste pottery with grog temper, and an unnamed bone–tempered pottery type (Aten 1967:10–15). Aten found that Goose Creek Plain and Goose Creek Red filmed were the earliest ceramics and that Goose Creek incised, the grog–tempered San Jacinto types, and the bone–tempered pottery appeared later, in that order.

Later work in the Galveston Bay area (Ambler 1967) has shown that the Galveston Bay focus is too broad and, for that reason, invalid as defined. Similarly, the Rockport focus is believed to be so broad that it oversimplifies the cultural history of the area just as the Galveston Bay focus did (Story 1968:5, Corbin 1974). It is clear that there were two ceramic traditions on the Texas Gulf Coast, but, on the basis of present data, it appears that some Rockport ware has its origin in the sandy paste pottery of Southeast Texas, since the sandy paste, the vessel forms, and the incised decoration have earlier counterparts in the Galveston Bay area (Campbell 1962:335).

In the coastal area between Galveston and Matagorda bays there is an overlap of Rockport ware and the Galveston Bay area types (Campbell 1962:335). It is in this area that the least archeological investigation has been done. In order to answer the many questions about the interrelationshps of the central part of the Texas Coast and the Galveston Bay area, investigations must be made in the Colorado/Brazos deltaic plain, since that area is the center of the overlap of the two ceramic traditions.

ETHNOGRAPHIC BACKGROUND

From data presented by Newcomb (1961:59, 60), Campbell (1960:148, 149), and Wheat (1953:16), it appears that in early historic times the Colorado/Brazos deltaic plain was a transitional area between two major linguistic groups of the Gulf Coast—the Karankawan speakers of the central part of the Coast who, at least in part, are represented by both the Rockport and Galveston Bay foci (Corbin 1974) and the Atakapan speakers of the Southwest Texas Gulf Coast, who must also be represented in part by the Galveston Bay focus. The Karankawan speakers in the Colorado/Brazos deltaic plain were the Capoques (Coco, Cocos, Coaque), who occupied the coastal area from Galveston Bay southwestward to the Brazos River, and the Kohanis (Cujane), who occupied the area around the mouth of the Colorado

River (Newcomb 1961:315, Campbell 1960:148).

The Atakapan–speaking Akokisa (Arkokisa, Orcoquizac) are placed by Newcomb (1961:315) in the area around the lower Trinity and San Jacinto rivers and along the eastern shore of Galveston Bay. Wheat (1953:16), in addition, has the Akokisa occupying the area north and northwest of Galveston Bay in the Addicks Basin region. The Hans, who are believed to be linguistically Atakapan but culturally similar to the Karankawas, shared the coastal area between Galveston Bay and the Brazos River with the Karankawan Capoques (Newcomb 1961:59, 317).

In addition to these groups, some Lipan Apaches and Tonkawa were pushed to the coast in the eighteenth century. The Mayeye band of the Tonkawa of Central Texas moved to the coast in 1770 and, by 1779, the Mayeye had united with the Capoque and ranged along the coast between the Colorado and Brazos rivers (Wheat 1953:161). Despite our knowledge about the various groups that occupied the Colorado/Brazos deltaic plain, few, if any, archeological sites can be identified with a specific group. However, the archeological remains in the area usually are attributed to the Karankawa.

Unfortunately, there is little ethnographic data on the subsistence patterns of the coastal groups. The ethnographic information available indicates that the coastal inhabitants followed a seasonal round regulated by availability of food, climatic considerations, and the presence of other groups in the area. For example, according to Newcomb (1961:66), the Capoque and the Hans of the coast camped on the offshore islands, catching fish in cane weirs and eating the roots of an unidentified underwater plant during the fall. By midwinter, the offshore islands and bars were cold and wet, and the underwater plant roots were useless as food. The bands were forced to move to the warmer mainland, where they subsisted on shellfish until spring. In the spring they gathered blackberries, and apparently they spent the summers on the lagoons and offshore islands and bars. This description provides some insight into a seasonal round on the Gulf Coast, but it is important to our understanding of the prehistory of the coast to determine what seasons were spent in what regions or ecosystems (such as Shy Pond) of the coast. It should be emphasized that sensitive and exacting archeological techniques must be used for interpretation of seasonal occupation, and special emphasis must be given to obtaining complete faunal samples. Only with data that are systematically obtained from rigorously controlled excavations will it be possible to reconstruct seasonal subsistence patterns.

THE COPPERHEAD SITE, 41BO13

Raymond Walley originally located the Copperhead site. A large pothole in the center of the site revealed a concentrated *Rangia* shell midden and several sherds. Other smaller potholes scattered through the midden revealed an extensive but thin horizontal accumulation of shell.

The Copperhead site is a *Rangia* shell midden 12.2 to 15.3 meters (40 to 50 feet) wide that extends along a long, low ridge on the northwest side of Shy Pond. The midden generally covers the higher central part of the ridge. Directly to the west, on the same ridge, are two *Rangia* shell middens designated sites 41BO11 and 41BO12. (Site designations at Shy Pond often are arbitrary, for site numbers have been assigned to areas where shell midden lenses are exposed on the surface or in excavations.) Sites 41BO11, 41BO12, and 41BO13 merge into one another, forming an almost continuous shell midden for some 183 meters (200 yards).

The northwest shore of Shy Pond now comes to within 45 meters (150 feet) of the Copperhead site, but, after a rain, the flat area between the ridge and the pond fills to within 15 meters (50 feet) of the site. The ridge rises about .91 meters (3 feet) above the level of Shy Pond.

Excavation Methods

Before excavation, after the heavy underbrush, shrubs, and vines had been cleared, a horizontal datum point designated 00 (North 0, South 0) was established and recorded on a wooden stake about 15.2 meters (60 feet) north of the Shy Pond shoreline (Figure 3). A north–south base line was established, laid out through the datum point, and excavation units were established on both sides. Because of several large trees on the site, the excavation units varied in their dimensions (Table 1). The southeast corner stake was used to designate each unit. A large nail driven into the base of a large oak tree near the N35/E10 coordinate served as a vertical datum point, with the elevation arbitrarily designated 100 feet. The elevation of the vertical datum point was used to determine the elevation in the excavation units and in all of the site plans. A topographic map was made with the help of a telescopic alidade. Because of the dense vegetation and lack of time, only the area adjacent to the excavations was mapped.

In the first two 5–foot squares, it became apparent that the simple stratigraphy and the shallow depth of the cultural deposits made digging by arbitrary elevation levels unnecessary. The soil overlying the midden was essentially devoid of cultural material; some was spot screened and some was removed and discarded without screening. All of the matrix from the midden was screened through quarter–inch wire mesh screen. All of the stone, sherds, clay lumps, bones, and historic materials were collected.

The objectives of the excavation were to (1) expose an extensive horizontal area of the midden, (2) sample the contents of the midden, (3) determine the extent of the midden, and (4) investigate the intrasite variability. The materials found above, on the surface of, and within the midden were cataloged separately. After the surface had been carefully exposed and cleaned (Figure 3), elevations were taken, and scale plans showing the extent of the shell in each unit were made. Adjacent units were similarly excavated until a large area of the midden was exposed and excavated. All of the shell matrix was screened, but time permitted excavation of only about half of the exposed part of the midden.

Late in the excavation, in an attempt to determine the extent of the midden, 15 trenches, 30.48 cm (1 foot) wide and 1.5 to 5.49 meters (5 to 18 feet) long were dug. Evidence from trenches failed to disclose the extent of the midden, but did show that it was considerable (Figure 4), and shell scattered on the surface indicates that the midden extends for about 183 meters (200 yards) along the ridge. The stratigraphy

Table 1. Dimensions of Excavation Units and Locations of Trenches at the Copperhead Site (41BO15)

Unit[1]	Dimensions	Location
N50/00	0.9x1.5 m (3x5 ft.)	
N50/E5	1.5x1.5 m (5x5 ft.)	
N50/E10	1.5x1.5 m (5x5 ft.)	
N45/00	0.9x1.5 m (3x5 ft.)	
N45/E5	1.5x1.5 m (5x5 ft.)	
N45/E10	1.5x1.5 m (5x5 ft.)	
N40/00	0.9x1.5 m (3x5 ft.)	
N40/E5	1.5x1.5 m (5x5 ft.)	
N40/E10	1.5x1.5 m (5x5 ft.)	
N25/W10	2.1x1.5 m (7x5 ft.)	
N25/W5	1.5x1.5 m (5x5 ft.)	
N25/W02	0.9x1.5 m (3x5 ft.)	
N20/W05	1.5x1.5 m (5x5 ft.)	
N15/W15	0.6x1.5 m (2x5 ft.)	
N15/W10	1.5x1.5 m (5x5 ft.)	
Trench 1	.3x3.04 m (1x10 ft.)	N of stake N30/W2
Trench 2	.3x3.04 m (1x10 ft.)	E of stake N55/E10
Trench 3	.3x3.04 m (1x10 ft.)	N of stake N55/E10
Trench 4	.3x3.04 m (1x10 ft.)	N of stake N60/00
Trench 5	.3x1.52 m (1x5 ft.)	N of stake N55/E11
Trench 6	.3x3.04 m (1x10 ft.)	W of stake N30/W17
Trench 7	.3x3.04 m (1x10 ft.)	S of stake N30/W17
Trench 8	.3x3.04 m (1x10 ft.)	W of stake N20/W17
Trench 9	.3x3.04 m (1x10 ft.)	N of stake N30/W17
Trench 10	.3x1.52 m (1x5 ft.)	S of stake N20/W17
Trench 11	.3x1.52 m (1x5 ft.)	E of stake N55/E25
Trench 12	.3x3.04 m (1x10 ft.)	N of stake N00/00
Trench 13	.3x1.52 m (1x5 ft.)	E of stake N25/00
Trench 14	.3x1.52 m (1x5 ft.)	S of stake N54/E30
Trench 15	.3x5.48 m (1x18 ft.)	N of stake N30/W10
Test Pit 1	.9x1.52 m (3x5 ft.)	Not oriented with grid. Extends northeast of N60/E22.
Test Pit 2	.9x.9 m (3x3 ft.)	Not oriented with grid. Extends southwest of N20/W23.

[1] Unit designation is the coordinates at the southeast corner stake.

at the site is simple (Figures 5, 6). Zone 1 (the uppermost zone) is a hard, compact black sandy clay called gumbo, extending to as much as 39.6 cm (1.3 feet) below the surface, averaging 30.48 cm (1 foot) in thickness. At the juncture of Zones 1 and 2 in some parts of the site the two zones are mixed.

Figure 3. Photographs of the Copperhead site: Above, view of excavations, looking north; Below, view of main excavation area with shell midden exposed.

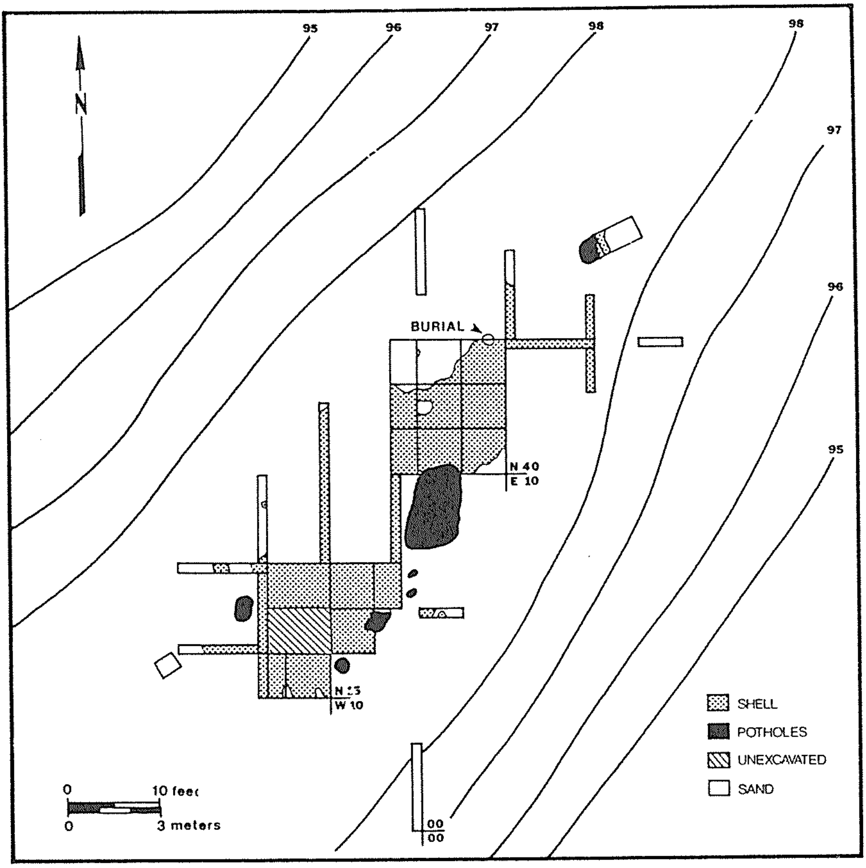


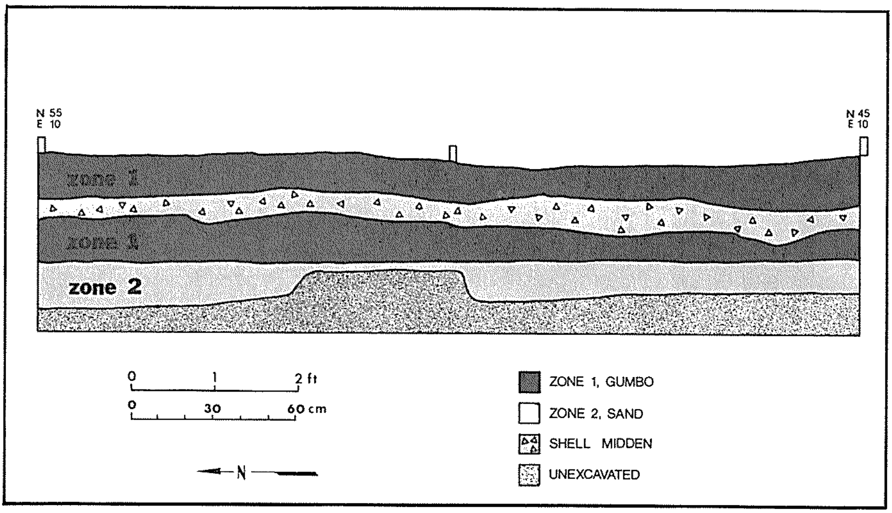
Figure 4. Topographic map of the Copperhead site showing excavation grid, trenches, and potholed areas.

Stratigraphy

The stratigraphy at the site is simple (Figures 5, 6). Zone 1 (the uppermost zone) is a hard, compact black sandy clay called gumbo, extending to as much as 39.6 cm (1.3 feet) below the surface, averaging 30.48 cm (1 foot) in thickness. At the juncture of Zones 1 and 2 in some parts of the site the two zones are mixed.

Lying entirely within Zone 1 is the shell midden, which forms elongated lenses. The depth at the top of the midden averages 18.2 cm (0.6 feet), but ranges between 9 and 21 cm (0.3 and 0.7 feet). Except for a few isolated contacts with the top of Zone 2, the bottom of the shell midden is 6 to 18 cm (0.2 to 0.6 feet) above the top of Zone 2. The thickness of the midden seldom exceeds 18 cm (0.6 feet). Most artifacts came from the surface and interior of the midden. The upper half of Zone 1 is largely devoid of cultural material. In Zone 1, cultural material was found at

A



B

Figure 5. A, Photograph showing general view of excavations, looking northeast. The stakes and string mark the line of profile. A burial is exposed in the foreground. B, Profile along line E10 from N50 to N55.

Figure 6. Photograph of the profile along line E10.

the same elevations inside and outside the midden. The presence of artifacts in the upper part of Zone 1 is largely the result of disturbance. In the distribution tables and in the remarks about provenience, Zone 1 is always the part of Zone 1 that overlies the midden. Zone 2 is a stratum of sterile red sand underlying Zone 1 and, where it is present, the midden. This stratum begins 27.4 to 39.6 cm (0.9 to 1.3 feet) below the surface and extends to an unknown depth.

Basically at the Copperhead site there is a lower stratum of medium-to-fine red sand that was apparently deposited during the formation of the point bar in the old meander belt of the Oyster Creek Channel stage of the Brazos River. The black sandy clay gumbo of Zone 1 was then deposited on the uneven eroded red sand surface of Zone 2. In some areas the gumbo became mixed with the red sand, producing a light red to greenish red matrix. Since the midden lies directly on the red sand surface of Zone 2 in several places, its accumulation obviously began soon after the start of the deposition of the Zone 1 gumbo. In most instances, however, the midden is 6 to 9 cm (0.2 to 0.3 feet) above the top of Zone 2, surrounded completely by the gumbo matrix of Zone 1. It is assumed that floods and overflow periodically covered the point bar ridge, depositing the layer of black sandy clay gumbo.

Burial

The poorly preserved burial of a juvenile was found in the northern half of Unit N50/E10 and the southern third of Unit N55/E10 (Figure 7). The outline of a burial pit 82.2 cm (2.7 feet)east to west and 103.6 cm (3.4 feet) north to south could be traced from the lower part of Zone 1 into the red sand of Zone 2 along the outside

Figure 7. Photograph of the burial exposed in the north end of unit N50/E10, looking southeast. Trowel points to the north.

edge of the midden. The burial was semiflexed and on the right side, with the head to the south and the face to the east (Figure 7). The skull was at 40.84 cm (1.34 feet) below the surface, well into the red sand of Zone 2. Four sherds, some *Rangia* valves, and a few fragments of animal bone were in the grave fill.

Since the burial was found at the close of the excavation, the skeleton was exposed, photographed in situ, drawn to scale, and removed by the Brazosport Museum under the direction of Raymond Walley, who found a small expanding stem arrowpoint (Figure 14, B) about 6 cm (0.2 feet) from the base of, and at the same elevation as, the spine. The tip of the point was oriented to the southwest, away from the spine. There is no indication that it penetrated any bone, nor is there any indication that it is a grave offering. All the artifacts could be accidental inclusions from the midden debris. The skeletal remains have not been analyzed, and no other features were recognized at the site.

Artifacts

Six hundred fifty–four artifacts were recovered from the Copperhead site (Table 2). They were sorted into ceramic, stone, bone, and shell categories, which were then broken down into more discrete groupings according to shared attributes. Functional terms are used for some of the artifact categories, but they are merely heuristic devices, and no specific functions are implied by their use. In most cases, purely descriptive designations are used.

The materials recovered from the Copperhead site consist of ceramic, lithic, bone, and some historic artifacts. Unutilized flakes have been treated as artifacts

Table 2, a. Distribution of Artifacts at the Copperhead Site, 41BO13

Artifact	Unit[1]:	N50 00	N50 E5	N50 E10		N45 00	N45 E5	N45 E10		N40 00	N40 E5	N40 E10		N25 W10	N25 W5		N25 W2	N20 W5		Total
	Zone[1]:	1	1	1	M	1	1	1	M	1	1	1	M	1	1	M	1	1	M	
Ceramic																				
Goose Creek Incised		–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Goose Creek Plain																				
Category 1 sherds																				
4-7mm thick		9	8	1	–	1	4	5	4	28	8	5	–	2	2	2	1	–	2	82
Category 2 sherds																				
5-7mm thick		1	1	1	2	1	5	5	9	–	6	4	–	4	–	1	1	1	5	47
3-4mm thick		–	2	–	–	6	4	6	12	1	13	8	2	–	–	–	–	2	10	66
Category 3 sherds																				
5-7mm thick		7	6	–	–	–	3	2	1	10	10	1	–	3	–	–	–	–	1	44
With asphalt		–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	6
3-4 mm thick		19	8	4	4	3	9	6	23	7	59	7	4	2	2	–	2	3	1	163
San Jacinto Plain		1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	3
Fired clay lumps		–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	3
Total ceramics		37	25	7	6	12	25	24	49	46	97	25	6	19	4	3	5	6	19	(415)

Lithic																			
Catahoula arrowpoint	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Expanding stem point	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Expanding base drill	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Thinned biface frags.	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	2
Utilized flakes	1	–	–	–	–	–	–	–	1	3	1	–	3	1	1	2	–	1	14
Steeply trimmed unifaces	–	1	–	–	–	–	1	–	–	2	–	–	–	4	–	2	1	–	11
Unutilized flakes	–	2	–	–	–	–	–	1	–	5	1	–	–	4	4	–	1	1	19
Core	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Total lithics	1	3	–	–	–	–	1	1	1	10	3	–	3	10	5	4	2	2	(46)
Bone																			
Pointed implement	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Awls, awl fragments	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	2
Incised alligator bone	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Tool–making residue	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Total bone	–	–	–	1	–	1	–	1	–	–	–	1	–	–	–	–	–	–	(4)
TOTAL ARTIFACTS	38	28	7	7	12	26	25	51	47	107	28	7	22	14	8	9	8	21	465

[1] Zone 1–surface to top of midden
Zone M-within the shell midden

Table 2, b. Distribution of Artifacts at the Copperhead Site, 41BO13

Artifact	T10 N15 W15		N15 W10		B1	T1	T3	T5	T6	T7	T8	T9	T13	TP1	NP	Total
Zone[1]:	1	M	1	M		1	1	1	1	1	1	1	1	1	1	
Ceramic																
Goose Creek Incised	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Goose Creek Plain																
Category 1 sherds																
4-7mm thick	–	–	2	2	1	4	4	–	–	–	3	–	–	–	–	16
Category 2 sherds																
5-7mm thick	1	–	9	3	1	1	3	1	–	6	–	–	1	1	6	33
3-4mm thick	–	–	4	4	–	–	–	–	–	–	–	–	–	1	4	13
Category 3 sherds																
5-7mm thick	–	–	2	3	–	–	3	–	2	–	–	1	1	2	7	21
With asphalt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
3-4 mm thick	–	–	11	6	2	–	1	1	–	2	–	–	5	2	7	37
San Jacinto Plain	12	2	4	–	–	–	–	–	–	1	–	–	–	–	–	19
Fired clay lumps	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	2
Total ceramics	13	2	32	18	4	5	11	2	3	9	3	1	7	6	25	(141)

Lithic																
Catahoula arrowpoint	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Expanding stem point	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1
Expanding base drill	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Thinned biface frags.	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Utilized flakes	–	–	3	4	–	1	–	–	–	1	–	–	–	–	2	11
Steeply trimmed unifaces	–	–	3	2	–	1	–	–	–	–	–	–	–	–	1	7
Unutilized flakes	–	1	2	6	–	2	–	–	–	–	–	–	–	–	5	16
Core	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Total lithics	–	1	8	15	1	4	–	–	–	1	–	–	–	–	9	(39)
Bone																
Pointed implement	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Awls, awl fragments	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	2
Incised alligator bone	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Tool–making residue	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Total bone	–	–	1	1	–	–	–	–	–	1	–	–	–	–	1	(4)
TOTAL ARTIFACTS	13	3	41	34	5	9	11	2	3	11	3	1	7	6	35	184

[1] Zone 1, surface to top of midden
Zone M, within the shell midden

B1-burial 1 grave fill
T-trench
TP-test pit
NP-no provenience

because, as indicators of occupational intensity, they are considered as good as the obvious artifacts such as sherds, utilized flakes, and fired clay lumps. The historic objects—four metal cartridge casings and one potsherd—were recorded to give an indication of the amount of mixing and disturbance that has taken place since the aboriginal occupation, but they are not discussed.

Ceramics

Six hundred sixty–one sherds were recovered from the Copperhead site. One rim sherd was decorated; the rest of the sherds were plain. For the analysis, a fresh break on each sherd was inspected under a 10x binocular microscope in order to identify the temper and grain size in the paste; the microscopic examination showed that all had sandy paste. Twenty–two sherds had grog as an additional tempering agent. Inclusions commonly found in the paste are organic materials such as carbonized roots, small pieces of hematite, and scattered unidentified white particles that appear to be calcium carbonate. No significant variation or intrasite distribution could be found in the size of the sand grains in the paste; on the Wentworth scale they fell between the upper range of very fine (0.074 mm) and the lower range of fine (0.49 mm). This grain size variation was found to be characteristic of the basal red sand of Zone 2 below the occupational level. The inclusions and the sand in the paste could result from the use of naturally occurring sedimentary carbonaceous sandy clay for making the pottery.

As a group, the sherds can be characterized as poorly fired, with very fine to fine sandy paste. All have soft paste and are very grainy and friable; none are harder than 2.5 on the Moh scale. The frequent breakage at poorly wedged coil junctures and the high incidence of rectangular sherds indicate that the vessels were made by the coiling technique. A study of sherds with breaks along the coils indicates that the coils were commonly wedged together by pressing down on the inside and pulling up on the outside.

In previous reports from Southeast Texas (Ambler 1967, Shafer 1968), sandy paste plain ware has been separated into temper and grain size categories. Other variations within temper and paste categories have been largely ignored or inadequately described. The regional variations in plain ware may have regional and chronological significance and so may be important for comparison with adjacent regions within a culture area. Unfortunately, these kinds of studies have not been made. Different regions with single pottery traditions may have significant surface treatment modes, so in the analysis the sandy paste plain ware was separated into more discrete categories based on the treatment of the surfaces.

All surfaces were either (1) floated and/or lightly polished or (2) smoothed and/or scraped. The exterior surfaces were generally buff to red; the interiors were buff to red or gray to black or dark brown. For convenience, these colors are described as oxidized (lighter colors—buff to red) or unoxidized (dark browns, gray to black). Shepard (1956:103–106) states that the firing atmosphere cannot be determined accurately from the color of the pottery because the nature of the clay and impurities in the clay also affect the color. However, the colors can be categorized as oxidized or unoxidized.

The term *floated* refers to the process of lightly rubbing the surface of the vessel, while the clay is still wet, with a film of water that floats the finer particles of the clay in the paste to the surface and results in a thin, lustrous film on the surface of the vessel, giving the appearance of a slip. After firing, the floated surface is darker than the paste and is often crazed. The floated surface is not durable; it erodes easily and deteriorates with wear. It is sometimes difficult to distinguish between floated and lightly polished surfaces. However, most of the surfaces appear to have been floated, so no distinction is made between them here.

The term *polished* generally refers to the process of rubbing the partially dried surface of a vessel with a hard object such as a smooth rock in order to compress the clay particles, thereby smoothing and polishing the surface.

The term *smoothed* refers to the process of wiping the surface with a pliant material such as the hand or a piece of leather, which causes a plastic flow on the surface of the clay that produces a smooth finish.

Scraping refers to rubbing the surface with a hard object such as a potsherd, gourd, rock, or piece of wood. The surface is thinned and made smooth by scraping, but small striations and grooves remain. A few sherds may have a combination of smoothing and scraping, but most appear to have been smoothed, so all are called smoothed here. The exterior surfaces of many sherds are greatly eroded, whereas the interior surfaces are not eroded at all. Many of the sherds without eroded surfaces have been smoothed. The floated surfaces usually are eroded more severely than the smoothed surfaces.

According to Shepard (1956:216–220), *smudging* is the result of an extreme reducing atmosphere that causes carbon to be deposited on the surface of the vessel, producing a gray–to–black color. When the unoxidized color is not dense gray or black, but is instead light gray, the term *reduced* is used instead of smudged; the difference between the two is a matter of intensity. Most of the sherds from the Copperhead site have blackened or gray interiors. It is not certain, but the blackened interiors may not be accidental, since the denseness of the black on many of the interior surfaces is greater than what would have resulted from a reduced atmosphere in direct firing. Nonetheless, it is not clear whether the smudging was an end product of manufacture or a byproduct of a cultural activity. Smudged is used here to describe sherds that are dark gray to dense black over their entire interior surfaces. The smudging frequently extends over the lip and onto the external rim surface.

The interior smudging, the overlapping of the smudging onto the external rim surface, the cores with reduced zones along the inner surface and an oxidized zone in a double band effect along the outer surface suggest that the pots were fired mouth down. Firing a vessel mouth down would concentrate the smoke in the inside, smudging the interior surface. If organic matter is deliberately placed inside the vessel, the smudging effect is maximized, because the smoke builds up and pours out of the vessel and up the outside. The smoke smudges the lower part of the outside, around the rim, but the flames of the fire oxidize the carbon in the smoke before any can be deposited higher up on the vessel. This type of firing process may explain the distribution of the smudging on the sherds; a smoking fire alone does not explain it.

On the basis of the tempering agent and the treatment of the surfaces, the sherds at the Copperhead site are divided into three categories, (1) sandy paste decorated, (2) sandy paste plain, and (3) grog-tempered plain. The sandy paste plain sherds are further divided into (a) sherds with both surfaces oxidized, as indicated by the surface color, (b) sherds with the interior surface floated and smudged, and (c) sherds with the interior surface smoothed and smudged. Typologically the pottery fits the description of Goose Creek Incised, Goose Creek Plain, and San Jacinto Plain as described by Aten (1967). Detailed descriptions of each are given to show the variation within the types. These variations may have regional significance and may be valid varieties of the established types.

It should be kept in mind that (1) the variations described may not have any cultural reality or significance to the makers, and (2) the descriptive categories are based on sherds rather than vessels or even partly reconstructed vessels. The differences described in these categories could result from variations in firing, functional intent, varying lengths of use in any one function, and, of course, technological variations.

Munsell (1942) color examples are given in the descriptions of categories. These colors are taken from one or more typical sherds that represent the range of colors in the category.

Goose Creek Incised (Figure 8, A, A')
No. of sherds: 1
Wall thickness: 4 mm
Surfaces: Both surfaces smoothed, but very grainy due to the sandy paste.
Color: Both surfaces and core are oxidized throughout to a very pale even brown (10YR 7/3).
Rim: Slightly everted with interior thinning and rounded lip.
Decoration: Six horizontal incised lines 2 mm apart, parallel to the rim. Series of incised diagonal lines from third line from the top, through the fourth line, stopping at fifth line.
Comments: This is the only decorated sherd from the site.

Goose Creek Plain, Category 1 (Figure 8, B–F) Surfaces and cores are oxidized; interior surfaces of a few sherds are dark, but do not merge with interior surfaces of Categories 2 and 3, which are smudged.
No. of sherds: 98
Wall thickness: 4 to 7 mm, but most are 5 to 6 mm.
Exterior surface: Most outer surfaces apparently floated, resulting in a thin, fine film that gives the effect of a polished or slipped surface. Floated film is easily eroded. Outer surfaces of other sherds were smoothed, but not well smoothed, while the clay was still wet. Smoothed surfaces less lustrous and much grainier than the floated surfaces because the coarser sand grains are left on the surface. Smoothed surfaces are much more durable and more resistant to erosion and use wear.
Interior surface: Almost all interior surfaces are smoothed, but a few may have been floated.

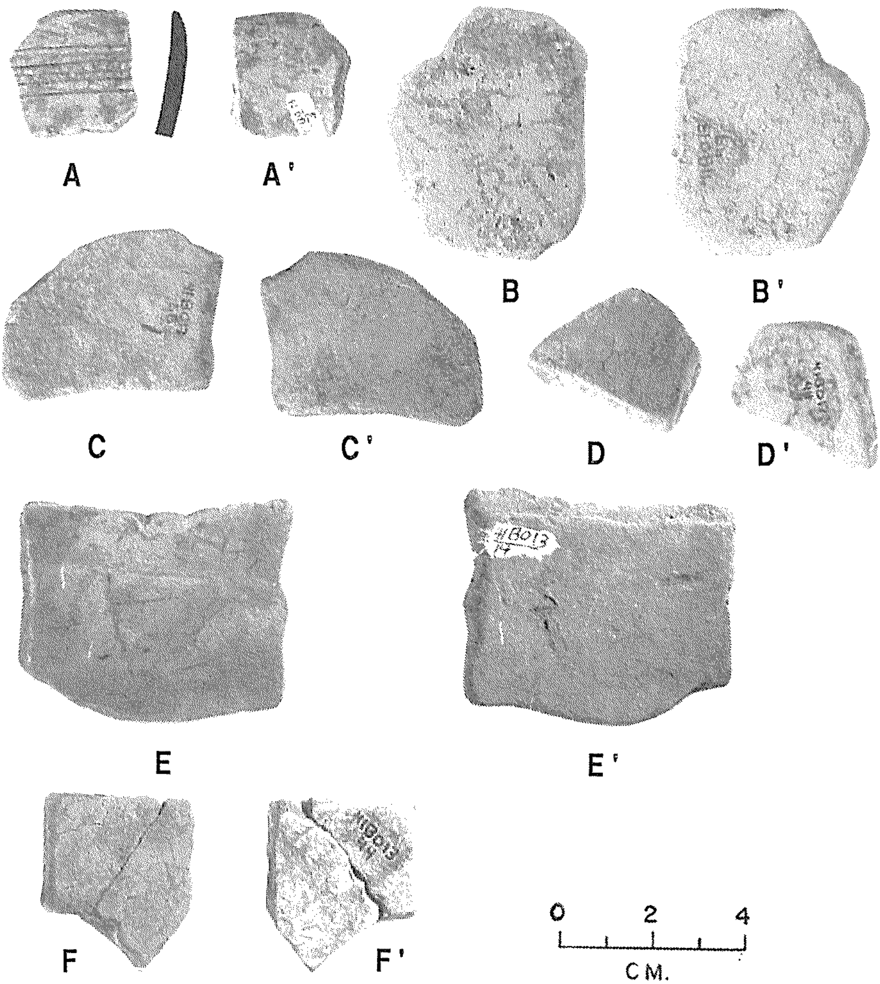


Figure 8. Body and rim sherds from the Copperhead site. The exteriors of rim profiles are on the left; prime letters indicate interior surfaces. A, A', Goose Creek Incised; B–F, Goose Creek Plain, Category 1 sherds.

Color: Core colors are generally a reddish brown (5YR 6/8 or 7/8), yellowish red (5YR 5/6), and very pale brown (10YR 7/3). Also present but not common are red (2.5YR 5/8) and white (10YR 8/2). When the (primarily inner) surface is smoothed, it tends to have the same color as the core; when the surface is floated, it takes on a gray or light gray color (10YR 6/1 or 7/1) that is darker than the core.
Rim: The one rim sherd is direct, with a rounded lip.
Comments: Some sherds are very poorly fired. Sherds with both surfaces smoothed are very grainy. A few sherds contain so much sand that they look like sandstone. Very sandy sherds that have both surfaces smoothed are much darker than the rest of the sherds in the category (Figure 8, E, E').

Goose Creek Plain, Category 2 (Figures 9, 10) Sherds in this category have smoother interior surfaces smudged a dense dark gray to black.
No. of sherds: 159
Wall thickness: Sherds cluster in two thickness groups, one of 80 sherds that are 5 to 8 mm thick, the other of 79 sherds that are 3 to 4 mm thick.
Exterior surface: Most exterior surfaces are floated, but a few may have been smoothed. Floated surfaces often are crazed and heavily eroded.
Exterior color: Exterior colors generally are darker than those in Category 1, with yellowish browns (10YR 4/3), brownish yellows (10YR 6/3 or 6/4), browns (10YR 5/2), and reddish yellows (7.5R 5/2) predominating. Floated surfaces are slightly darker than smoothed surfaces, and cores are gray as in Category 1 and grayish brown (10YR 5/2).
Interior surface: All inner surfaces are smoothed, with uneven surfaces, flowing striations, and incomplete obliteration of the coils. Some interiors, especially of the thinner group, are well smoothed and have a dense black, glossy, lustrous surface finish. Many of the thicker group both feel and look very grainy. Smoothed surfaces are durable, and, unlike many surfaces that are floated, none are eroded. Interior surfaces are smudged; smudging permeates the core, producing a two–layered effect with a dark reduced zone along the inner surface and an oxidized zone along the outer surface. On several sherds the inner smudging is only a filmlike layer that does not penetrate into the core, resulting in a smudged film on an oxidized core with the same color as the outer surface.
Interior color: Smudged inner surfaces are dark gray (7.5YR 4/0) and very dark gray (7.5R 3/0) to black (2.5Y 2/0). Core colors along the inside edge are generally light grayish brown (2.5Y 6/2) and grayish brown (2.5Y 5/2). Color along the outside edge of the core is generally the same as the outside surface.
Rims: Among the sherds 5 to 7 mm thick are five rim sherds; three are slightly everted with interior thinning and rounded lips, and two are direct rims with flat lips. Among the sherds 3 to 4 mm thick is one interior-thinned direct rim sherd that has a sharp lip with a series of shallow nicks along the inside rim surface.
Comments: Sherds 3 to 4 mm thick generally are better made and fired, with well–smoothed outer surfaces and well–smoothed, glossy, smudged inner surfaces. The better quality of these sherds may be a result of their thinness, which promotes better firing. The sherds of one vessel 5 to 7 mm thick are from a deep jar or bowl (Figure 10). Also in this category are seven sherds perforated from the outside.

Goose Creek Plain, Category 3 (Figures 11, 12) The sherds in this category have oxidized outer surfaces and floated and smudged inner surfaces. The inner surface treatment cannot always be determined because the entire inner surfaces of many of the sherds are heavily eroded, apparently as a result of thin–floated surfaces.
No. of sherds: 271
Wall thickness: Sherds cluster in thickness ranges similar to those in Category 2. In the 5–to–7–mm thickness range are 71 sherds; in the 3–to–4–mm thickness range are 200.

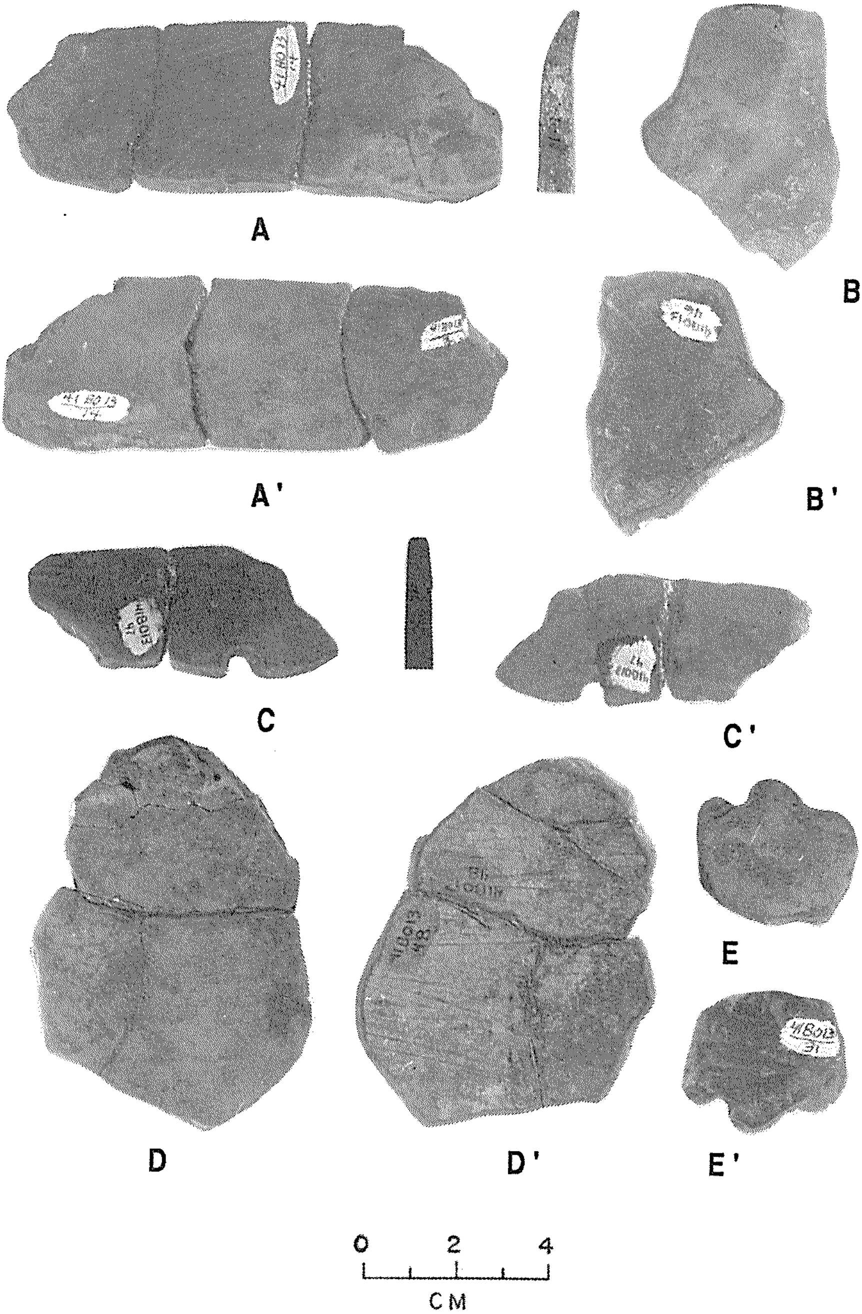


Figure 9. Body and rim sherds of Goose Creek Plain, Category 2, from the Copperhead site. Prime letters indicate inner surfaces.

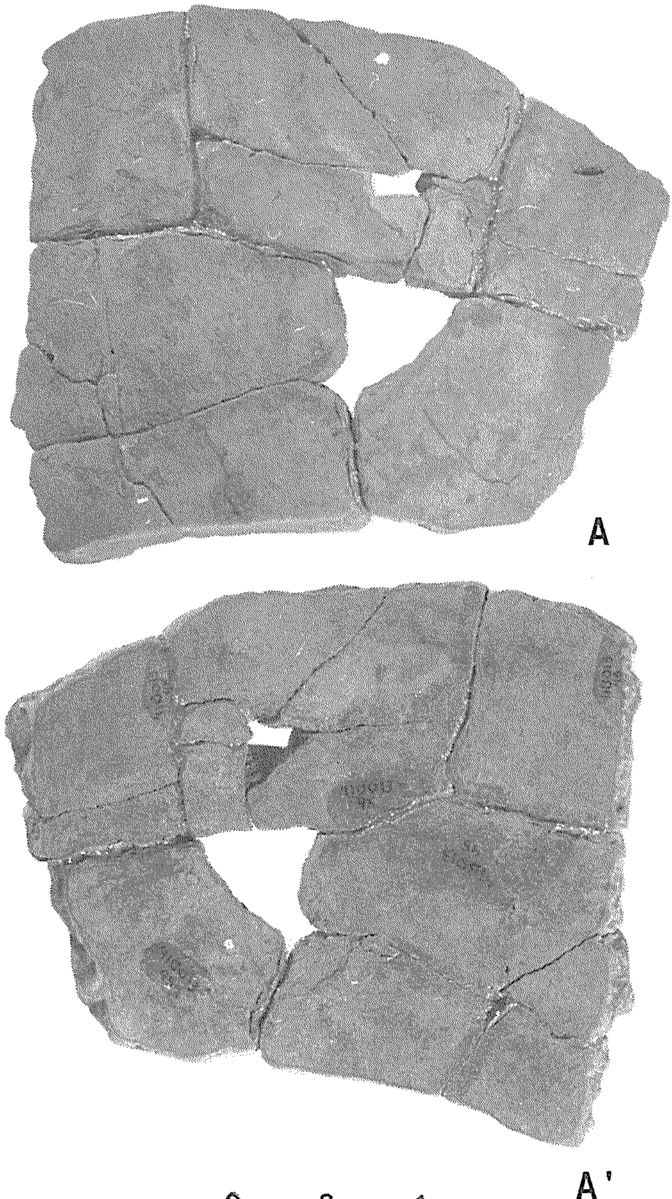


Figure 10. Goose Creek Plain, Category 2 body sherd from the Copperhead site: A, outer surface; A' , inner surface.

Exterior surface: Same as Category 2, but, in addition, six sherds from one vessel have floated exterior surfaces, and two of these have small patches of asphalt on the exterior surfaces.
Rims: Seven different rim forms were represented in the total of 12 rim sherds. In the 5–to–7–mm thickness group, the vessel with the asphalt on it had a direct rim with a rounded lip. In the thinner 3–to-4–mm thickness group were the following rim forms:

Direct with rounded lip (1)
Direct with flat lip (2)
Direct with interior thinning (2)
Direct with exterior thinning (1)
Direct with flat lip slightly overlapping outside edge (1)
Slightly everted with interior thinning and rounded or pointed lip (1)
Slightly everted with rounded lip (3)

Comments: This category predominates by far at the site and has both the most rims and the widest variety of rim forms of any category of Goose Creek Plain. Four of the sherds are perforated from the outside, one basal sherd has a rounded base, and one is the only example of asphalt decoration on a vessel.

San Jacinto Plain (Figure 13) Sherds in this category are plain and have a fine sandy paste with crushed fragments of sandy paste sherds as additional tempering.
No. of sherds: 22
Wall thickness: 7 to 9 mm
Exterior surface: Outer surfaces are floated and are severely eroded, except for the areas around the rims, which are smudged. The smudging apparently results from an extension of the inner surface smudging out onto the outside of the vessel.
Exterior color: Floated surface is light gray (5Y 7/1) on a core of a lighter light gray (5Y 7/2). Cores of a few sherds are reddish yellow (5 YR 7/6). Fragments of very dark gray to black crushed sherds that range between 1 and 4 mm in diameter are interspersed freely in the paste. These are seen clearly against the light gray paste wherever the floated surface has been eroded.
Interior surface: Interior surfaces are smoothed, with shallow striations and incomplete obliteration of the coil junctures. All interior surfaces have dense dark gray to black smudging.
Interior color: Interior colors are very dark gray to black, as in Categories 2 and 3.
Rims: The four rim sherds are direct, with interior thinning and rounded lips.
Exterior color: Same as Category 2.
Interior surface: All interior surfaces are either floated or completely eroded, probably indicating that they originally were floated. Sherds retaining interior surface are smudged like those in Category 2. Layered reduced and oxidized zones of the core are the same as in Category 2. Six sherds of one vessel with floated and heavily eroded surfaces have small, random, isolated streaks and specks of asphalt on the inner surfaces, but there is asphalt on the outer surfaces of only two of the six sherds.
Interior color: Eroded surfaces and interior reduced core zones are light grayish

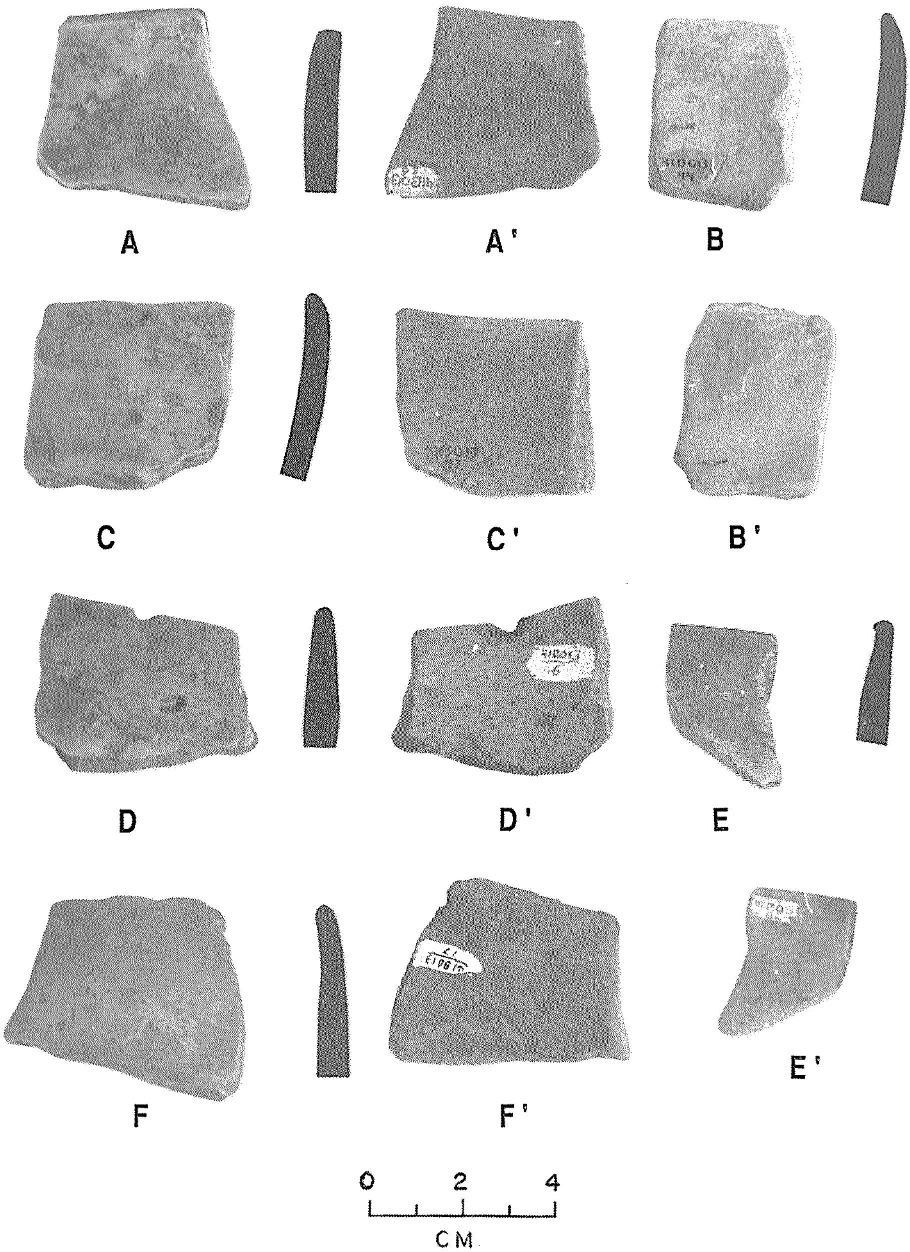


Figure 11. Sherds of Goose Creek Plain, Category 3 are from the Copperhead site: Prime letters indicate inner surfaces.

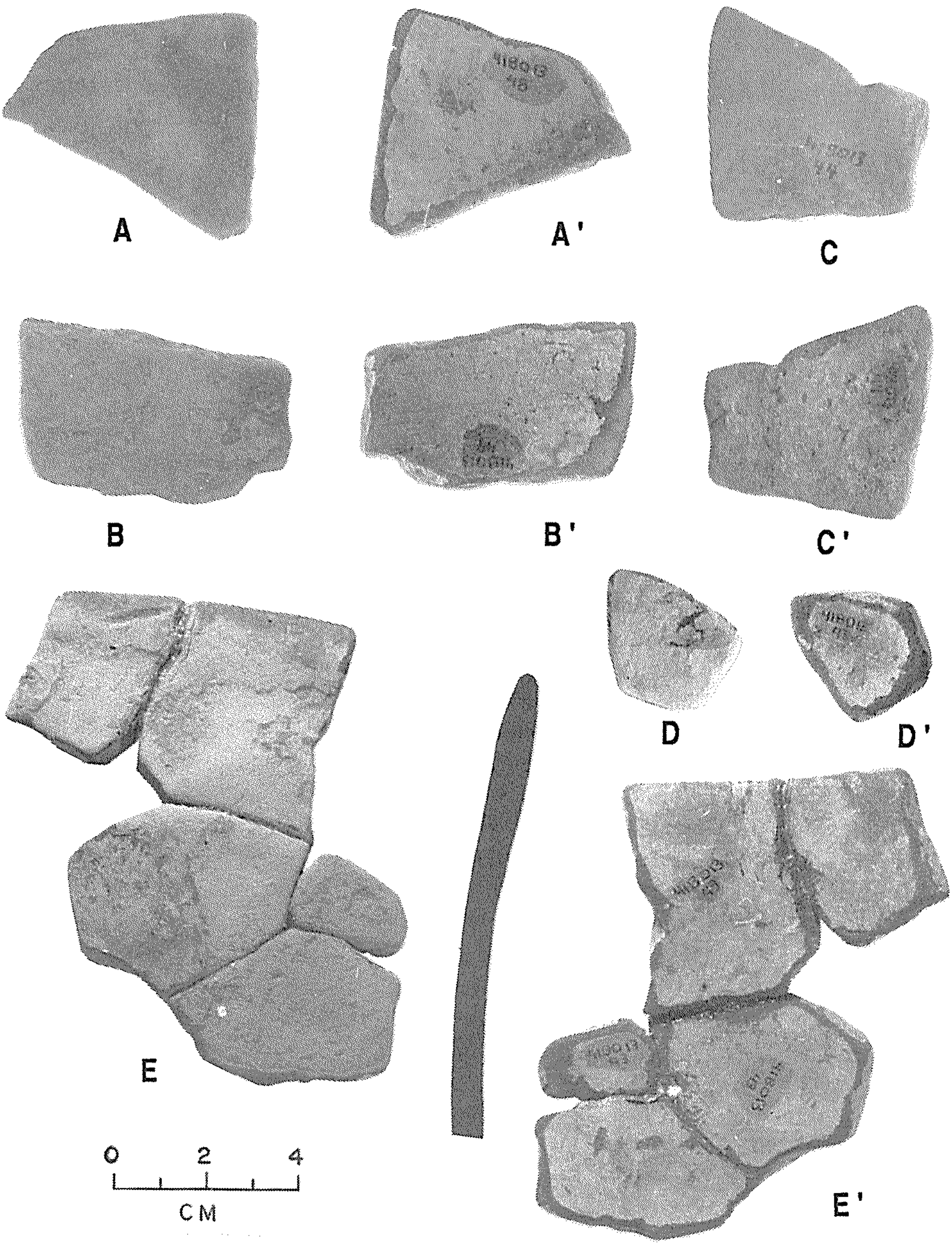


Figure 12. Sherds (A, B, and D), and reconstruction (E), of Goose Creek Plain ware from the Copperhead site.Prime letters indicate inner surfaces.

brown and grayish brown (2.5Y 6/2–5/2). A few sherds, as in Category 2, have only thin, dark, black smudged filmlike layers on oxidized cores of reddish yellow (7.5R 6/8), light yellowish brown, very pale brown (10YR 7/3–7/4), pale brown, and a few light grays (5Y 7/1). Floated smudged surfaces are dark gray to black as in Category 2.
Comments: This is the only category at the site with a limited intrasite distribution. Except for one sherd from Unit N50/–00, all grog–tempered sherds came from the south end of the site. This difference in horizontal distribution could represent a time difference, the occupation of the site by a different group, trade, or just that grog–tempered pottery was not commonly made at the site. In the next site to the west, 41BO12, which is on the same ridge and merges with the Copperhead site, were several grog–tempered sherds. At least two vessels are represented in this category; one is a partially reconstructed deep cylindrical jar.

Summary of the Copperhead Site Ceramics

Most of the pottery at the Copperhead site falls into the Goose Creek type as originally defined by Wheat (1953:184–189). According to Aten's (1967:10–15) definition, the decorated rim is Goose Creek Incised, Categories 1, 2, and 3 are Goose Creek Plain, and the grog–tempered pottery is San Jacinto Plain. The ceramic types and vessel forms are consistent with those found in the Galveston Bay series to the east. All of the sherds whose forms can be determined are from cylindrical jars or deep bowls. All appear to be cooking vessels, and none are special function vessels. Taken as a group, the pottery of the Copperhead site is most like the pottery described for the Addicks Basin, some 90 km (55 miles) to the north (Wheat 1953:184–189). In both regions the prevalent surface treatment technique is floating fine particles of the paste onto the surface to produce a smooth finish or pseudoslip that is easily eroded and often is crazed or crackled. Also in both regions are sherds with dense black interior surfaces. In the Cedar Bayou–Wallisville area, Ambler (1970:4) describes plain pottery with darker surfaces—especially the inner surfaces—and speculates that they may be a later variant of Wallisville Plain or an early variant of Goose Creek Plain.

On the basis of the pottery from the Copperhead site and Addicks Basin, and perhaps other regions, floated surfaces might be characteristic of Goose Creek ware in specific regions. Where they may have limited distribution, they may be characteristic of certain time periods, or they may even represent an early stage of ceramic development after the floated surfaces came into the region from the Southeast Texas coast. Smudged or blackened inner surfaces may have similar significance. Only from additional work in the coastal area can this be determined, but pottery with dark inner surfaces apparently is one variant or variety of the sandy paste pottery tradition in some areas of the coast. The dates of this pottery, however, may not be comparably early in all areas.

According to the ethnographic and archeological data, the Indians of the upper Texas coast were seminomadic hunters and gatherers. But why is pottery relatively abundant among these groups when, generally speaking, pottery is not abundant in hunting and gathering groups? Among the possible explanations are

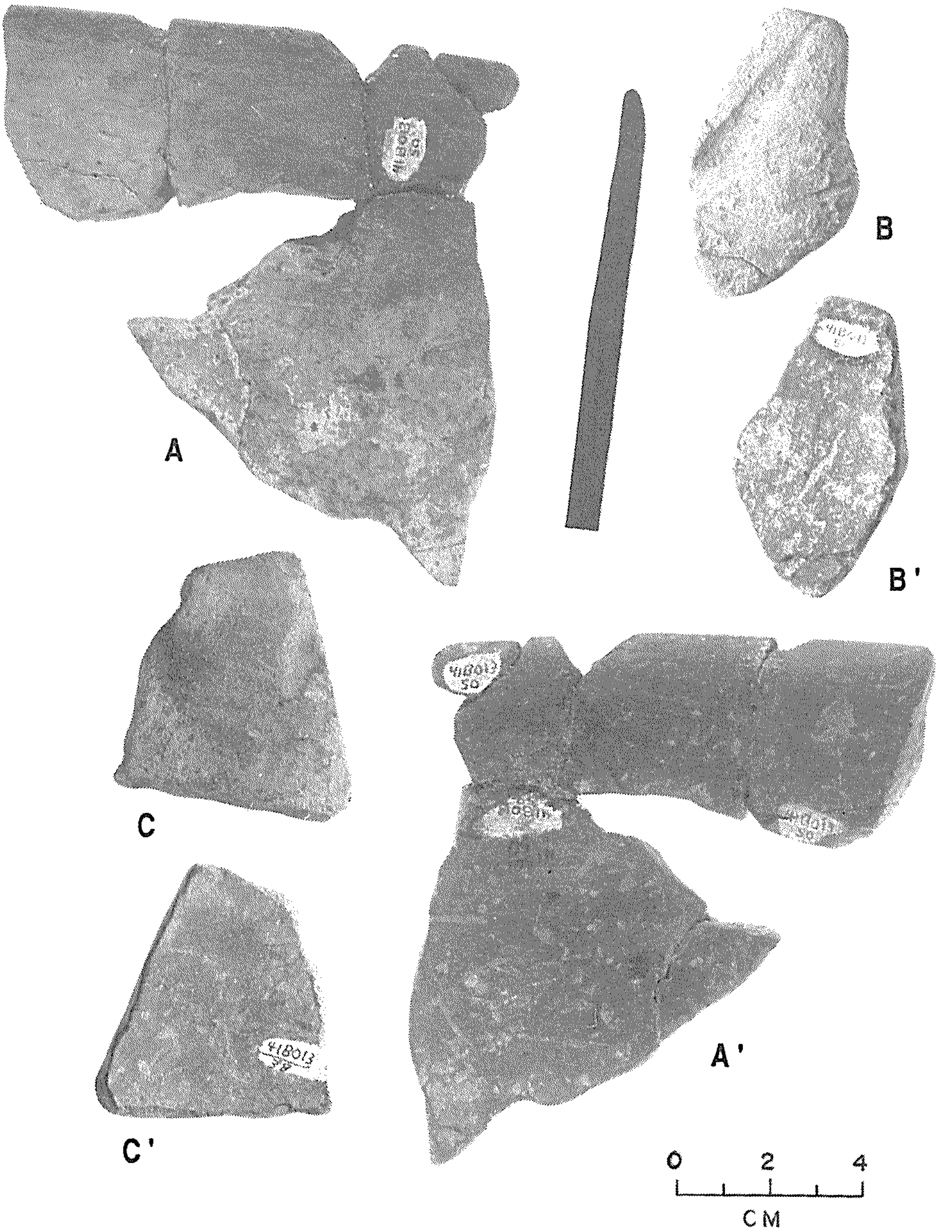


Figure 13. San Jacinto Plain body and rim sherds with floated exteriors and smoothed, smudged interiors, from the Copperhead site. Prime letters indicate inner sufaces. Note smudging along outer surfaces of the rims.

1) The difficulties of transporting ceramics were offset by the development of a food–processing technology.

2) Canoe travel made transporting these easily broken containers feasible.

3) Specific areas or sites were staging areas, or winter houses, where pottery was cached, so it was not always necessary to carry it around.

Future research projects need to address this question and test the possible answers.

Lithic Artifacts

Siliceous stone does not occur naturally in the Colorado/Brazos deltaic plain. The small, irregularly shaped chert pebbles that were used at the Copperhead site had to be obtained by trade or on trips inland. According to local informants, chert pebbles occur at Damon Mound, 48 to 56 km (30 to 35 miles) north of the site, but they may be too small to have been used. The nearest sources, other than Damon Mound, for siliceous material are the gravel deposits in the alluvial valleys 136 to 145 km (85 to 90 miles) inland (Garner 1967).

Apparently because of the scarcity of siliceous material, lithic artifacts are not abundant at sites in the region. Only two arrowpoints, one drill, three biface fragments, 78 flakes, and one small core were found at the Copperhead site, making a total of 85 lithic artifacts recovered. Because the siliceous pebbles they used were so small, the flakes are naturally quite small; many fit Hester and Shafer's (1975) descriptions of small prismatic blades.

Bifacially Flaked Artifacts

Arrowpoints. Two arrowpoints were recovered. A Catahoula point (Figure 14, A) recovered from the backdirt is well made, bifacially flaked, and has a lenticular cross section. The material is fine–grained yellowish tan chert. It is 35 mm long and as much as 6 mm wide. The expanding stem arrowpoint (Figures 14, B, B'), found in the burial pit fill is bifacially flaked, but is crudely made, with an asymmetrical lenticular cross section. The material is coarse, grainy, fossiliferous chert. The crudeness of the workmanship may be due to the inferior material. This point is 25.5 mm long, 14 mm wide, and 4.5 mm thick.

Drill. One well–made bifacially flaked expanding base drill (Figure 14, C, C') was recovered. The material is fine–grained tan chert. The bit is narrow, with an ovate cross section, and expands abruptly to form the base. It is 15.5 mm long, tapers from 2 mm thick at the distal end, or bit, to 4 mm thick at the base, and ranges in width between 3 mm at the distal tip and 13 mm at the base.

Fragments. Three bifacially flaked fragments were recovered in the excavations, but they are too small to permit identification. The largest is a rather thick distal blade fragment of reddish tan chert with a lenticular cross section (Figure 14, D, D'). The maximum thickness is 5.5 mm, the length from the distal tip to the break is 30 mm, and the width across the break is 17 mm. At the distal tip a flat section of cortex 4–mm square forms a flat, blunt point. The flat cortex on the distal end suggests either that it was not a projectile point or that it was broken before it was completed.

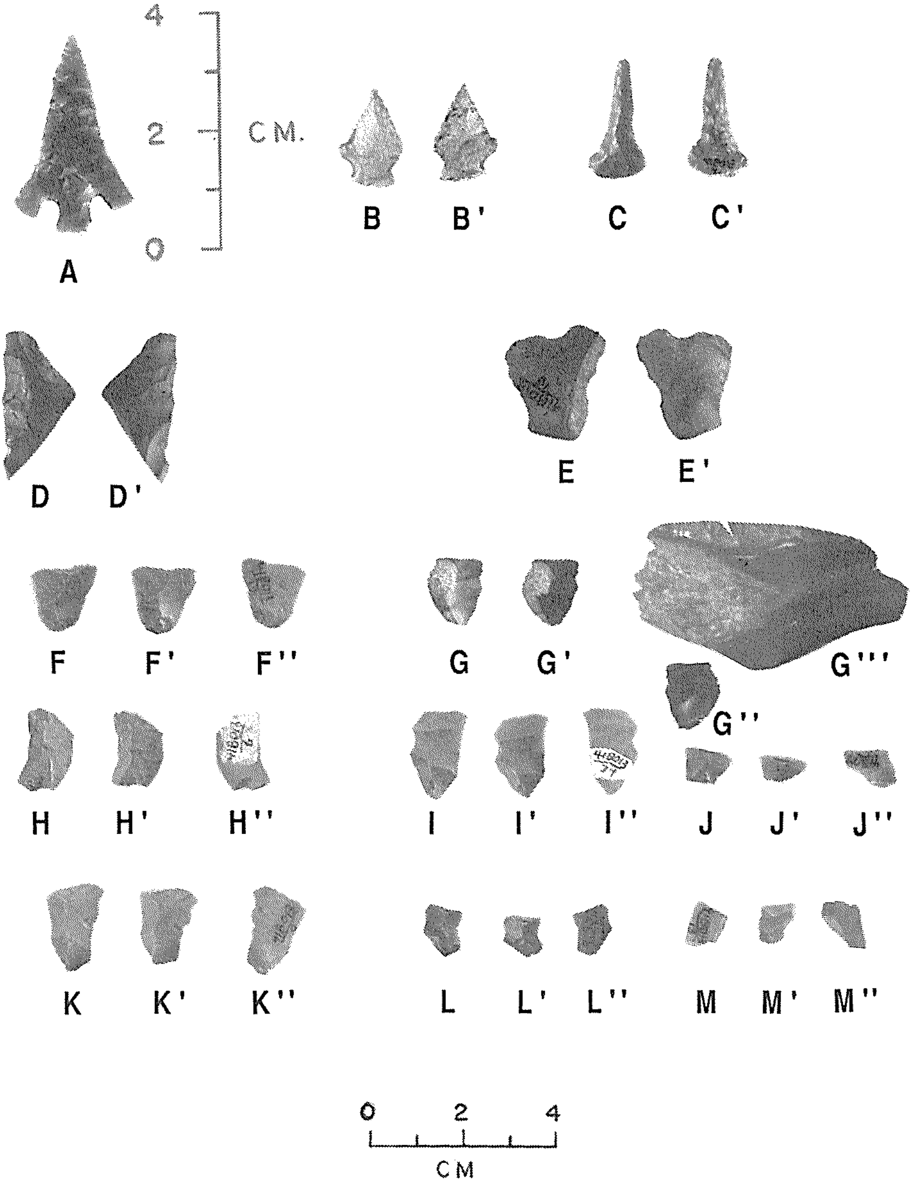


Figure 14. Lithic artifacts from the Copperhead site. The scale to the right of A is for A only. The bulb of percussion is down on all flakes. A, Catahoula point; B, expanding stem point; C, expanding base drill; D, biface fragment, possibly dart point or knife; E, notched flake; F–M, small steeply trimmed unifaces (F'–M' show dorsal faces at a 45° angle to show steep retouch, F"–M" show bulbar faces, M is retouched on right lateral edge); G, flake scraper, enlarged about 6X to show flake facets.

A very small bifacially chipped distal tip fragment of reddish chert has an ovate cross section and may be the distal end of a drill bit, but, since the fragment is only 7.5 mm long, it is impossible to make a conclusive identification.

The third bifacially worked fragment of light tan chert is a small part of the lateral edge of a thinned biface. The fragment is 7 x 4 mm, with a maximum thickness of 3 mm.

Unifacial Artifacts

Flakes. Because of the dearth of lithics at the site, as much information as possible was garnered from the flake sample. The flakes were sorted into four categories: (1) cortex flakes, (2) secondary cortex flakes, (3) interior flakes, and (4) nondescript flakes (Table 3). The first three categories were further divided into subcategories based on natural and prepared striking platforms. Flakes in all the categories were examined under a binocular microscope to determine whether any flakes had been used or modified. The flakes were divided into these categories in order to determine whether there had been apparent selection of specific flake types for specific tools.

Both Epstein (1963) and Shafer (1969) have published descriptions of flakes made of siliceous cobbles and pebbles. Similar terms are used, but there are differences. However, when cobbles are used as the source for flakes, all of the resulting flakes or pebbles, regardless of size, can be grouped into the same general categories. The flint flake attributes and flake category definitions used here generally follow Shafer (1969:3–5). A flake, in order to be placed in one of the categories, must have the striking platform and the bulb of percussion; if they are missing, the flake goes into the nondescript category. The following flake type definitions are used.

Table 3. Flake Types at the Copperhead Site

Flake Type	Utilized[1]	Unutilized	Total
Cortex			
Natural platform	1	2	3
Prepared platform	–	6	6
Secondary cortex			
Natural platform	2	2	4
Prepared platform	18	7	25
Interior			
Natural platform	7	1	8
Prepared platform	14	3	17
Nondescript	1	14	15
Minute flakes[2]	–	22	22
Cores with prepared platform	–	1	1
Total	43	36[2]	79[2]

[1] Includes the small flake unifaces

[2] Minute retouch flakes are not added into the total

1) *Cortex flake.* A cortex flake has the dorsal face covered with cortex. The striking platform can be natural or prepared.

2) *Secondary cortex flake.* A secondary cortex flake is any flake that has cortex on some part of, and at least one flake facet on, the dorsal face. The amount of cortex on the dorsal face can be large or small. The striking platform can be natural or prepared.

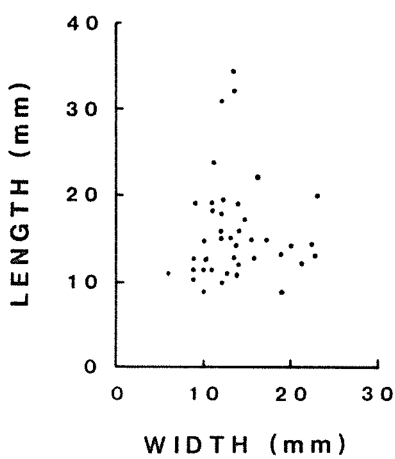
3) *Interior flake.* An interior flake has no cortex on the dorsal face; however, it can have cortex on the striking platform, but only when the platform is natural.

4) *Nondescript flake.* A nondescript flake has no readily identifiable attributes, such as a striking platform or a bulb of percussion. This category also includes flake fragments on which no attributes can be identified.

As a result of the small size of the siliceous pebbles used, the flakes are very small (Table 4). Measurements taken on the 25 utilized flakes, the 18 small unifacially trimmed flakes, and 18 of the unutilized flakes showed a mean length of 12.7 mm, a mean width of 13.1 mm, and a mean maximum thickness of 3.4 mm. The maximum flake length is 34 mm, the maximum width is 22.5 mm, and the maximum thickness is 6 mm.

Most of the flakes are very thin with small, elongated narrow striking platforms and very diffused, indistinct bulbs of percussion. Most of the flakes are rectangular with expanding lateral edges. Two lipped flakes are strongly arched (Epstein 1963:29, Shafer 1969:4). Of the 63 flakes from the site with striking platforms intact, 48 are prepared and 15 are natural. The striking platforms of the remaining 15 flakes are not intact. The one core from the site has a prepared platform. Because

Table 4. Scattergram Showing Lengths and Widths of Utilized Flakes at the Copperhead Site, 41BO13



N=41
Mean length=15.7 mm
Mean width=13.4 mm
Mean thickness=3.2 mm

of the small size of the chert pebbles used, it was thought that evidence might be found for a bipolar flake manufacturing technique, since bipolar technique has been found in the Caddo area to the north, where pebbles of similar size were used (Shafer 1970). No evidence of the bipolar technique is detectable in the flakes or the one core, but in the analysis it was noted that the small flakes are very suggestive of small blades. Subsequent studies by Hester and Shafer (1975) and Patterson (1975), who worked with more data, describe a blade technology on the Texas Gulf Coast. The material described by them is analogous to the lithic sample at Shy Pond, so Shy Pond should be listed as a site that has a similar blade technology, but since the material from the Coast is not available for reexamination, their terminology is not used in these descriptions.

From the microscopic analysis of the flakes, it was determined that 43 of the 78 flakes recovered have evidence of use or modification. However, several of the 36 unutilized flakes are fragmentary, and some undoubtedly have been used. A significantly high proportion—55 percent of the flakes recovered—have evidence of use.

In addition to the 78 flakes already discussed, 22 very small flakes, ranging between 2 and 4 mm in both length and width, were recovered during the fine screening of shell/matrix samples in the laboratory. They represent debris from the manufacture of chipped tools and were recovered only from the units with shell samples that were fine screened in the laboratory.

Utilized Flakes. The 25 utilized flakes (Figure 14, E; 15, A–I; Table 2, 3) like the rest of the flakes, are very small. The largest flakes in the sample are in this category, but the mean length is still only 16.9 mm, the mean width, only 13.5 mm, and the mean thickness, only 3.7 mm. All of the utilized flakes are unifacially retouched on one or more edges from use or perhaps intentionally. The retouch is not extensive and usually is concentrated at curved junctures or toward the end of an edge. The angle of the retouched edge is very acute, and, for this reason, they are separated from the 18 flakes classified as small steeply trimmed unifaces, described below. The utilized flakes are retouched on one lateral edge, on both lateral edges, or on the distal end opposite the striking platform. Twelve flakes are unilaterally modified, and six are bilaterally modified; on six flakes, the distal ends opposite the striking platforms are modified, and one flake has a unifacially chipped notch on the distal end opposite the striking platform (Figure 14, E).

The utilized flakes are sorted according to the type of flake from which they are made (Table 3). Sixteen flakes are on secondary cortex flakes, 14 have prepared platforms, and two have natural platforms. Seven utilized flakes are made from interior flakes, three have prepared striking platforms, and four have natural platforms. One utilized flake was made from a cortex flake with a natural platform, and one utilized flake is on a nondescript flake. From the flake types in the sample, it is apparent that secondary cortex flakes are predominant. This predominance may be a factor of the use of raw material that apparently produced secondary cortex flakes most often. However, it is interesting to note that the smaller interior flakes seem to have been selected for the small steeply trimmed unifaces.

Steeply Trimmed Unifaces. In the sample of 43 utilized and/or modified blades from the site, 18 are classified as small, steeply trimmed unifaces. The functional term scraper, often used for similar artifacts, is avoided here. These unifaces differ from the utilized flakes in having a series of minute flakes removed from the edge perpendicular to the long axis of the flake, producing a very steep, almost vertical, working edge. The steepness of the retouch on the flakes is the basis for differentiating them from the other utilized flakes with acute working edges. The unifaces have expanding lateral edges and are plano/slightly convex or flat in cross section, with very thin maximum thickness. Thickness, measured in the area of maximum thickness on the flake, ranges between 1.1 and 4 mm, with a mean thickness of 2.4 mm. The area of maximum thickness, however, is not a measurement of the modified working edge. The length of the scrapers ranges between 9 and 19.5 mm, with a mean length of 14.1 mm. The width ranges between 9 and 14.5 mm, with a mean width of 12.7 mm. The trimmed unifaces have had very small pressure flakes removed from the ventral face to produce a very steep edge along a straight line or a part of a straight line. The angle of retouch is about 55° to more than 80°, forming an almost vertical working edge. In some cases, a snap, or hinge, fracture has been retouched to produce the steep working edge. Under the binocular microscope the ventral edge of the steep retouch characteristically has a crushed and worn edge. No striations were seen on the working edges or on the ventral faces. The working edges of the flake scrapers in this sample are always on a straight plane; there are no steeply beveled ovate or circular forms. Several of the flakes have the bulb of percussion on a thick noncutting part of the flake opposite the steeply retouched edge, so the worked edges cannot be interpreted as backing opposite cutting edges.

The straight working edges and the crushing along the steeply retouched ventral edges suggest that these small unifaces could have functioned in shaping thin bone, wood, or antler by shaving off fine slivers or by pulling or pushing the ventral face of the flake against the object. One thinned pointed bone implement fragment (Figure 14, E) has marks that apparently are the result of shaving and shaping with a scraping tool. The small size of these tools and the other utilized flakes suggests that they would have functioned more efficiently had they been hafted in some manner or used in composite microblade tools. Fifteen of the unifaces are steeply retouched on the distal end of the flake, perpendicular to the axis of percussion. The remaining three are steeply retouched on a lateral edge at a right angle to the axis of percussion, but, since the long axes of these three examples cross at a right angle to the axis of percussion, they are wider than they are long, so, like the other 15 examples, the working edges are perpendicular to the long axes of the flakes. The three laterally retouched unifaces are so shaped that, because of the thickness or shape of the flake, they are most easily held or hafted from a lateral edge.

Ten of the 18 trimmed unifaces are retouched across most of the distal end, perpendicular to the long axis of the flake, six are retouched on the left half of the distal end, and two are retouched on the right half of the distal end. If the scraper had been pushed along the ventral face of the working edge by a right–handed

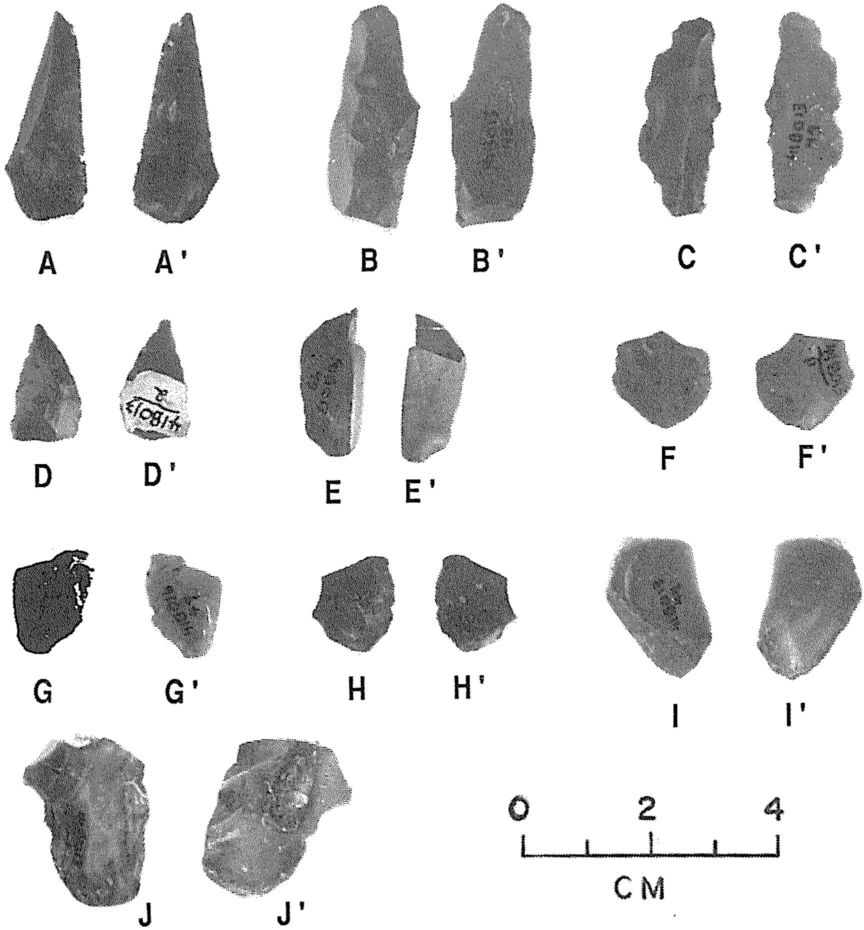


Figure 15. Utilized flakes and core from the Copperhead site. The bulb of percussion is down on all flakes. A–I, utilized flakes (prime letters show bulbar faces); C, Utilized thinning or billet flake; J, small chert core.

person, the left half of the distal end would have been the area most extensively used and most in need of being retouched. This might explain the placement of the steep working edge, but, of course, this interpretation is highly hypothetical, for the manner of using a tool is based on several motor habits and other factors.

Eleven of the 18 unifaces have steep retouching only on the distal ends of the long axes of the flakes. The other seven are composite tools, for they have, in addition, one or more acute edges with small, irregular, discontinuous marginal flake scars on a lateral edge, probably the result of use as a cutting edge, as in the case of the 25 utilized flakes.

Eleven of the 18 unifaces are on interior flakes with prepared platforms, three are on interior flakes with natural platforms, and four are on secondary cortex flakes with prepared platforms. The number of different flake types indicates that interior

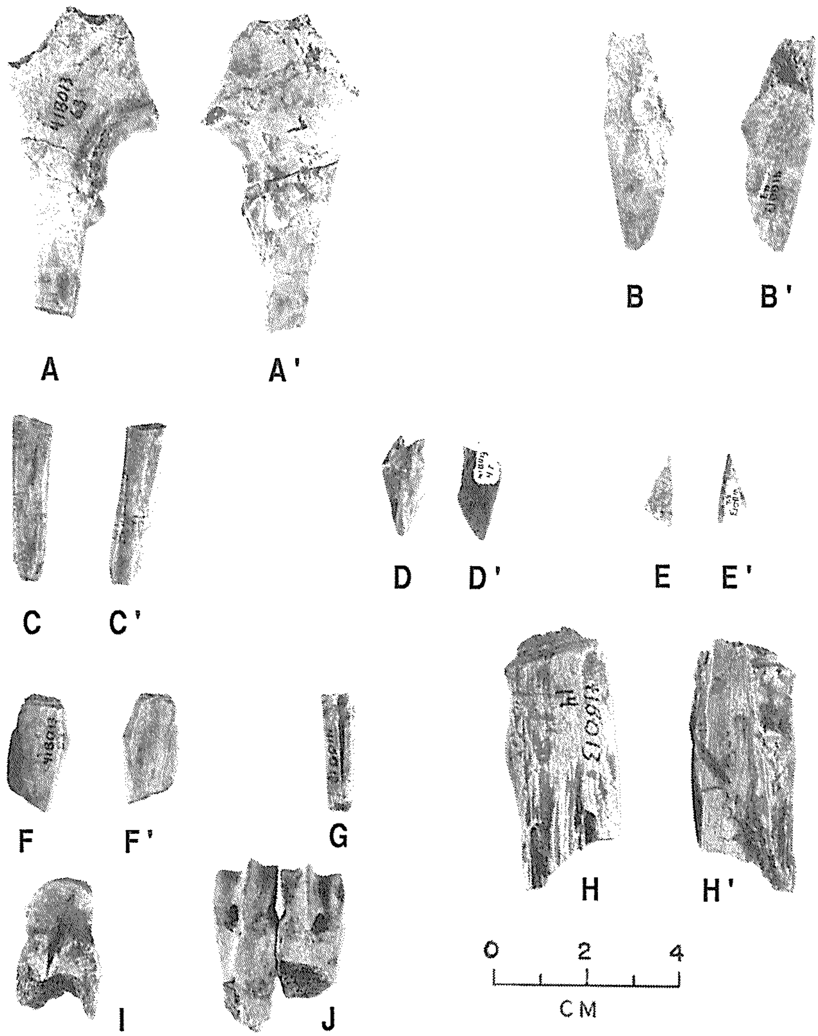


Figure 16. Bone artifacts from the Copperhead site. A–D, modified deer ulnas; E, bone artifact; F, bone fragment; G, H, alligator bone fragments; I, J, deer metapodials.

flakes may have been deliberately selected for the small unifaces. In contrast, secondary cortex flakes are the most commonly utilized flakes.

Similar small trimmed unifaces, referred to as scrapers, have been reported from the Laguna Madre sites (Campbell 1956:28, 29) and the Ingleside Cove site (Story 1968:27, 28) in the Central Gulf Coast. The Copperhead unifaces are much thinner than the ones reported from either of these sites. The thinnest uniface reported from the Ingleside Cove site is 5 mm thick, which is thicker than the largest uniface, in fact, thicker than all but five flakes from the Copperhead site. The Copperhead site unifaces also differ in that they have exclusively straight, or nearly

Table 5, a. Distribution of Faunal Remains, Copperhead Site, 41BO13

Animal	Unit[1]: N50 00	N50 E 5	N50 E10		N45 00	N45 E 5	N45 E10		N40 00	N40 E 5		N40 E10		N25 W10	Total
Zone[1]:	1	1	1	M	1	1	1	M	1	1	M	1	M	1	
Mammals															
White-tailed deer															
Odocoileus virginianus	1	13	1	2	1	4	2	6	3	24	–	5	4	3	69
Unidentified medium sized	3	41	4	10	21	13	11	45	7	42	4	2	11	10	223
Dog size carnivore															
Canis sp.	–	–	–	–	–	–	–	1	–	1	–	–	1	2	4
Rabbit/Hare															
Sylvilagus aquaticus	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Sylvilagus sp.															
Lepus californicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Raccoon															
Procyon lotor	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Squirrel															
Sciurus niger	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2
Opossum															
Didelphis marsupialis	–	–	–	–	–	1	–	3	–	–	–	–	–	–	4
Unidentified small mammal	1	–	1	13	3	–	–	42	–	2	–	–	–	–	62
Cotton rat															
Sigmodon hispidus	–	–	–	–	–	–	–	4	–	–	–	2	–	–	6
Unidentified small rodent	–	–	–	1	–	–	–	10	–	–	1	–	2	–	14
Birds															
Duck															
Anas sp.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Unidentified	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Reptiles															
Alligator															
Alligator missisippiensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0

Hard shell turtle															
Pseudemys sp.	2	7	–	1	–	5	6	7	–	12	1	–	5	3	49
Unidentified snake	–	1	–	–	–	–	–	3	–	–	–	–	3	–	7
Amphibians															
Frog															
Rana sp.	–	–	–	–	–	–	–	1	–	1	–	–	–	–	2
Salamander	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Fish															
Gar															
Lepisosteus sp.	–	–	–	1	–	–	–	–	–	–	1	–	–	–	2
Gar or bowfin scales	–	–	–	20	–	–	–	22	–	–	–	–	4	–	46
Drum teeth															
Pogonias cromis or															
Archosagus probolocus	–	–	–	1	–	–	–	1	–	–	–	–	–	–	2
Unidentified fish	–	–	–	21	–	–	–	115	–	–	29	–	3	–	168
Mollusks															
Oyster															
Crassostrea virginica	–	–	–	–	–	–	–	4	–	–	–	–	–	–	4
Conch															
Busycon sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Cockle															
Dinocardium robustum	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Clam															
Mercenaria campechiensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Rangia cuneata															
15-30mm[3]	–	–	–	–	–	23.6kg		–	–	–	–	–	–	–	23.6kg
Over 30mm[3]	–	–	–	–	–	1.3kg		–	–	–	–	–	–	–	1.3kg
Subtotal	–	–	6	71	–	–	19	266	–	83	36	9	34	–	(537)
TOTAL	8	62	77		25	23	285		10	119		43		19	671

[1] Zone 1, surface to top of midden
Zone M, within the midden

[2] The small fauna in Zone M from units N15/W10, N20/W5, N25/W5, N40/E10, N40/E10, N45/W5, N50/E10, and Trench 6 were obtained by screening the matrix adhering to bulk shell samples.

[3] The *Rangia* shell samples are recorded in kilograms. These weights are not added into the total.

Table 5. b, Distribution of Faunal Remains, Copperhead Site, 41BO13

Animal	Unit[1]: N25 W5		T13 N25 W2	N20 W5		T10 N15 W15	N15 W10		T1	T3, T5	T2 T6,7 T8,9		TP1	NP1	Total
Zone[1]:	1	M	1	1	M	1	1	M	1	1	1	M	1	1	
Mammals															
White-tailed deer															
Odocoileus virginianus	2	1	–	1	–	2	1	7	–	3	–	–	2	7	26
Unidentified medium size	5	3	3	3	3	–	20	14	3	14	1	–	3	28	100
Dog size carnivore															
Canis sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Rabbit/Hare															
Sylvilagus aquaticus	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Sylvilagus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Lepus Californicus	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Raccoon															
Procyon lotor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Squirrel															
Sciurus niger	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2
Opoaaum															
Didelphis marsupialis	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Unidentified small mammal	2	–	–	–	7	–	–	–	–	–	–	–	4	2	15
Cotton rat															
Sigmodon hispidus	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Unidentified small rodent	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Birds															
Duck															
Anas sp.	–	–	–	1	–	–	–	–	–	1	–	–	1	1	4
Unidentified	1	–	–	–	–	–	–	1	–	–	–	–	–	3	5
Reptiles															
Alligator															
Alligator mississippiensis	–	–	–	–	–	–	1	1	–	–	–	–	–	–	2

Hard shell turtle															
Pseudemys sp.	4	2	–	2	1	–	5	13	2	1	4	–	1	9	44
Unidentified snake	–	–	–	–	4	–	–	–	–	–	–	–	–	1	5
Amphibians															
Frog															
Rana sp.	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Salamander	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Fish															
Gar															
Lepisosteus sp.	–	–	–	–	4	–	–	1	–	–	–	–	–	–	5
Gar or bowfin scales	–	33	–	–	36	–	–	63	–	–	–	6	–	–	138
Drum teeth															
Pogonias cromis or															
Archosagus probolocus	–	–	–	–	–	–	–	7	–	–	–	–	–	–	7
Unidentified fish	–	27	–	8	–	–	–	147	–	–	–	14	–	–	196
Mollusks															
Oyster															
Crassostrea virginica	1	–	–	–	–	–	–	–	–	–	–	-	–	–	1
Conch															
Busycon sp.	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Cockle															
Dinocardium robustum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Clam															
Mercenaria campechiensis	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Rangia cuneata															
15 to $30mm^3$	–	–	–	–	–	–	14.75kg		–	–	–	–	–	–	0
Over $30mm^3$	–	–	–	–	–	–	7.2kg		–	–	–	–	–	–	0
Subtotal	16	67	–	15	55	–	28	257	–	–	7	20	–	–	(465)
TOTAL	83		3	70		2	287		5	19	27		11	54	561

[1] Zone 1, surface to top of midden
Zone M, within the midden

[2] The small fauna in Zone M from units N15/W10, N20/W5, N25/W5, N40/E10, N40/E10, N45/W5, N50/E10, and Trench 6 were obtained by screening the matrix adhering to bulk shell samples.

[3] The *Rangia* shell samples are recorded in kilograms. These weights are not added into the totals.

straight, working edges. The scrapers from the Ingleside Cove site and the sites on the small islands in the Laguna Madre are ovate or ovoid in form, with convex working edges, and have thicker cross sections. It is possible that similar small flake scrapers have not been reported elsewhere on the Gulf Coast because the flakes have not been examined carefully, and they have been combined with the utilized flakes with acute working edges. The absence of similar scrapers elsewhere on the coast cannot be explained by the available raw materials, the technology, or different tool function. The same raw materials are used elsewhere on the coast, and there is no basis for assuming that a different technology or a different tool function was used at the Copperhead site. The steeply trimmed unifaces, as well as the other utilized flakes, have the characteristics of small blades as described by Hester and Shafer (1975:175-185). From the data available at the time, they found that the blade technology described in their paper was confined to the central and lower Texas coast. However, the blades at the Copperhead site and subsequent work by Patterson (1975) extend this technology into the upper Texas coast.

Bone Artifacts

Only five obvious bone artifacts were recovered—a thin, flat, pointed bone implement, two nearly complete deer ulna awls, and two distal tips of deer ulna awls. Possible bone tools or residue from the manufacture of bone tools include a long, slender fragment of alligator bone with a longitudinal groove incised in one surface (Figure 16, G), a piece of alligator bone with a groove–and–snap break (Figure 16, H, H'), a fragment of a long bone with a groove–and–snap break (Figure 16, F, F'), and four split deer metapodials (Figure 16, I, J).

Pointed. This artifact fragment (Figure 16, E, E') may be the distal end of a projectile point, a compound fishhook, or an awl made from a piece of long bone that has been ground and/or scraped very flat and thin. Under magnification, a series of parallel striations can be seen along the lateral edges; they apparently are the result of manufacturing and shaping with a scraping tool. No similar striations could be seen on the flake surfaces, but this could be the result of differential preservation of the bone. The artifact has a broken length of 25 mm and width, at the break, of 16 mm. The thickness at the distal point is 1 mm, at the break, 2.5 mm.

Ulna Awls. The four bone awls (Figure 16, A–D) are made from ulnae that have the shaft and distal ends shaped. Two nearly complete awls are definitely made from the ulna of the white–tailed deer, and the two distal ends also are probably white–tailed deer. One nearly complete right ulna awl (Figure 16, B) has polish along the edges and the distal end. Under the binocular microscope, striations vertical to the long axis of the awl are easily detected. The proximal end of the ulna awl is broken. Another nearly complete left deer ulna with the distal end broken (Figure 16, A) has polish near the proximal end where it would have been held. Distal fragments of two other ulna awls (Figure 16, C, D) are only slightly polished.

Shell Artifacts

No definite shell artifacts were recovered, but, since there was a dearth of lithic tools, it is probable that unaltered and broken *Rangia* valves functioned as scraping and cutting tools. From a site near the Copperhead site there are, in the Brazosport Museum of Natural Science, five large flat oyster shells whose anterior edges are ground to knifelike sharpness. Another ground oyster shell was found at the Dow–Cleaver site (Aten 1971:44). These ground oyster shells apparently functioned as cutting tools. A rectangular fragment of a conch whorl shows no indication of modification or use.

Faunal Analysis

Vertebrate bones and invertebrate shells were abundant at the site (Table 5). All the vertebrate bones found on the quarter–inch screen were kept, regardless of size or condition. In addition, extensive samples of *Rangia cuneata* shell were taken. All the shell was collected from Unit N15/W10 and from the northwest quadrant of Unit N45/E10. Smaller shell samples were taken from N20/W5, N25/W5, N40/E5, N40/E10, N50/E10, and Trench 6. No matrix samples, as such, were taken, but the matrix that adhered to the *Rangia* samples was water–screened through sixteenth–inch wire mesh. The faunal debris was sorted from the rest of the debris with the aid of low magnification. Almost the total sample of small rodent bones and teeth, snake vertebrae, frog bones, fish vertebrae, scales, spines, teeth, and miscellaneous small bones was secured in this manner. Because the shell samples taken varied in size, the adhering matrix was disproportionate, so comparisons cannot be made among the units. The microfaunal sample does not necessarily indicate what would have been recovered had matrix samples been taken or had fine screening been an integral part of the excavation procedure. The units from which shell samples were taken, especially N15/W10 and N45/E10, are given emphasis disproportionate to the other units because of the addition of the microfauna to the totals.

Vertebrate Fauna

Except for the fish, the bones of white–tailed deer are by far the most numerous of the vertebrates, indicating that deer were a major source of food. Deer are represented by virtually all skeletal elements (Table 5), suggesting that the animals were butchered at the site. The absence of any antler and any but juvenile and adult deer may indicated that the site was occupied in the summer or that deer hunting took place in the summer. The white–tailed deer is represented by 95 identified bones, and, in all probability, a major portion of the 324 unidentified medium–sized mammal bones are of white-tailed deer. At least four deer are represented in the 95 identified bones.

Fish and turtle bones are the most numerous vertebrate remains. The 564 fish bones are a very small part of what must have been at the site, since most came from the matrix adhering to the shell samples. The small size (0.2 to 0.4 mm diameter) of many of the fish vertebrae suggests that nets or weirs were used. Ninety–three turtle shell fragments were recovered, all from hard–shell turtles called sliders, which are common in the area; some were from quite large turtles. Duck, frog, salamander, snake, and two small alligator bones are also in the sample.

Terrestrial species in addition to deer include raccoon, squirrel, opossum, rabbit, cotton rat, and at least two *Canidae* sp. All of these species are found on wooded ridges and prairies around Shy Pond.

Very few whole bones of large mammals were recovered. Some of the bones are burned, and some are broken, apparently for recovery of the marrow and the manufacture of bone tools. Most of the bones, even quite small ones, are broken into very small angular pieces. All metapodial shafts are split; two metapodials have a conical protrusion between the condyles that would result from driving an object between the condyles to split the bone (Figure 16, I, J). One long bone fragment has a small groove that was made in order to snap the bone, either to reach the marrow or to obtain a bone fragment suitable for making a tool (Figure 16, F). The only whole bones are those that contain no marrow (calcanea, phalanges, astraguli, metatarsals, and caudal vertebrae) and are not suitable for the manufacture of tools.

The two alligator bones from the Copperhead site were modified, the larger by a large groove–and–snap fracture and the smaller by a deep longitudinal groove incised in one surface (Figure 16, G, H).

Molluskan Fauna

The brackish water clam *Rangia cuneata* is the only mollusk found at the site in quantity. Commonly found along most of the Gulf Coast, *Rangia* is an estuarine species that is found landward but overlapping the range of oysters. It is most abundant in the heads of estuaries and tidal bayous where water has a salinity of as much as 15 ppt (parts per thousand), and its range extends for several kilometers up the mouths of permanent freshwater streams where, at times, the salinity may be less than 0.3 ppt (Hopkins 1969, Hopkins and Andrews 1970). Because *Rangia* can tolerate a wide range of salinity and their range overlaps the range of freshwater mollusks and higher–salinity mollusks such as oysters, it has been suggested that environmental conditions and changes as well as dietary information might be inferred from study of the shell characteristics of *Rangia* shell and shifts in the percentages of *Unio, Rangia,* and *Crassostrea* in individual or groups of shell middens in a limited area (McIntire 1958:47, Story 1968:62).

The shell midden sites around Shy Pond are composed almost entirely of *Rangia,* which range in anterior–posterior length between 15 and 61 mm, but most of which are less than 30 mm long. Extensive *Rangia* samples were taken from two units in N15/W10 at the Copperhead site. In this unit, 67 percent (14.5 kg, or 32 lbs.) of the *Rangia* range in anterior–posterior length between 15 and 30 mm, and 5.4 percent (1.3 kg, or 3 lbs.) are more than 30 mm long. The density of the shell and the size percentages differ significantly in the two units. The differing volumes and densities of shell might represent different lengths or intensities of occupation, or repeated occupations at one area or the other over a period of years. The differences in the percentages might result from any one or all of the following factors.

1) Significant chronological difference between the two areas of the site.
2) R*angia* collected at different times of the year.
3) Exploitation of discrete monotonic populations.

In all probability the low salinity in the area of Shy Pond supports a nonbreeding monotonic subpopulation consisting of classes of clams of limited size. New populations are introduced only when spawn are introduced in salt water that pushes into the area from the Gulf, so the presence of monotonic populations would affect numbers 1 and 2 in the list above.

It is apparent that no *Rangia* measuring less than 15 mm were collected by the inhabitants of Shy Pond. This may be because the smaller *Rangia* represent such a small amount of food, or it could be a result of the shell–gathering technique.

Fairbanks, in his study (1963) of the *Rangia* of Lake Pontchartrain, Louisiana reported that *Rangia* between 14.25 and 23.75 mm were uncommon and were found only during the summer months. Fairbanks postulates that *Rangia* spawned in March or April will reach 15 mm in length, depending on environmental conditions, by the end of one year, and during the next six warm months of the growing season (March–April through September–October), will increase from 15 to 24 mm in length. Relatively few clams stay within the size range of 14.25 to 23.75 mm very long, so this size range is common for only a short time in the spring and summer months (Fairbanks 1963:20, 21). In support of Fairbanks, Wolfe and Petteway 1968:102) worked out a von Bertalanffy growth curve for *Rangia* that shows that *Rangia* one year old would be expected to be 16 mm long, and *Rangia* two years old, 28.3 mm long.

Most of the *Rangia* from the Copperhead site range between 15 and 30 mm, with the greater number in the lower end of the range. If the von Bertalanffy growth curve is applicable to the Shy Pond area, then the small size of the *Rangia* indicates that the inhabitants of the Copperhead site were collecting them during the late spring and summer months. Also in support of this conclusion, the *Rangia* at the site apparently were collected during their growing season.

During the growing season, *Rangia* steadily add to the edge of their shells, forming a series of shell accretion bands, one for each growing season. Between the accretion bands are small narrow lines, or grooves, which are growth interruption lines that are formed by a halt in the shell accretion during the nongrowing season. By inspecting the edges of several *Rangia* shells, it is possible to determine from the growth accretion bands or growth interruption lines whether the *Rangia* were collected during a growing season. Observations made on the *Rangia* at the Copperhead site show that they were collected during the growing season. At Lake Pontchartrain, the growing season covers the months from March through September (Fairbanks 1963:20, 21). These data show that the *Rangia* at that site were collected during the spring to fall growth period. In addition, by comparing the width of the growth accretion bands of past growth seasons, it is possible to determine if the *Rangia* were collected early or late in the growing season. The *Rangia* at the Copperhead site, for the most part, were collected in the latter part of the growing season, or late summer to early fall. *Rangia* 40 to 60 mm long were used for the inspection of the growth accretion bands and growth interruption lines, because at this size they have a number of bands and lines that are more readily apparent and so more suitable for analysis.

Although a late summer to early fall occupation is indicated for the Copperhead site, the applicability of the von Bertalanffy growth curve and the Lake Pontchartrain data to the *Rangia* in the Shy Pond area may be debatable. It has been found that the size and growth rate of a *Rangia* population is affected by both salinity and bottom substrata. *Rangia* attain greater size in water of low salinity (Parker 1955:209) and in sand bottom sediments over clay silt sediments (Tenore, Horton, and Duke 1968). Originally it was thought that the small size of the *Rangia* indicated age classes because the Shy Pond area is a marginal environment that might inhibit the growth of the *Rangia*. However, it is known that *Rangia* can thrive in water of very low salinity for several months with no apparent detrimental effects on growth (Hopkins and Andrews 1970:868). So a lower salinity for the Shy Pond area apparently does not explain the small size of the *Rangia* population. At present, there are no studies that indicate how differing marginal environments affect the growth rates and size ranges of *Rangia*. Studies similar to the Lake Pontchartrain study by Fairbanks (1963) are needed if the growth rates and seasonal age classes for the Shy Pond and adjacent areas are to be determined more accurately.

The fact that *Rangia* more than 30 mm long are not as common as might be expected may be an indication of monotonic populations or an indication that the pond was being so thoroughly exploited each year that few of the *Rangia* were left to grow beyond 30 mm. If this is the case, then the *Rangia* in the midden represent the yearly harvest of the one– to two–year–old *Rangia* that have matured since the last harvest. The larger specimens would represent the ones that had escaped harvesting in past seasons. If this interpretation is true, the oldest areas of occupation around the pond would have higher proportions of *Rangia* more than 30 mm long.

Rangia shells are the most apparent faunal remains at the Copperhead site and are definitely the most important food mollusk. However, the importance of *Rangia* to the diet of the aboriginal inhabitants can be easily overemphasized. From measurements on *Rangia* from the lower Neches River, it was found that *Rangia* with mean lengths of 45 mm and mean shell weights of 22.2 g have mean wet meat weights of 4.6 g (Hopkins 1969, Hopkins and Andrews 1970:868). This is a ratio of 0.2 g of wet meat per 1 g of shell weight (0.2 lbs. of wet meat per 1 lb. of shell weight). However, the ratio of meat weight to shell weight is variable, since meat quality changes with the season, spawning, and the local environment. For example, *Rangia* in sand sediments have a significantly higher ratio of meat to shell than those in clay silt sediments (Tenore, Horton, and Duke 1968:241). In all probability, the ratio differs for *Rangia* from the Copperhead site. which have a mean length of 20 to 30 mm, but there is no other published meat to shell ratio for *Rangia cuneata*. The ratio of 0.2 g of wet meat per 1 g of shell weight probably is a reasonable approximation from which to calculate the food weight represented by the two large shell samples taken from the Copperhead site.

Using this ratio, the 21.7 kg (48 lbs.) of shell from the entire 5–foot square Unit N15/W10 represent 4.34 kg (9.6 lbs.) of meat. The 24.9 kg (55 lbs.) from the northwest fourth of the 5–foot square Unit N45/E10 represent about 5 kg (11 lbs.) of meat, or about 20 kg (44 lbs.) for the entire unit. In addition to the *Rangia*, the two units yielded bones from white–tailed deer and unidentified canines, rabbits, squirrels, cotton rats, birds, turtles, various fish, salamanders, and alligators (Table

5). The *Rangia* from Unit N45/E10 represent a significant percentage of utilized food, but in no way do they constitute the greatest part, especially when the other fauna represented at the site are taken into consideration. This contrasts with the Trinity Bay area, where Dillehay (1975:11, 12) concludes that "the use of the shellfish *Rangia cuneata* . . . as a food source has not been overemphasized, for the data show that it was the most important single food item in the diet of the prehistoric inhabitants."

Except for *Rangia*, the only mollusks at the Copperhead site were five fragments of oysters (*Crassostrea* sp.), one fragment of conch (*Busycon* sp.), one fragment of a *Dinocardium robustum*, one fragment of a *Mercenaria campechiensis*, land snails (*Mesodon romei*, not collected), and a few freshwater mussels (*Unio* sp.) that were so fragmentary that they could not be collected.

Summary

The four most important food sources at the Copperhead site were deer, *Rangia*, fish, and turtles. Also represented in decreasing importance, as indicated by the number of bones, are *Canis* sp., opossums, ducks, squirrels, raccoons, frogs, alligators, salamanders, oysters, and freshwater mussels.

Again, it should be noted that the excavation techniques used at the site favored the recovery of the bones of the larger vertebrates. The gumbo matrix around the shell midden is difficult to dry–screen through quarter–inch mesh, and no water was used. The lack of fine screening and the lack of adequate matrix samples result in a disproportionate emphasis on the larger vertebrates, which presents an unbalanced picture of the importance of the small fauna to the inhabitants. If a more representative sample of the fauna at the site were available, it could be assumed that a different picture would be presented here.

Except for the *Rangia* clams and the oysters, the fauna are what would be expected in this riverine environment in the Austroriparian biotic province. The *Rangia* and oysters are brackish water estuarine species. The *Dinocardium* is a continental shelf species, and the *Mercenaria campechiensis* is a tidal flat clam. The *Dinocardium* and the *Mercenaria campechiensis* probably were beach–collected or perhaps traded from the coast. The oysters from the site are small, smooth, rounded, and white, characteristic of oysters from a marginal area of low salinity as is found typically near the head of an estuary (Parker 1955:480). The oysters had to have been brought to the Shy Pond area from somewhere nearer the coast. The freshwater mussels indicated that freshwater mollusks were being exploited to a small extent. Taken as a whole, the faunal assemblage at the Copperhead site indicates that a variety of habitats such as the brackish- to freshwater ponds and tributaries, the wooded levees and ridges, and the coastal prairies were being exploited. It should be emphasized that canoe transportation, which, in all probability, was being used, would put all of these environments within easy exploitation distance.

Summary of the Copperhead Site

The Copperhead site is a Late Prehistoric stage *Rangia* shell midden that dates, from geological evidence and the presence there of grog–tempered sherds, sometime after A.D. 1000. The site is on a point bar ridge that parallels the northwest shore of Shy Pond. The elongated accumulation of *Rangia* shell and midden debris probably is the result of repeated seasonal occupations over a period of years by small groups. The early historic accounts of the Capoques and the Hans indicate that during the winter season they were on the mainland, where they subsisted on shellfish. The faunal evidence indicates that the Copperhead site was occupied in the late summer to early fall, with deer, *Rangia*, and fish the main food sources.

The faunal sample indicates that localized habitats were being exploited. Bodies of brackish water to freshwater were being exploited for *Rangia*, ducks, frogs, salamanders, alligators, snakes, turtles, gars, drums, and other fish. The wooded ridges were being exploited for deer, opossums, raccoons, rabbits, and squirrels. The absence of fauna from tidal flats and open bays indicates that none of these habitats were close enough to be exploited to any extent, and the geological history indicates that these habitats were no more available in the past than they are now. The five oyster fragments, the one *Dinocardium robustum* fragment, the conch whorl fragment, and the *Mercenaria campechiensis* clam were collected elsewhere and brought to the site. Perhaps the coastal bay habitats were exploited at another time of year, when the people were occupying areas closer to, or on, the coast.

Sandy paste pottery was found throughout the excavations. With but two exceptions, all of the pottery is undecorated. The only decorated sherds were one Goose Creek Incised rim with lines parallel to the lip and one plain rim sherd with a nicked lip.

The Goose Creek Plain ware is grouped into three descriptive categories based on the surface treatment and color. The inner surfaces have the most diversity; in all three categories, most of the outer surfaces were floated with an oxidized buff to red and brown. Most interior surfaces in Category 1 are smoothed, but a few are floated. All of the Category 1 sherds have inner surfaces that are light red, yellow, brown, and other similar oxidized colors. The interior surfaces of Category 2 sherds are smoothed and smudged a dark dense gray or black. The interior surfaces of Category 3 sherds are floated and have smudged or reduced dark gray or black surfaces. The floated surfaces of Category 3 often are heavily eroded, apparently because of their soft unstable surfaces.

In addition to the Goose Creek ware, 22 sandy paste San Jacinto Plain sherds have grog as an additional tempering agent. All but one of the grog–tempered sherds came from the southwestern part of the excavated area. This intrasite distribution may represent a later occupation, for it is known from the Galveston Bay area that grog–tempered wares are stratigraphically later than the sandy paste ware (Aten 1970).

Within all the pottery categories are a variety of similar rim forms. The most common forms are straight and slightly everted, with interior thinning and rounded or flat lips. From the rim and body sherds it is apparent that the predominant vessel forms were deep bowls and jars.

Lithics are scarce, but a large percentage of the flakes are utilized. The most common stone artifacts were rather distinctive small thumbnail–sized flake uni-

A

B

Figure 17. Cleaver site: A, view, looking north; B, main part of excavation with shell midden exposed, looking south. Trench 1 in foreground; Trenches 2 and 4 to the right; Trench 3 in background; Trench 5, with shell removed, to left.

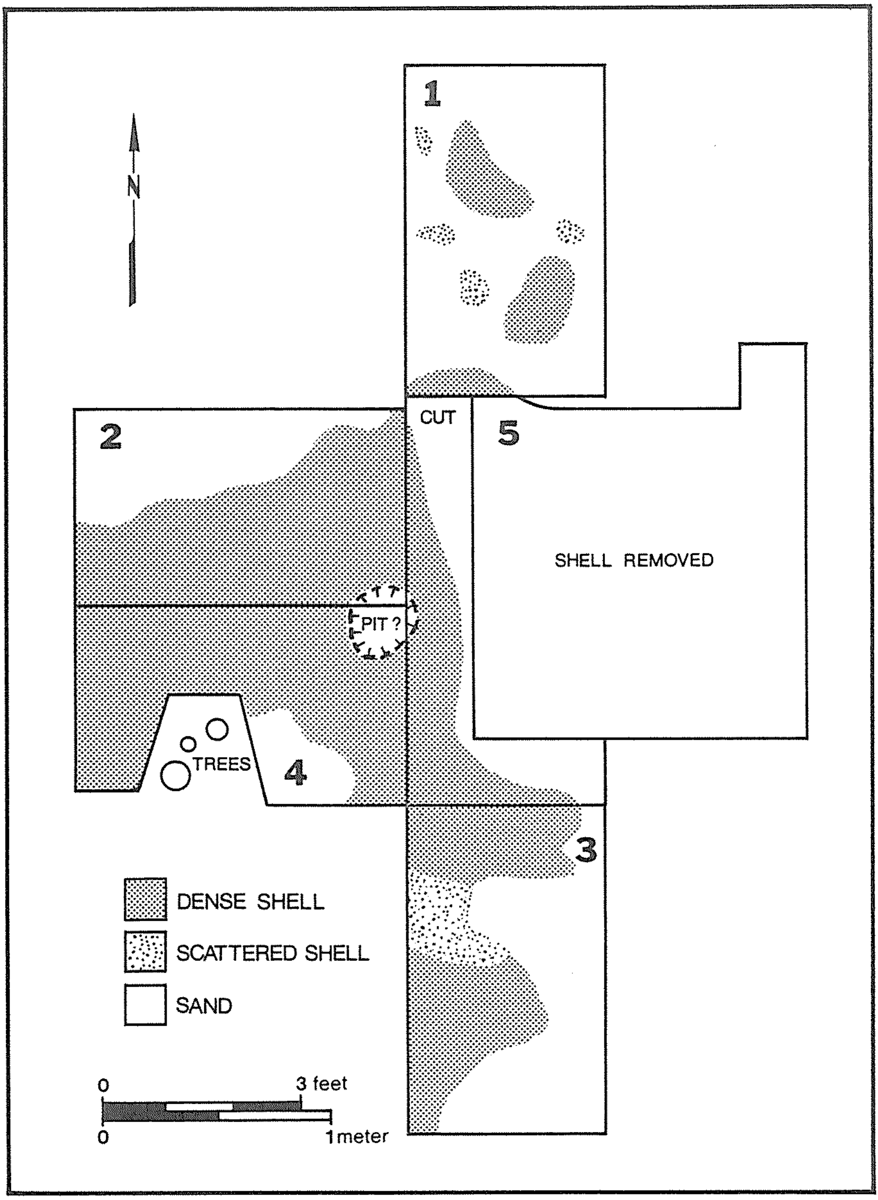


Figure 18. Cleaver site (41BO15): plan of excavation showing extent of midden in Trenches 1-5.

faces that provide some insight into how lithic resources were used in the Shy Pond area. The only typed stone artifact recovered is a Catahoula point, but a bifacially flaked expanding base drill, a small expanding stem point, and three biface fragments also were found.

THE CLEAVER SITE, 41BO15

For a day and a half, while the Copperhead site was drying out following a rain, the Cleaver site was briefly investigated (Figure 17). The site is about 229 m (250 yards) north of the Copperhead site on a long sandy ridge that appears to be another point bar ridge parallel to the northwest side of Shy Pond. According to local informants, the site is on the second ridge from the northwest side of the pond. (The Copperhead site is on the first ridge.) This second ridge is covered with dense brush and a thick stand of trees. Unlike the Copperhead site, the *Rangia* shell midden at the Cleaver site is overlain by a layer of brown sand instead of black gumbo, but it is not known whether other sites on this ridge also are overlain by sand.

The Cleaver site is a small *Rangia* shell midden, perhaps as few as 6.1 m (20 feet) long and about 4.6 m (15 feet) wide. In the center of the midden, C. L. Cleaver, for whom the site is named, excavated a 5 x 5–foot unit called Trench 5 herein (Figure 18). He donated his notes, artifacts, and faunal material from the unit to the Brazosport Museum of Natural Science in Lake Jackson, Texas.

Excavation Methods

The objective of the excavation was to expose a large horizontal area of the midden. To accomplish this, four 3 x 5–foot trenches (Trenches 1 to 4) were extended from Cleaver's unit, Trench 5. Trenches 1 to 4 were excavated down to the top of the midden. Since the overlying sand is virtually sterile, it was not screened. Arbitrary controls were not deemed necessary for the excavation, so the surface of the midden was exposed and cleaned, and its limits as seen in the trenches were plotted (Figure 18). The elevation of the midden was calculated from the northwest stake, and photographs were taken of the excavation trenches. Time did not permit excavation of the midden in Trench 5, so small pits were dug at the periphery of the excavations; they failed to reveal additional shell accumulations. The limited time available, combined with the very dense brush, prevented the crew from making a contour map of the site.

Stratigraphy

Stratigraphically, the Cleaver site comprises two zones. Zone 1 is a grown sand layer that extends from the surface to 36.5 cm (1.2 feet). The top 15 cm of Zone 1 is virtually sterile. Within Zone 1, about 15 cm below the surface and above the top of Zone 2, are scattered thin clumps of *Rangia cuneata* that range in thickness between 3 and 15 cm (0.5 and 1 foot). The shell concentrations are at varying elevations; there is no single horizontal shell midden extending over the site. Zone 2 is a basal stratum of sterile reddish sand that extends from about 36 cm (1.2 feet) below the surface to an unknown depth.

The stratigraphy is similar to that at the Copperhead site, except for the brown sand that overlies the midden instead of the black sandy clay gumbo. At both sites, Zone 2 evidently represents the sand deposited during the formation of the point bar ridges. The brown sand of Zone 1 at the Cleaver site is the result of fluvial action following the deposition of the basal red sand of Zone 2. As at the Copperhead site, the shell midden of the Cleaver site lies entirely within Zone 1. The scattered thin

Table 6. Distribution of Ceramics at the Cleaver Site

Ceramic Category	Trench: 1	2	3	4	5	Cut	
	Zone[1]: 1	1	1	2	1–2	1–2	Total
Sandy Paste Plain							
Category 1	1	–	–	–	8	–	9
Category 2	–	3	–	6	–	9	18
Category 4	7	19	–	11	33	2	72
Category 5	–	–	–	2	8	3	13
Bone-tempered Plain	–	3	1	–	–	–	4
TOTAL SHERDS	8	25	1	19	49	5	107

[1] Zone 1, surface to top of shell midden
Zone 1-2, surface through shell midden

clumps of shell at varying elevations and the small size of the site is what would be expected in the initial building process of a shell midden. The site apparently represents a brief occupation, or a series of brief occupations, over a short period of time, possibly by a single family group.

No definite features were found at the site, but there was a small, shallow depression at the juncture of the southeast corner of Trench 2 and the northwest corner of Trench 4. Several sherds were lying in the bottom and around the edge of the depression, but no conclusive determinations were made concerning its function.

Artifacts

The only recognizable artifacts recovered from the excavation at the Cleaver site were 107 sherds, all plain, with sandy paste. No lithic material or artifacts of bone or shell were recovered.

Ceramic Artifacts

The potsherds of the Cleaver site were analyzed and sorted, as far as possible, in the same manner as the sherds from the Copperhead site. The 107 sherds were sorted into five categories, only two of which are found at the Copperhead site (Table 6).

The Cleaver and Copperhead sites share the Goose Creek Plain ware categories 1 and 2. Category 3, the largest category of sherds at the Copperhead site, and grog–tempered sherds are not found at the Cleaver site, nor are the Goose Creek Plain ware categories 4 and 5 or the bone–tempered sandy paste ware found at the Cleaver site.

Goose Creek Plain, Category 1 (Figure 19, A–E). The same as Category 1 of the Copperhead site, but this is a smaller and more uniform sample.
No. of Sherds: 9

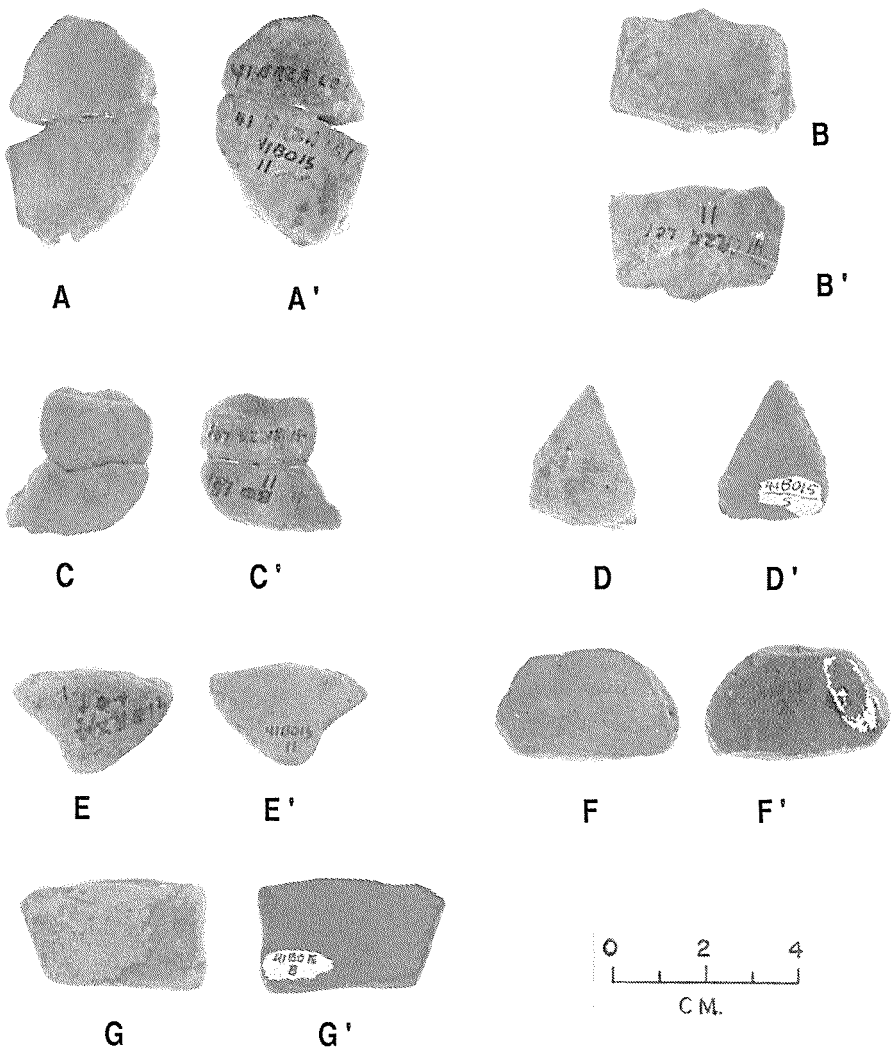


Figure 19. Body sherds from the Cleaver site. Prime letters indicate inner surfaces. A–E, Goose Creek Plain, Category 1; F, G, Sandy paste Category 2 sherds.

Wall thickness: 7 mm
Exterior surface: Floated
Interior surface: Smoothed, with uneven wavy surfaces.
Color: Both surfaces and the core are oxidized a yellowish red.

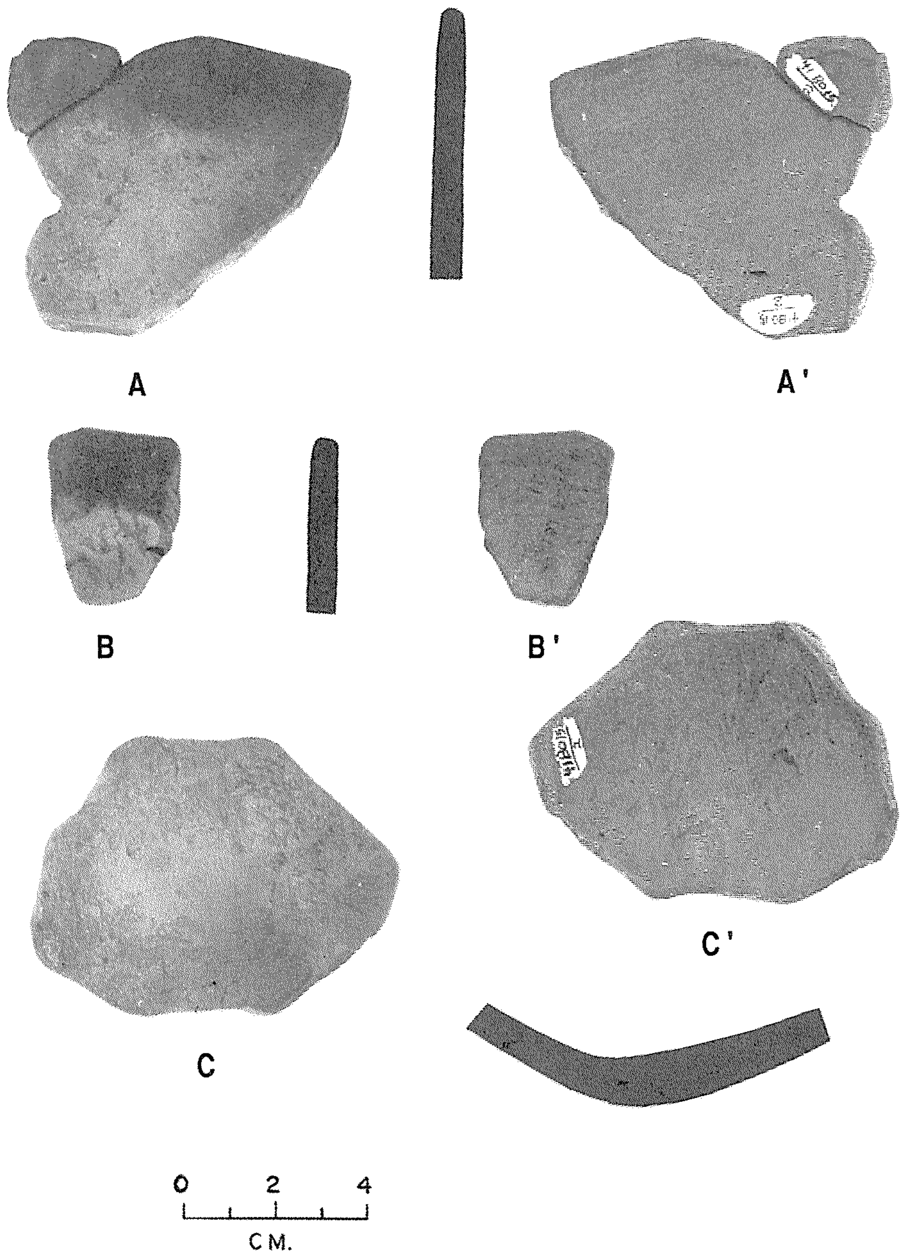


Figure 20. Goose Creek Plain Category 4 sherds from the Cleaver site. Rim profiles have exteriors to the left. Prime letters indicate interior surfaces.

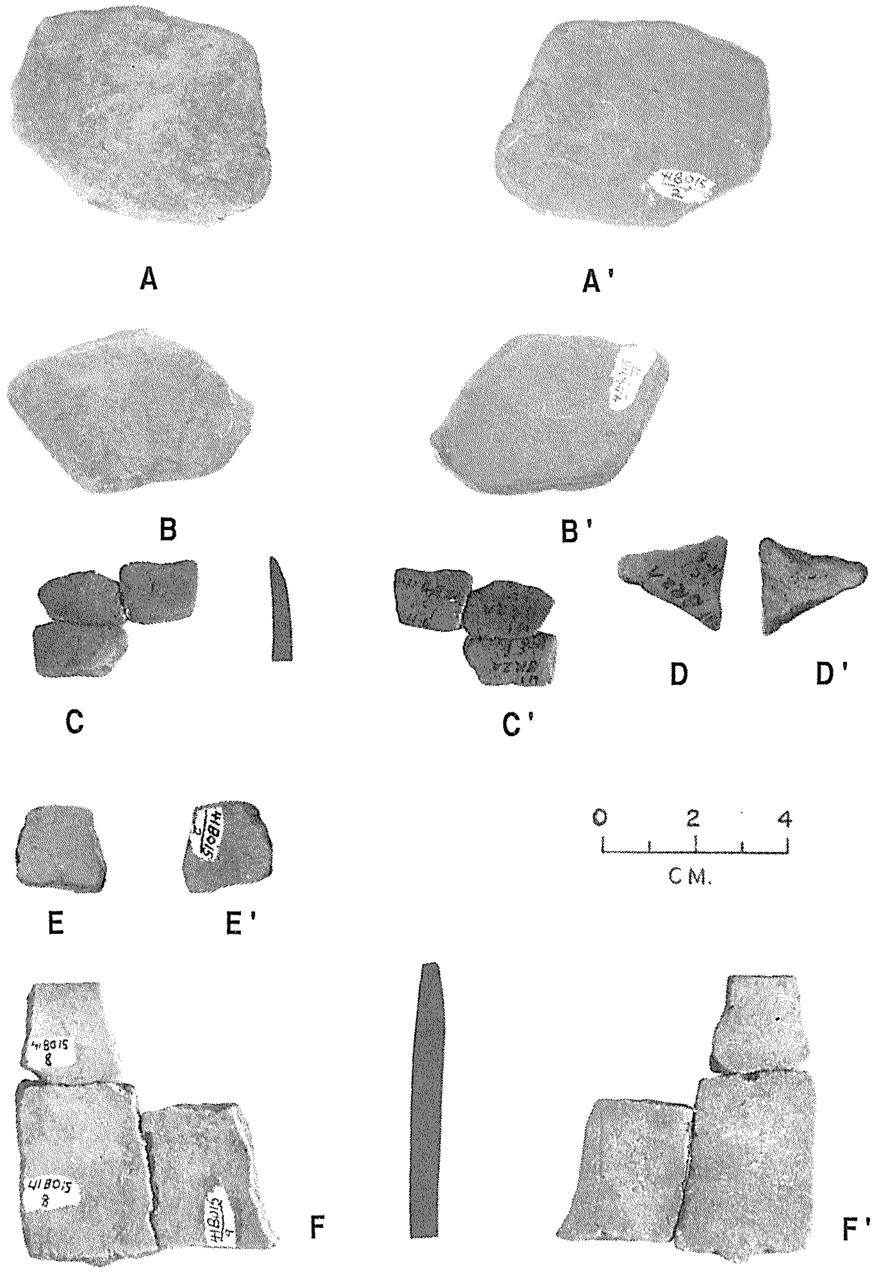


Figure 21. Body and rim sherds from the Cleaver site. Rim profiles have exteriors to the left. A'–F' are interior surfaces. A–B, Goose Creek Plain, Category 4; C–E, Goose Creek Plain, Category 5; F is a sandy paste bone tempered sherd.

Goose Creek Plain, Category 2 (Figure 19, F, G). identical to Category 2 of the Copperhead site, but all sherds have wall thicknesses of 5 to 7 mm,
No. of sherds: 9

Goose Creek Plain, Category 4 (Figure 20; 21, A, B). These sherds could fit into Category 2 of the Copperhead site, but there are minor differences in color and the interior surface. Only the thicker sherd group is found.
Wall thickness: 5 to 7 mm.
Exterior surface: Floated.
Exterior color: Same as Category 2 of the Copperhead site.
Interior surface: Smoothed.
Interior color: Gray (5Y 5/1).
Rims: The smudged or reduced gray of the interior spreads on to the exterior surface of the rim. Among the rims are one direct with a rounded lip, two direct with flat lips, and two direct with interior thinning. It is sometimes difficult to determine whether lips are flat or rounded; perhaps these rims should be considered slight variations that might occur on a single vessel. Some of the rounded lips could be eroded flat lips.
Comments: The interior surfaces may be smudged, but the light gray color and thick core zone of the same color along the interior surface suggests that instead of being smudged (as in Category 2) the interior surfaces have been reduced, but not to the degree that could be called smudging. Firing the vessel with the mouth down could result in such variations. Except for the fact that it does not have a dense dark gray to black interior, this category is the same as Category 2 at the Copperhead site. Two perforated sherds and one basal sherd from a round–based vessel are in this group.

Goose Creek Plain, Category 5 (Figure 21, C–E). Thin, dark sherds, most of which probably are from one vessel.
No. of sherds: 13
Wall thickness: 4 to 5 mm.
Surfaces: Both surfaces are smoothed. Color is dark, but surfaces are not smudged.
Color: Surfaces and core are dark grayish brown (10YR 3/2).
Rims: The two rim sherds are slightly everted, with interior thinning and pointed lips.

Bone–Tempered Plain Ware (Figure 21, F, F'). Sherds have a very fine sandy paste with many fragments of crushed bone as additional tempering agent.
No. of sherds: 4
Wall thickness: 4 to 6.5 mm.
Surfaces: Both surfaces are well smoothed.
Color: Both surfaces and the core are very pale yellow (10YR 7/4).
Comments: These four sherds represent, at the most, two vessels. The incised lip is the only example of decoration at the Cleaver site.

Summary of Ceramics from the Cleaver Site

The Goose Creek Plain ware pottery of the Cleaver site differs from the pottery of the Copperhead site in several respects. Category 4, the predominant category of the Cleaver site, is similar to Category 2, the second largest category of the Copperhead site. There are relatively few Category 2 sherds with dense black, often glossy, well–smoothed interior surfaces at the Cleaver site. The Category 3 sherds, with very dark gray to black floated interior surfaces are the largest category at the Copperhead site, but are not found at the Cleaver site.

The bone tempering suggests that the Cleaver site may date later than the Copperhead site. In the Galveston Bay area, bone tempering appears stratigraphically later than sandy paste ware and grog–tempering (Aten 1970). If the Copperhead site is indeed earlier than the Cleaver site, the vessels represented by the Category 3 sherds with surfaces that were popular early in the Shy Pond area, probably were later completely replaced in favor of the more durable and functional smoothed vessels. From a functional point of view, the floated surfaces, especially floated *interior* surfaces, may not have been less useful as cooking vessels because these unstable surfaces are easily eroded and worn. This difference in popularily between floated and smoothed interior surfaces may be chronological or it may merely represent the different techniques of individuals or groups. This problem needs to be investigated at other sites in the area.

The Cleaver site also differs in the absence of the thin (3 to 4 mm thick) sherds that are typical of Categories 2 and 3 at the Copperhead site. The thin sherds in Category 5 at the Cleaver site do not correspond to any of the categories at the Copperhead site. The only example of decoration at the Cleaver site is the bone–tempered rim sherd that has diagonal lines incised across the flat lip. No grog–tempered sherds were found at the site.

As suggested earlier, the differences between the pottery of the Cleaver and Copperhead sites may be an indication that there were different groups with different finishing and firing techniques. The differences also may have chronological or functional significance, but we do not know enough of the prehistory of the area to determine which interpretation is correct. More sites in the area need investigation, and radiocarbon dates are needed to establish the sequence of changes in the ceramic tradition and to plot the distribution of specific ceramic traits or techniques.

Faunal Analysis

No part of the midden was excavated in Trenches 1 to 4; no fine screening was done in these trenches, and no matrix samples were taken. For these reasons the faunal remains recovered cannot be considered a good representation of the fauna at the site. In addition, the methods of excavation were not favorable for the collection of the microfauna at the site. However, the fauna collected by Mr. Cleaver from the midden in Trench 5 contribute significantly to the faunal sample from the site.

The vertebrate fauna of the Cleaver site follow essentially the same pattern as the fauna at the Copperhead site, but at the Cleaver site there are some probable

Table 7. Faunal Remains of the Cleaver Site

	Trench: 1	2	3	4	5	Cut	
Animal	Zone[1]: 1	1	1	1	1–2	1–2	Total
MAMMALS							
Bison							
Bison bison	–	–	31	1	2	–	34
White-tailed deer							
Odocoileus virginianus	–	–	–	2	10	–	12
Medium-sized mammal fragments	1	2	7	–	16	–	26
Rabbit							
Sylvilagus sp.	–	–	3	–	–	–	3
Cottontail							
Sylvilagus floridanus	–	–	1	–	–	–	1
Jackrabbit							
Lepus californicus	–	–	–	–	1	–	1
Raccoon							
Procyon lotor	–	–	–	–	1	–	1
Opossum							
Didelphis marsupial	–	–	1	–	–	–	1
Small-sized mammal fragments	–	–	4	1	1	–	7
BIRDS							
Duck							
Anas sp.	–	–	1	–	1	–	2
Unidentified fragments	–	–	2	–	1	–	3
REPTILES							
Alligator							
Alligator mississippiensis	–	–	–	–	15	1	16
Hard shell turtle							
Pseudemys sp.	–	1	–	1	–	–	2
AMPHIBIANS							
Frog							
Rana sp.	–	–	1	–	7	–	8
FISH							
Gar							
Lepisosteus sp.	–	–	1	–	–	–	1
Unidentified fish spine	–	–	1	–	–	–	1
MOLLUSKS							
Oyster							
Crassostrea virginica	–	–	–	–	–	1	1
Freshwater mussel							
Unio sp.	–	–	6	–	–	–	6
Land snail							
Mesodon romeri		not collected					
Clam							
Rangia cuneata		not collected					
TOTAL	1	3	62	3	55	2	126

[1] Zone 1, surface to top of shell midden
Zone 2, surface through shell midden

bison ribs and more alligator bones (Table 7). However, the 34 bison rib fragments found at the Cleaver site represent, at the most, only a few ribs. The Cleaver site also differs in having only a few turtle carapace fragments. There are very few data on the microfauna, so comparisons of microfauna from the Cleaver site with the limited microfauna sample from the Copperhead site cannot be made. As at the Copperhead site, very few whole bones were recovered; the bones are broken into small angular fragments, probably in order to obtain the marrow.

Because of the small sample and the excavation methods, all that can be said of the fauna is that bones of white-tailed deer, bison, rabbit, raccoon, opossum, duck, alligator, turtle, frog, and fish were found. The only invertebrate remains were six fragments of freshwater mussels, one oyster shell fragment, and several *Mesodon romeri* land snails. No *Rangia* samples were taken, however, Robert Cole, of Lake Jackson, collected a small sample of *Rangia* from Trenches 2 and 4 for analysis and radiocarbon dating.

The *Rangia* in the sample, as suggested by the width of the growth bands, apparently were collected near the end of a growing season, suggesting, as at the Copperhead site, a late summer to early fall occupation. Because there were so few specimens in the sample and the collecting was so selective, size ranges were not determined.

The faunal sample from the site is only partially representative of what could be expected from the exploitation of the area. The deer, rabbits, opossums, and raccoons came from the wooded ridges around the pond; the *Rangia*, turtles, frogs, alligators, and fish came from the brackish water to freshwater ecosystems of the area. The presence of bison and jackrabbits indicates that there was some exploitation of the coastal prairies.

Summary of the Cleaver Site

The Cleaver site is a small Late Prehistoric stage *Rangia* shell midden. The compactness of the site, together with the thin shell lenses, indicates a rather brief occupation by a small family group or other social unit. The shell lenses may be the remains of house floors. The fact that no artifacts except sherds were found indicates a brief or a specialized occupation, and the homogeniety of most of the sherds indicates that most were made by a similar process, possibly by one person or by a few related individuals. The four bone-tempered sherds indicate that the site may date somewhat later than the Copperhead site.

Comparison of the distribution of pottery with the distribution of faunal remains brings to light some interesting details. In Trench 5, where the extent of the shell midden was unknown because the shell had been removed when it was excavated by Mr. Cleaver, there was an even proportion of ceramic (49) to faunal (55) remains. Trench 1, with a limited distribution of shell midden, has few sherds (9) and few faunal remains (1), except for *Rangia*. Trenches 2 and 4, with the most extensive amounts of shell, have a greater proportion of sherds (44) to faunal remains (6). The most striking anomaly is in Trench 3, where half the trench was covered with shell, and the most bones (62), but only one sherd, were found. The reason for this distribution is not known, but it could be postulated that food debris was tossed clear of the living floor. If the presence of pottery is an indication of a living area, Trenches 2, 4, and 5 represent a living area, whereas Trench 3 and part of Trench 5 are the areas where food debris was thrown. This interpretation is highly speculative, but it would explain the intrasite distribution of the sherds and vertebrate food debris. However, this uneven distribution does show that animal and cultural remains are not distributed evenly across the site, and this fact has implications for the reliability of determinations of prehistoric diets and subsistence patterns made from small test excavations, a concern that has been expressed by Dering and Ayers (1977:7). In order to eliminate similar problems in the future, all research on coastal subsistence should take into consideration the sampling biases built into the sites.

The limited faunal sample from the site, as at the Copperhead site, indicates that several specific habitats were being exploited. The brackish water to freshwater ponds and distributaries were sources for *Rangia,* mussels, alligators, fish, ducks, and frogs, and the wooded ridges were exploited for deer, rabbits, opossums, and other small mammals. In addition to the fauna found at the Copperhead site, several probable bison rib fragments were found at the Cleaver site, suggesting that bison from the coastal prairies were hunted and butchered elsewhere or that there was contact with groups that hunted bison. Some bison bones have been noted in collections from various Shy Pond sites in the Brazosport Museum, and local informants state that bison bones occasionally are found in the area.

DATING

The absence of diagnostic artifacts makes the task of dating these two sites difficult, but there are several possibilities. Grog temper appeared in the area by A.D. 1000 and bone temper, by A.D. 1400 in the Galveston Bay area (Aten 1970), and, according to Dillehay (1974), bison appeared by A.D. 1300. It should be noted, however, that the ceramics of the Shy Pond area do not necessarily align perfectly with other sequences and that a time lag is to be expected between areas. Radiocarbon dates are needed from sites in the area to assess the development of the ceramic tradition in the Shy Pond area and the diffusion of ceramic traits from the Galveston Bay area. It is assumed that the first ceramics and subsequent ceramic traits spread by diffusion from the Galveston Bay area, since pottery appeared there earlier (by A.D. 400) than in the areas of the coast to the west (Aten 1971).

Paired charcoal and *Rangia* samples from the Cleaver site were submitted for dating to the Radiocarbon Laboratory at The University of Texas at Austin. The shell samples were collected by Robert Cole from the surface of the shell midden in Trenches 2 and 4, several months after the excavation was concluded. The charcoal sample (Tx–1116B) yielded a date of 180±60 B.P. (A.D. 1770±60), and the *Rangia* sample (Tx–1116A) yielded a date of 860±50 B.P. (A.D. 1090±50) (Valastro, Davis, and Varela 1975:81). No correction for dates on *Rangia* shell in this area has been worked out (shells should give anomalously early dates due to carbonates in estuarine water here) and the shell date Tx–1116A cannot be used. A date on charcoal, however, should not be affected by environmental factors, and the Tx–1116B figure of A.D. 1770±60, giving a 67 percent chance that the true radiocarbon age is between A.D. 1710 and 1830, can be used as a valid piece of chronological evidence, even though a single radiocarbon date such as this can be taken only as a preliminary approximation.

Other evidence suggests a time earlier than A.D. 1700. Presidio San Agustin de Ahumada and Mission Nuestra Señora de la Luz were established in A.D. 1756 (Tunnell and Ambler 1967:12), and trade materials must have been available during the eighteenth century from these and other sources such as shipwrecks. If the Cleaver site had been occupied after A.D. 1700 one could reasonably expect it to contain historic materials. Since there are no such materials, the site is most probably earlier than A.D. 1700.

It is also probably later than A.D. 1400. There are bison remains in the site, and we know from the work of Dillehay (1974) that bison were not present on the coastal prairie until after A.D. 1300. In addition, if the bone tempering in the pottery at the Cleaver site is, as we believe, a trait diffused from the Galveston Bay area, then the site should be later than A.D. 1400.

The radiocarbon date does not contradict this evidence, since (1) it is a single date, so must be taken only as a suggestion, and (2) if the two–sigma error is taken (a sound statistical practice in radiocarbon dating), the chances are 95 percent that the radiocarbon age is between A.D. 1650 and 1890.

On the basis of current evidence, then, a range of A.D. 1400 to 1700 is a reasonable estimate for the time of the Cleaver site.

Among excavated sites, the Cleaver and Copperhead sites correlate most closely in time and artifact assemblages with Zones 2 and 2A at the Dow–Cleaver site (41BO35) south of Shy Pond (Aten 1971). The Dow–Cleaver site is the only other excavated site in this area of the coast with radiocarbon dates. Aten believes that the *Rangia* radiocarbon samples had been affected by recent chemical contamination and, by some statistical juggling, arrived at a date of A.D. 1320±80, which falls within his expected calendar span of A.D. 1300 to 1600. This is believed to be a realistic date range, but some reliable radiocarbon dates from this area are desperately needed.

SUMMARY AND CONCLUSIONS

The prehistory of the Gulf Coast area between Galveston and Corpus Christi bays is largely unknown. In an attempt to remedy this situation, excavations were carried out in the summer of 1967 at the Copperhead and Cleaver sites, two *Rangia* sites on Shy Pond. The sites are on two ridges that, because of their modest elevation above the surrounding terrain and the protection they provided from high water, were sought out for habitation.

The two excavated sites and the other sites visited in the area are thin accumulations of *Rangia* shell and midden debris, rarely more than 30 cm thick. A great many small shell midden accumulations in the area, such as the Cleaver site, apparently are the result of repeated occupations over a period of time. Neither of the excavated sites has clearly stratified shell zones or massive shell accumulations that might indicate a long time span or a long, continuous occupation.

The artifact yield from the sites is meager; at the Cleaver site, only sherds were found. At the Copperhead site, in addition to sherds, there are small utilized flakes, small steeply beveled flake scrapers, three biface fragments, one Catahoula arrowpoint, one untyped expanding stem arrowpoint, one bifacially chipped expanding base drill, four bone awls, and a fragment of a possible bone point, awl, or compound fishhook.

Not surprisingly, the cultural components represented by the two sites do not fit neatly any of the Late Prehistoric stage foci or phases so far defined for the Texas Gulf Coast (Suhm, Krieger, and Jelks 1954:123–133). However, the sandy paste ware of the sites is most closely related to the sandy paste ware of the Galveston Bay area. Attributes held by the Copperhead and Cleaver wares in common with the Galveston Bay area ware are the cylindrical jar and deep bowl vessel forms, rim profiles, lip nicking, incised decorations, conchoidal or rounded bases, grog temper, and bone temper. On the basis of the sherd attributes, it is most feasible to credit the origin of the pottery tradition and technology to the Galveston Bay area. The six sherds with traces of asphalt are not considered necessarily representative of Rockport focus influence from the central Gulf Coast, since, as suggested by Shafer (1966:30), the application of asphalt to pottery seems to be rather widespread on the Gulf Coast.

Despite the similarity of the Shy Pond pottery to the pottery of the Galveston Bay area, there appear to be some differences in the popularity/occurrence of decorated pottery. At the Copperhead site, 22 grog–tempered San Jacinto Plain sherds were found in addition to the sandy paste sherds, but the only obvious examples of decoration were one incised rim sherd and one interior nicked lip. At the Cleaver site, aside from the plain sandy paste sherds, were four bone–tempered sherds, one of which is a rim with diagonal lip notching.

In the Galveston Bay area, incised decoration steadily increased in popularity after it was introduced around A.D. 400, and was common by the time grog–and–bone temper appeared in the Galveston Bay area at about A.D. 1100 and A.D. 1400. But why is there almost no decorated pottery in the Brazos delta area? During this time period, incised decorated pottery is common in the Matagorda and Corpus Christi Bay areas, and it is obvious that the incised decorated ceramics spread from the Galveston Bay area. There is some question about the applicability of the pottery sequence in the Galveston Bay area to the Colorado/Brazos deltaic plain, but sandy paste pottery and both grog–tempered and bone–tempered pottery certainly were not any earlier, and probably were later, in the Colorado/Brazos deltaic plain than in the Galveston Bay area. Using the Galveston Bay sequence, the grog tempering at the Copperhead site suggests an occupation sometime after A.D. 1000, and the bone tempering at the Cleaver site suggests an occupation sometime after A.D. 1400 (Aten 1970). However, it is possible, but not probable, that bone tempering spread from the central coast or from Central Texas at an earlier date, since both the Rockport ware of the central coast and the Leon Plain of Central Texas have bone tempering (Suhm and Jelks 1962).

At the Copperhead site, sandy paste cooking ware with floated interior surfaces predominated; at the Cleaver site the interior surfaces are only smoothed and/or scraped. The grog tempering at the Copperhead site and bone tempering at the

Cleaver site support the possibility that floated interior surfaces are earlier and were later replaced by the more durable smoothed and/or scraped surfaces. Also common to both of these excavated sites and noted in collections from other sites in the area, is the high incidence of lace holes used for repairing cracks. The holes apparently were part of deliberate attempts to make vessels last as long as possible. The other most obvious ceramic trait at the Copperhead site is the prevalence of the dense dark gray to black interior surfaces that apparently were the result of smudging. This trait is not prevalent at the Cleaver or Dow–Cleaver sites.

In the Colorado/Brazos deltaic plain, the Copperhead and Cleaver sites correlate most closely in time and artifact assemblages with Zones 2A and 2B at the Dow–Cleaver site, 8 km (5 miles) south of Shy Pond. The two zones, which date to about A.D. 1300 to 1600, have plain sandy paste, bone–tempered, and grog–tempered ceramics, but no decorated wares (Aten 1971:52). Additional comparisons of the Shy Pond sites with the Dow–Cleaver site were made by Aten (1971).

Lithic artifacts are scarce, probably because of the scarcity of siliceous material in the area. The flakes that are found are characteristically very small and bladelike, and a large percentage are utilized. The small, steeply retouched unifaces from the Copperhead site are distinctive, but their significance and distribution on the Gulf Coast is not known, since no similar unifaces have been reported elsewhere on the coast. Small scrapers that differ in many respects from the Copperhead examples are reported from the island sites in the Laguna Madre that belong to the Rockport focus (Campbell 1956:28–29). The Catahoula arrowpoint and the small expanding base, bifacially flaked drill, together with the pottery, suggest stronger affiliations with the Galveston Bay area than with the central Gulf Coast.

The archeological record of the Shy Pond area indicates that there was no significant change in the technology or subsistence pattern during the occupation of the area. The artifact sample available for study from the two excavated sites and other sites in the area comprises a narrow typological range. The scarcity of decorated pottery may be shown by future work to be a significant characteristic of the sandy paste pottery found to the west of the Galveston Bay area. The scarcity of traits held in common by the Shy Pond and adjacent areas indicates that Shy Pond may have been isolated from outside influences or that innovations were not generally accepted. The lack of typological variations may be best interpreted as representing a very short time period; cultural stability and/or cultural stagnation are other possible explanations. The basic similarity of the Shy Pond sites to one another makes it possible to consider them part of a single cultural late prehistoric hunting–and–gathering pattern. The archeological evidence in Newcomb (1961) and data from Service (1962) indicate that the simplest form of social structure above the family—the band (probably patrilocal)—was characteristic of the coastal Indians of Texas. At the band level of sociocultural integration,

> all of the functions of the culture are organized, practiced, or partaken of by no more than a few associated bands made up of related nuclear families. The economy...is organized by and takes place entirely within these units; there are no special economic groups of specialized productive units....no specialized occupation

> group, no economical institutions....no special consuming group or classes. The economy...remains merely an aspect of kinship organization. The widest level of integration achieved was that established through affinal ties with other bands [Service 1962:108].

At a given time of each year the band occupied a certain locality within a territory or area to exploit a primary food resource. Some sort of seasonal round was made through the rest of the territory during the remainder of the year. Favorable campsites were revisited year after year, resulting in the accumulation of large shell middens in the areas where mollusks were being gathered. Many of the smaller middens represent the time needed to exploit the mollusks, plant resources, or game in the area during one season, part of one season, or on a short visit.

The apparent absence of deer antler and bones of very young deer, the size ranges of the *Rangia* being collected, and the width of the *Rangia* growth rings indicate a late summer to early fall occupation of the Shy Pond area. Since the groups are assumed to have been migratory, houses probably were very simple; the small circular shell middens commonly found in the area probably are the remains of living and/or house floors. Since the food resources being exploited probably were not stored, the absence of storage facilities is to be expected. Generally, features other than burials, hearths, pits, and shell house floors are seldom found in these sites.

In the archeological record of this part of the Texas Gulf Coast there is little evidence to indicate any major change in the technology of the subsistence pattern. This stability can be attributed in part to the environmental potential of the coast, where there were few alternatives to exploitation of the estuarine and littoral environments for mollusks, fish, plants, and game. If the environmental potential of the area was sufficiently great to support large groups living year-round in sedentary villages, the aboriginal inhabitants do not seem to have taken advantage of it. Evidently the quantity and distribution of food resources forced the inhabitants to break for most of the year into small bands or individual family units that could seasonally exploit the environment to their advantage. Only in favorable areas and/or in certain seasons of the year could entire bands or multibands get together. Some groups in the Southeast Texas Gulf Coast area may have had garden plots (Newcomb 1961:323), but in the Shy Pond area, probably no forms of agriculture were practiced.

It is reasonable to expect the Shy Pond and adjacent areas to have similar cultural stages, social structures, and settlement and subsistence patterns. It is also reasonable to expect that some traits appear at Shy Pond later than in the adjacent areas. Similar artifacts, pottery types, and sequential developments that correlate with adjacent areas are to be expected. But although correlations are to be expected, local variations and developments that represent the individuality and integrity of the cultures in their adaptation to the particular environment of the Shy Pond area must be sought and investigated. This was attempted in the analysis of the material from the Copperhead and Cleaver sites, but in general, any individual or local adaptations that may have occurred have been masked by cultural similarities with the Galveston Bay area.

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Thomas R. Hester conducted the excavations under the general direction of Dee Ann Story, then Director of the Texas Archeological Research Laboratory. Larry Thompson and James McMichael, both of Lake Jackson, and Daniel Fox, of San Antonio, served as crew members. Robert Cole provided a sketch of the Shy Pond area that was the basis for Figure 2 and a sample of *Rangia* shell for radiocarbon dating. C. L. Cleaver, for whom the Cleaver site is named, excavated the first 5 x 5–foot unit at that site and made available the material he excavated from the site for analysis. The Brazosport Museum of Natural Science in Lake Jackson made their facilities available, thereby enabling the crew to work in the evenings while the excavations were in progress. Appreciation is extended also to all of the individuals in Lake Jackson and members of the Brazosport Museum who volunteered their time.

During the writing of this report, Lawrence Aten, then of the Texas Archeological Survey, made a trip to the area and provided valuable information concerning the geomorphology, provided additional data on the prehistory of the Galveston Bay area, and made pertinent comments about the Shy Pond sites and this report. Billy Davidson helped in identifying the vertebrate fauna, but the responsibility for the accuracy of the faunal identifications and any interpretations expressed herein rests with the author.

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The Swan Lake Site (41AS16) On Copano Bay, Aransas County, Texas: Settlement, Subsistence, and Sea Level

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ABSTRACT

Archeological investigations at the Swan Lake site (41AS16) in Aransas County, Texas, yielded preliminary data regarding the cultural and natural history of the Coastal Bend region. Cultural materials at the site include substantial quantities of shellfish, fish, and terrestrial animal remains. These materials date from roughly 6000 B.P. to 300 or 400 B.P. and are interpreted as residue left by prehistoric fishermen. A few black drum (*Pogonias cromis)* otoliths, together with other evidence, indicate that the Swan Lake Site was occupied seasonally, usually from late winter to early summer. Oysters (*Crassostrea virginica*) and fish were the staple meat. The site illustrates one segment of a settlement/subsistence model that was confined to the littoral.

Holocene eolian, storm, and tidal sediments at the site reveal much about its natural history. Most of the cultural materials were found within two inactive clay dunes adjacent to an abandoned wind-tidal flat. For the wind-tidal flat and clay dunes to have been active, relative sea level probably would have been 0.9 to 1.2 meters higher than at present. Cultural materials in the dunes indicate that this sea-level highstand may have begun by 4500 B.P. After sea level fell to near its present level, the wind-tidal flat and clay dunes became inactive, and a soil formed. Radiocarbon dates on the buried clay-dune soil indicate that dune growth stopped by about 2500 B.P. Since that time, loessic sediments have blanketed the abandoned tidal flat and clay dunes.

A preliminary version of this paper was presented at the 57th Annual Meeting of the Texas Archeological Society at Laredo, Texas, October 31 to November 2, 1986.

INTRODUCTION

Archeological testing of the Swan Lake site was performed in 1985 by personnel from Prewitt and Associates, Inc. of Austin, Texas (Prewitt, Lisk, and Howard 1987). Sponsored by the Galveston District, U. S. Army Corps of Engineers, the testing assessed the eligibility of the site for inclusion on the National Register. The Swan Lake site, designated 41AS16 by the Texas Archeological Research Laboratory, is in southwestern Aransas County on the Copano Ranch owned by Dr. George Strickhausen III, of Corpus Christi. The work was supervised by Susan V. Lisk, under the direction of Elton R. Prewitt.

The site is on two low knolls on the western shoreline of Swan Lake, an inlet on the south side of Copano Bay near the mouth of the Aransas River (Figure 1). The

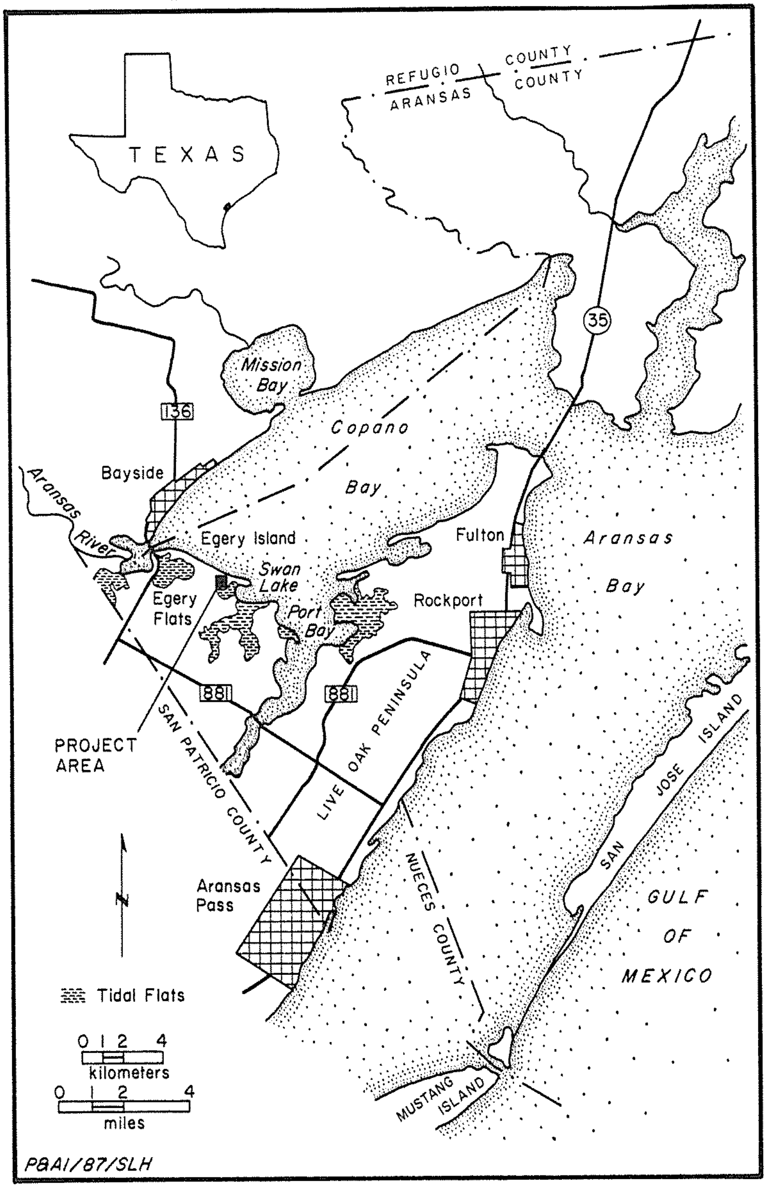


Figure 1. Regional location map, Swan Lake site, 41AS16, Aransas County, Texas.

two knolls differ in size and in the amounts of cultural material on the surface. Both the smaller, eastern knoll and the larger, western knoll are surrounded by a low, hummocky area, except for the area where the Swan Lake shoreline truncates the eastern knoll. Five distinct areas comprise the Swan Lake site (Figure 2). Area 1

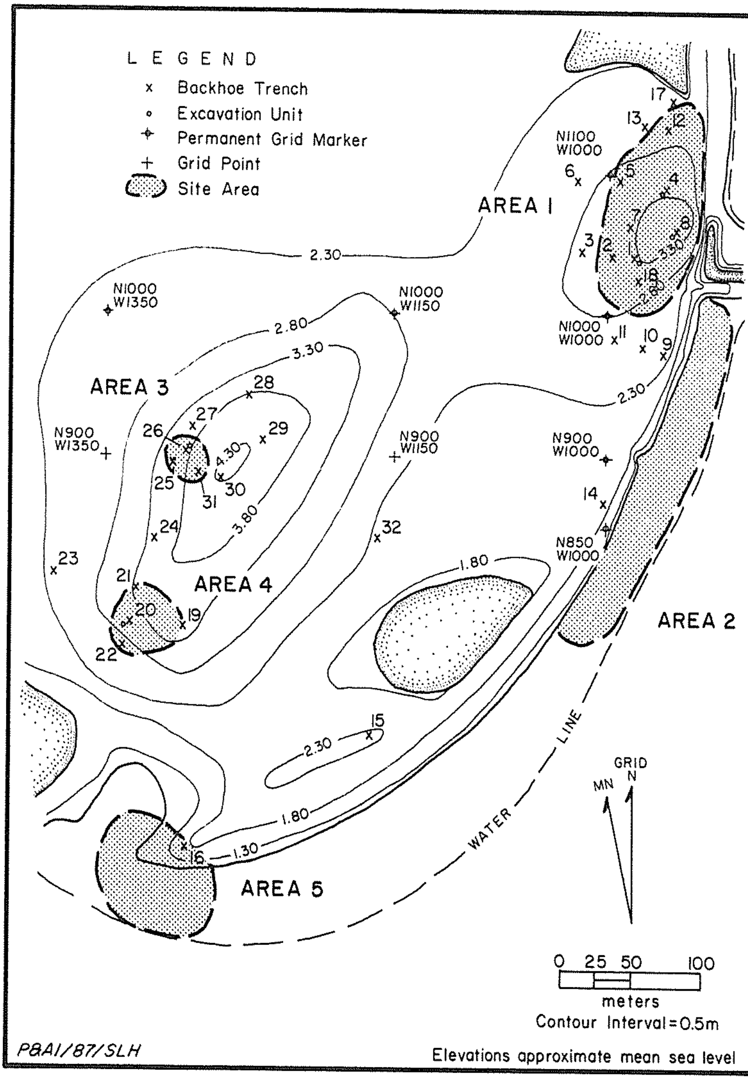


Figure 2. Site map, Swan Lake site, 41AS16.

is on the eastern knoll; Area 2 is on the deflated shoreline, extending southwestward from Area 1; Areas 3 and 4 are on the west-central and southern flanks of the western knoll; Area 5 is on the shoreline just south of the larger knoll.

The Swan Lake site is contained within Holocene eolian deposits that rest on the Pleistocene Beaumont Formation (Brown et al. 1976:16-21). Soils on the knolls are sandy loams; clays occur in the surrounding low-lying areas (Guckian and Garcia 1979:53-55). Vegetation is typical of the region, with thickets of mesquite and other thorny shrubs on the knolls and a prickly pear-midlevel grass association on the flats (Guckian and Garcia 1979:33). The tidal marshes and shallow waters of Swan Lake support communities of cordgrass and other salt-tolerant grasses (White et al. 1983:70-81). The humid subtropical climate has two periods of peak precipitation, April through June, and September through October. Persistent southeasterly winds are interrupted during the winter by strong northerly winds associated with the passage of cold fronts. Average temperatures vary from 92° F in August to 45° F in January (Guckian and Garcia 1979:1-2, 82-83).

The fauna comprise both aquatic and terrestrial assemblages . A wide variety of fish and shellfish inhabit the shallow bays and inlets. Oyster, scallop, sunray venus, and whelk are some of the more important shellfish. Small fish such as croaker, anchovy, and silversides are the most abundant vertebrate groups. Seatrout, redfish, black drum, sea catfish, and porgy, which represent the economic groups (Gunter 1944; Calnan 1980) are plentiful. Terrestrial fauna include a variety of gastropods and vertebrates such as gopher, field mouse, skunk, deer, and other small mammals. An array of reptiles, amphibians, and crustaceans live on and near the site area, and there are also many species of waterfowl, including large numbers of migratory birds.

The Swan Lake site was recorded by George C. Martin and Wendell Potter in 1929 during their extensive survey around Copano Bay and the Live Oak Peninsula (Martin n.d.). In 1967, Edmund Page, of the Coastal Bend Archeological Society, visited the site (Texas Archeological Research Laboratory, County Files). It was surveyed for the first time by a professional archeologist (Warren 1984) when subdivision of the Copano Ranch was anticipated. Corps of Engineers archeologists and the State Historic Preservation Officer concurred with Warren that the site was eligible for nomination to the National Register, and, in 1985, the Corps contracted with Prewitt and Associates, Inc. to gather data at the site with which to obtain a determination of eligibility from the Keeper of the Register in Washington, D. C.

The Swan Lake site was studied through a program of machine and hand testing combined. Machine testing consisted of the excavation of 32 backhoe trenches averaging about 3 meters long and 1 meter deep. Trenches were excavated on the knolls to supplement surface observations, and around the flanks of the knolls to define site boundaries. Other trenches, located off the knolls, determined the integrity of site areas 2 and 5 and exposed areas lacking cultural deposits.

After trenching was completed, one wall of each trench was cleaned, studied, and recorded. This information was used to select areas for hand-excavated test pits. Five 1 x 1–meter units were dug adjacent to trenches, largely in 5–cm arbitrary levels corresponding to the stratigraphy observed in the trenches. There were three test pits in Area 1, and one each in Areas 3 and Area 4. All hand-excavated fill was water–screened through nested quarter– and sixteenth–inch sieves.

STRATIGRAPHY

Both Pleistocene and Holocene sediments occur at the Swan Lake site. The strata are discussed from oldest to youngest.

Beaumont Formation Fluvial-deltaic Deposits

The oldest unit at the site is the late Pleistocene Beaumont Formation (Figures 3, 4), which is a fluvial-deltaic deposit (Brown et al. 1976). The Beaumont is recognized by its tan–to–orange color, abundant caliche, and sandy clay composition. It was probably deposited during the Sangamonian Interglacial (Winker 1979) at roughly 107,000 to 128,000 B.P. (Moore 1982; Imbrie et al. 1984), when sea level was near its present level. The formation was weathered and eroded during the Wisconsinen Glaciation, when sea level was as much as 150 meters below present sea level (Frazier 1974).

Before dissection by streams, the Beaumont was relatively flat lying, rising slightly near channels. Topographic relief on the Beaumont of at least 2.5 meters at the site (Figures 3, 4) indicates that postdepositional erosion has taken place. Modern topography mimics the Beaumont surface; the top of the Beaumont is higher under the two knolls comprising the Swan Lake site. The top of the Beaumont is higher on the western knoll (3.8 meters elevation) than on the eastern knoll (2.8 meters elevation).

Holocene Sediments

Holocene sediments cover the Beaumont across most of the site (Figures 3, 4). They are generally coarser than Beaumont deposits, are light to dark gray, and may contain caliche and cultural material. These sediments range between 42 cm and more than 1.1 meter in thickness. Clay dunes, wind-tidal flats, and loessic sheets are the three major Holocene depositional units at the site. The Holocene sediments also contain three significant shell horizons.

Clay Dunes

The knolls are formed by clay dunes that were deposited on the eroded surface of the Beaumont (Figures 3, 4). These silty clay dunes contain cultural material and have abrupt upper boundaries and some soil development. At the top of the dunes is a blocky, dark, organic-rich soil zone a few centimeters thick, underlain by a texturally similar but less organic zone. Sparse caliche has formed in the lower part of the 15- to 60-cm-thick dune deposit.

Though not exposed at the surface, the clay dunes can be mapped on aerial photographs. The western knoll has an oval outline, elongate from northeast to southwest (Figure 2). The eastern knoll has a similar shape, but the oval is truncated at the Swan Lake shoreline. Cultural debris found within the clay dunes included burned clay nodules, bones, charcoal flecks, and scattered marine shells.

Wind-tidal Flats

A depositional unit not found on the knolls is found in the topographic low between the knolls. This unit is stratigraphically equivalent to the clay dunes, but has a coarser sediment, lighter color and is locally laminated. In addition, the elevation of the top of the unit (about 1.8 meters) is consistent across the low. These sediments probably were deposited in a wind-tidal flat similar to Egery Flats (Figure

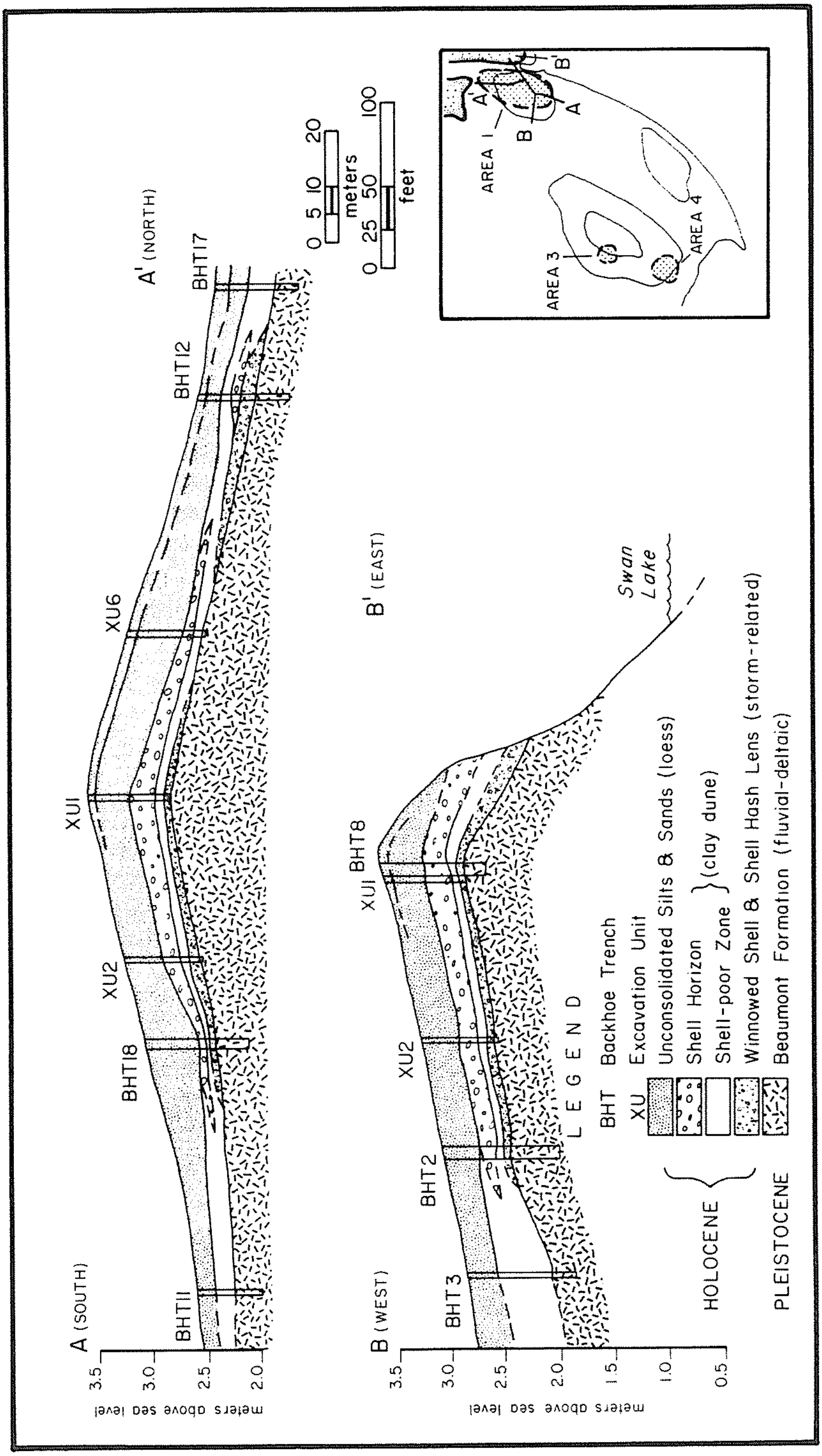


Figure 3. Cross sections from 41AS16, Area 1.

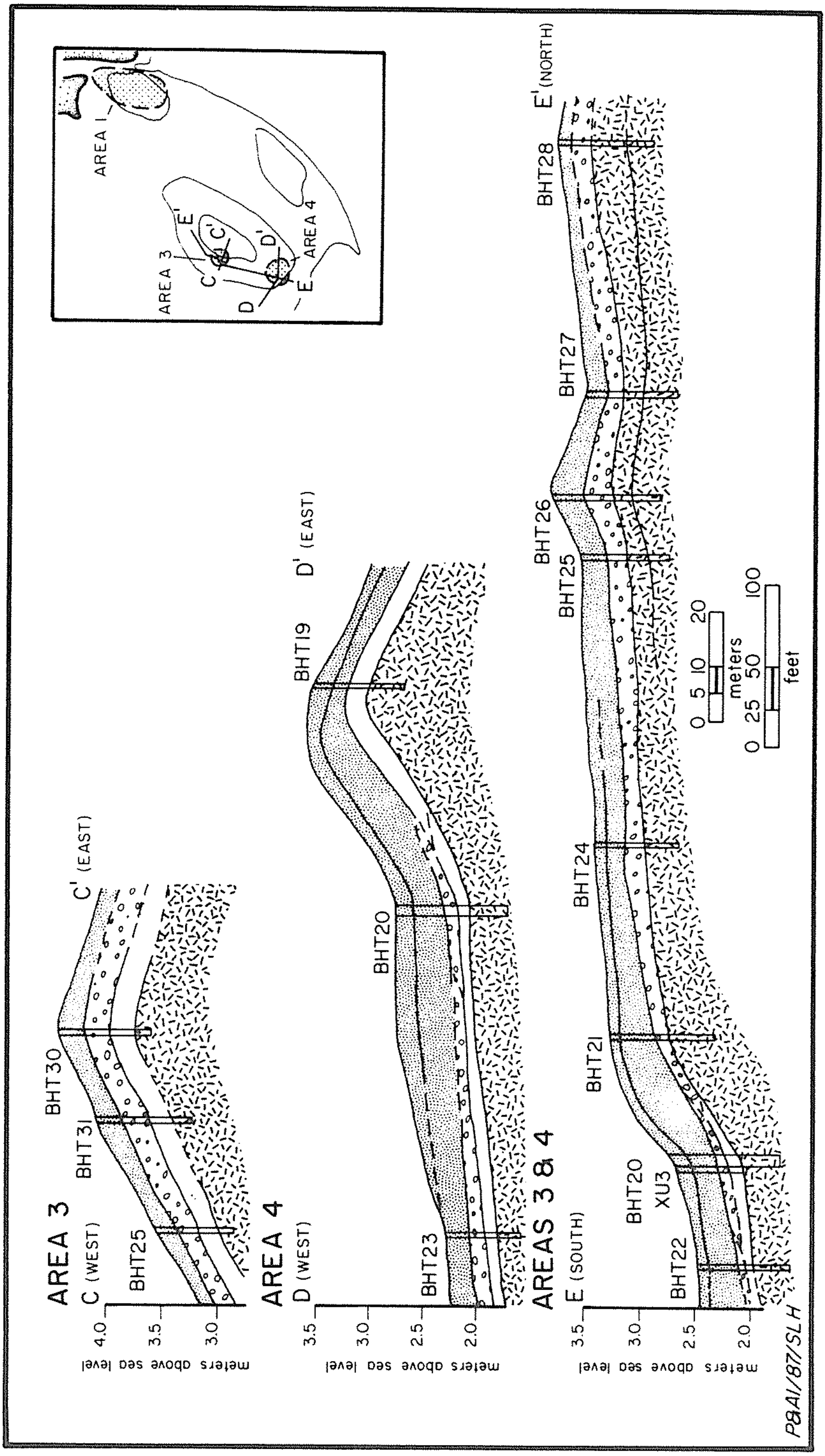


Figure 4. Cross sections from 41AS16, Areas 3 and 4.

2). The Swan Lake tidal flat is southeast of the western clay dune and was the probable source of sediment for the growing dune. The wind-tidal flat appears to be devoid of cultural material despite its stratigraphic equivalence to the clay dunes. Because the tidal flat would have been periodically inundated during growth and human occupation of the clay dunes, the absence of cultural material is consistent with a tidal flat interpretation.

Loessic Sediments

The most recent deposit in the area is also the most uniform (Figures 3, 4). This deposit is composed of well-sorted, silt-sized particles that are bound together weakly and rest unconformably on inactive Holocene clay dunes and wind-tidal flats. This unit is found at the surface, is 7 to 47 cm thick, and contains relatively few shells and other cultural materials. Its areal extent, sorting, and lack of cohesion suggest that it is an eolian loesslike deposit, laid down when silt-laden wind was slowed by vegetation. Deposition probably has continued to the present.

Shell Horizons

There are three significant shell horizons within the Holocene section at the Swan Lake Site. The oldest is a dense storm-winnowed shell lens that contains pockets of shell hash; it is a few centimeters thick and lies directly on the Beaumont underneath the eastern clay dune in Area 1 (Figure 3). Cultural debris representing an early occupation at the site is scattered among the whole and fragmented marine shells comprising this deposit. Thicker but less dense accumulations of shell occur among clay dune sediments higher in the Holocene section (Figures 3, 4). These shell deposits, one on each knoll (Areas 1 and 4), contain abundant cultural material and are probably contemporaneous. Their presence in clay dune sediments indicates that humans discarded shells while the clay dune was actively expanding. The third shell horizon is more sparsely distributed in the loessic sediments in Areas 1, 3, and 4 which overlie the clay dunes. Intermixed with other cultural debris, the shells indicate continued human use during deposition of the loessic sediments after growth of the clay dune had ended.

MATERIAL CULTURE AND FAUNAL REMAINS

The artifacts recovered during the testing of the Swan Lake site are divided into four major groups: lithics, ceramics, bones, and shells. The 56 lithic pieces consist of two arrow points, seven dart points, one drill/perforator, two biface fragments, two unifaces, three cores, 10 pieces of edge-modified debitage, and 29 pieces of unmodified debitage. Both arrowpoints lack their stems but are probably Perdiz (Suhm and Jelks 1962:283; Turner and Hester 1985:187). The dart points include four Matamoros, one Catan, one Abasolo, and one Bell (Suhm and Jelks 1962:165,175,215; Turner and Hester 1985:61,72,78,122). One arrowpoint (Fig. 5, a) is from loessic sediments in Area 1; the other (Fig. 5, b) is from the surface in Area 5. One Matamoros point (Figure 5, c) is from dredge spoil taken from Area 1, and the other three (Figure 5, d-f) are from the surface of Area 2. The Catan

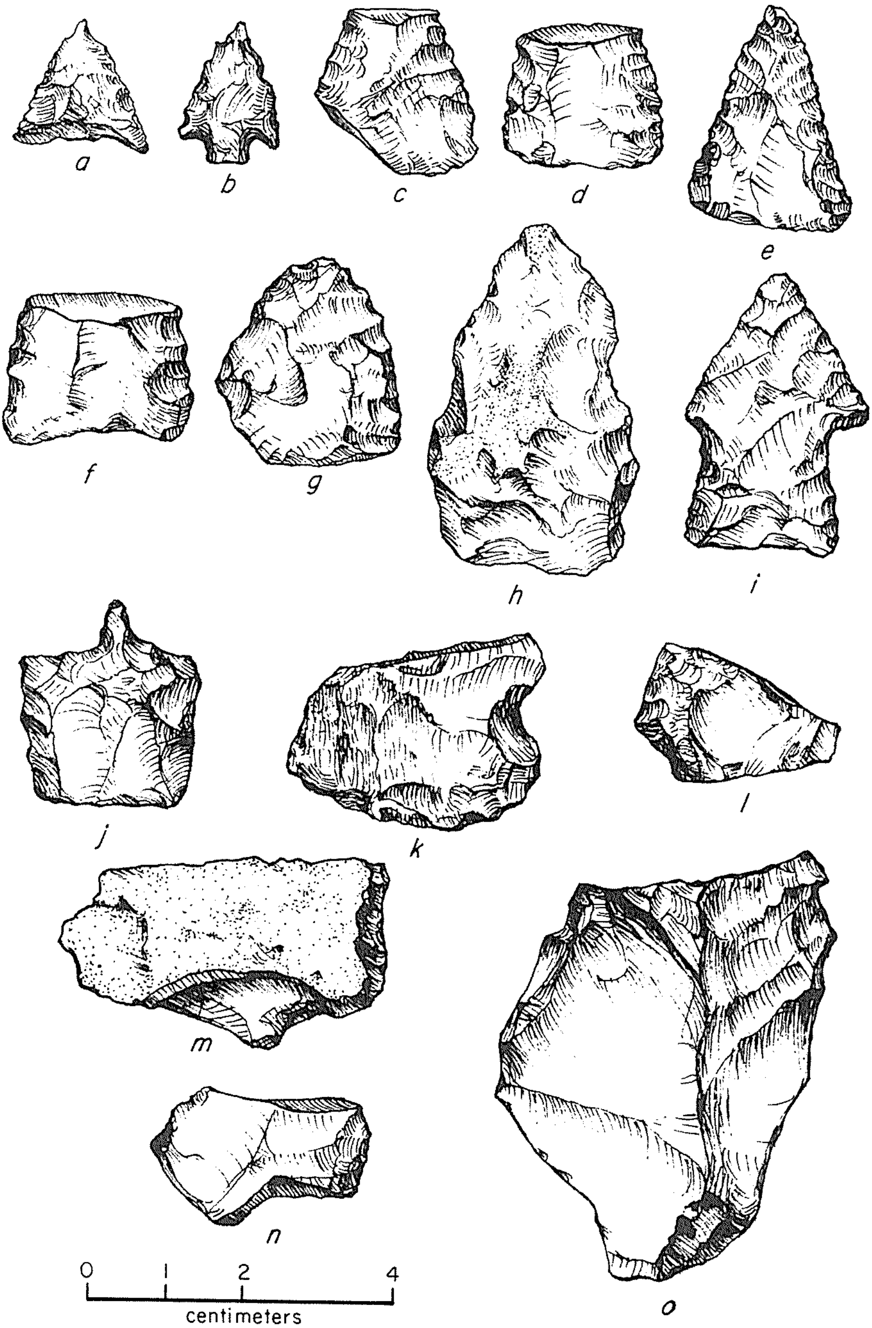


Figure 5. Lithic artifacts from 41AS16: a-b, Perdiz (?) arrowpoints; c-f, Matamoros dart points; g, Catan dart point; h, Abasolo dart point; i, Bell dart point; j, drill/perforator; k–l, biface fragments; m–n, unifaces; o, expended core.

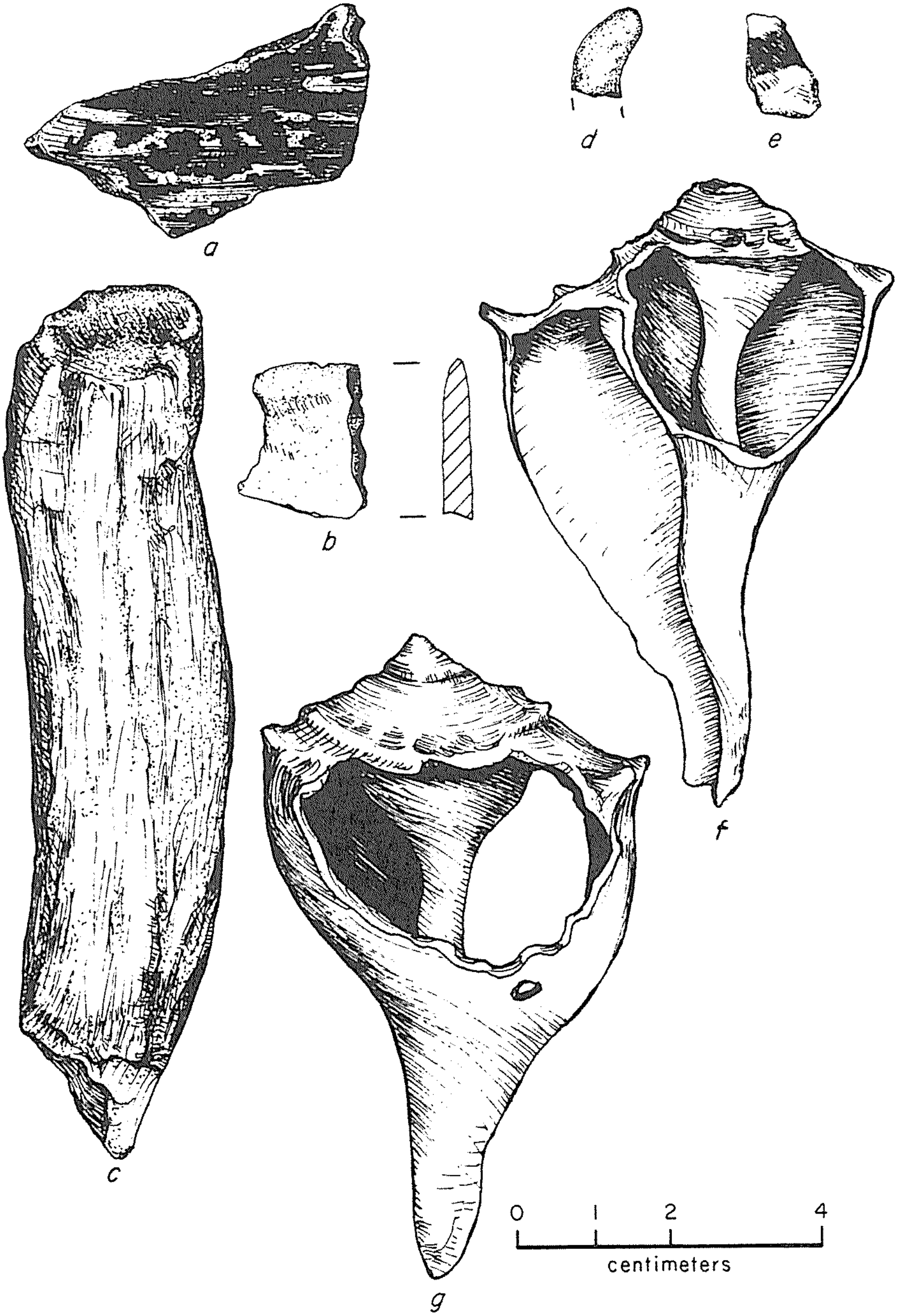


Figure 6. Ceramic, bone, and shell artifacts from 41AS16: a. Rockport Black-on–Gray body sherd; b, Rockport Ware rim sherd; c, antler billet; d, possible antler tine tool; e, asphaltum-painted bone fragment; f, modified *Busycon contrarium*, Group A; g, modified *B. contrarium*, Group B

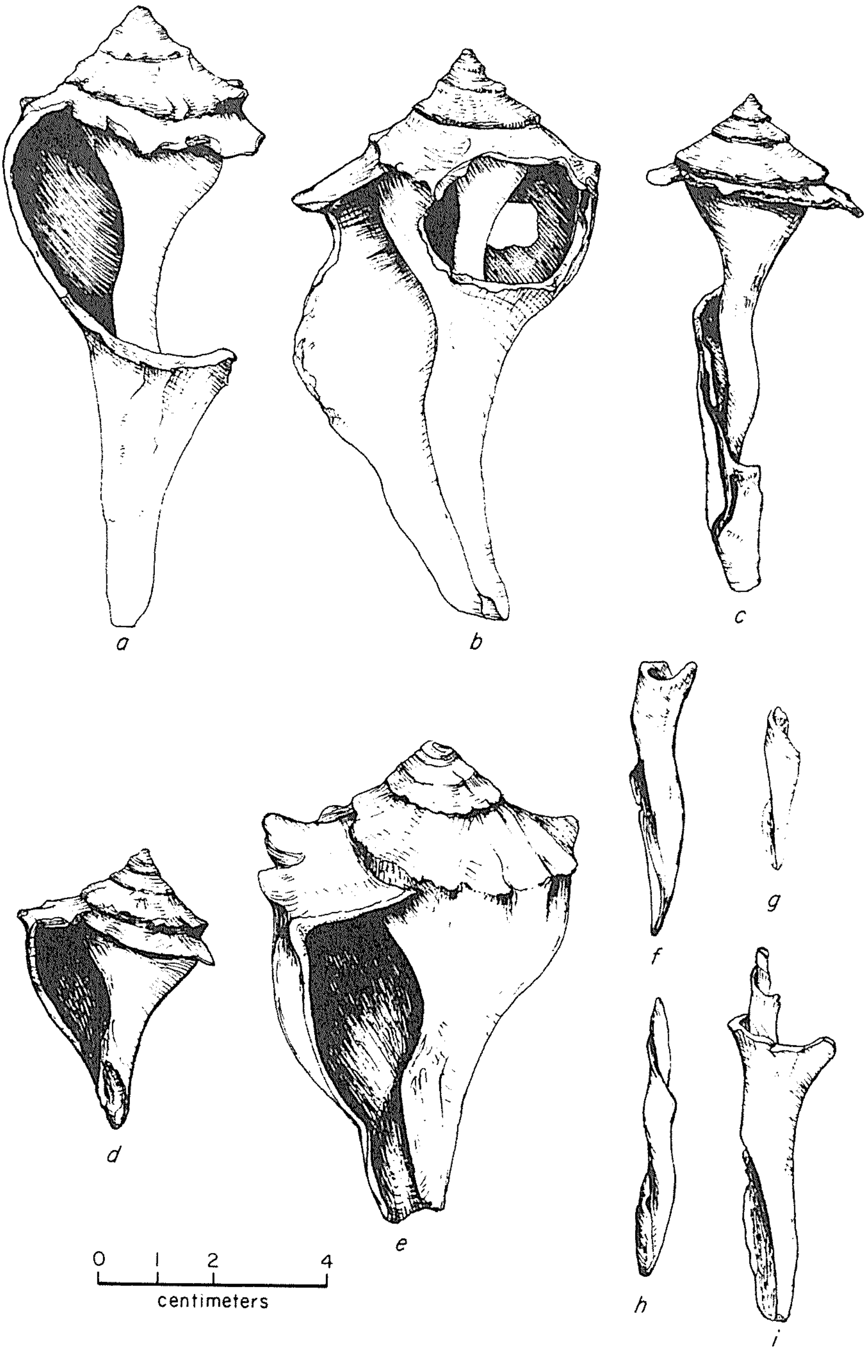


Figure 7. 41AS16 Shell artifacts; modified *Busycon contrarium.,* from 41AS16: a, Group C; b, Group D; c, Group E; d, Group F; e, Group G; f, Group H; g, Group I; h, Group J; i, Group K.

(Figure 5, g) is from the upper shell horizon of the clay dune in Area 1, and the Abasolo (Figure 5, h) is from the shell-poor zone of the clay dune. The Bell point (Figure 5, i) is from the surface of Area 2. The drill (Figure 5, j) and both biface fragments (Figure 5, k-l) were found within the upper shell horizon in the clay dune, and the two unifaces (Figure 5, m-n) are from the winnowed shell and loessic sediments in Area 1. One core is from the upper shell horizon of the clay dune in Area 1, and the other two are from the surface, one in Area 1 and the other (Figure 5, o) in Area 2. One piece of edge-modified debitage is from the surface of Area 1 and one is from the surface of Area 5; the remainder are from excavations in Area 1: two in the winnowed shell, one in shell-poor clay dune deposits, three in the upper shell horizon of the clay dune, and two in the loessic sediments. All of the unmodified debitage is from excavated contexts: one in the winnowed shell, two in the shell-poor clay dune deposits, thirteen in the upper shell horizon of the clay dune, and thirteen in loessic sediments. One is from loessic sediments in Area 3, and four are from loessic sediments in Area 4; the remainder are from Area 1.

Six small ceramic sherds, five from Area 3 and one from Area 4, were found in loessic sediments. The sherds (Figure 6, a-b) have sandy paste, and one is bone tempered. The interiors of four are coated with asphaltum. All of them can be classified as Rockport ware sherds (Suhm and Jelks 1962:131-136).

Three bone artifacts consist of an antler butt billet (Figure 6, c), an antler tine flaking tool (Figure 6, d), and an unidentified bone fragment (deer size) encircled by a single painted black asphaltum stripe (Figure 6, e). The billet is from backhoe excavations in Area 1 and is probably from either the upper shell zone of the clay dune or from overlying loessic sediments. The other two are from loessic sediments in Area 3.

The 310 modified or possibly modified marine shells comprise the largest artifact category. Five species are represented—*Busycon contrarium, B. spiratum, Pleuroploca gigantea, Fasciolaria lilium,* and *Macrocallista nimbosa.* The 177 lightning whelks are divided into 17 categories and the 119 sunray venus clams are divided into 10 categories. The four pear whelks, five Florida horse conchs, and five banded tulip conchs are similar to groups within the lightning whelk categories. Seventy–six of the lightning whelks represent variations of what traditionally have been called kill holes (Figures 6, f-g and 7, a-i), 82 represent various columella modifications, and 16 are combinations of whorl and columella modifications. The columella modifications generally consist of abrasion, snapping, or both, on the anterior ends, but some are also abraded on the posterior ends to form small pointed implements. Functionally, these categories may represent a suite of oyster exploitation tools such as shucking wedges and picks (single-tine oyster forks). In contrast, those with kill holes only may represent net weights for use with various fishing devices.

Seven of the sunray venus clams are chipped into what traditionally are recognized as scrapers (Figure 8, a). The chipping is along lateral edges and is similar to the chipping found on lithic items. Another 27 may have served similar functions, but are not as clearly chipped (Figure 8, b). Seven are elongated and pointed on one or both ends (Figure 8, c). These appear to be sharpened and are

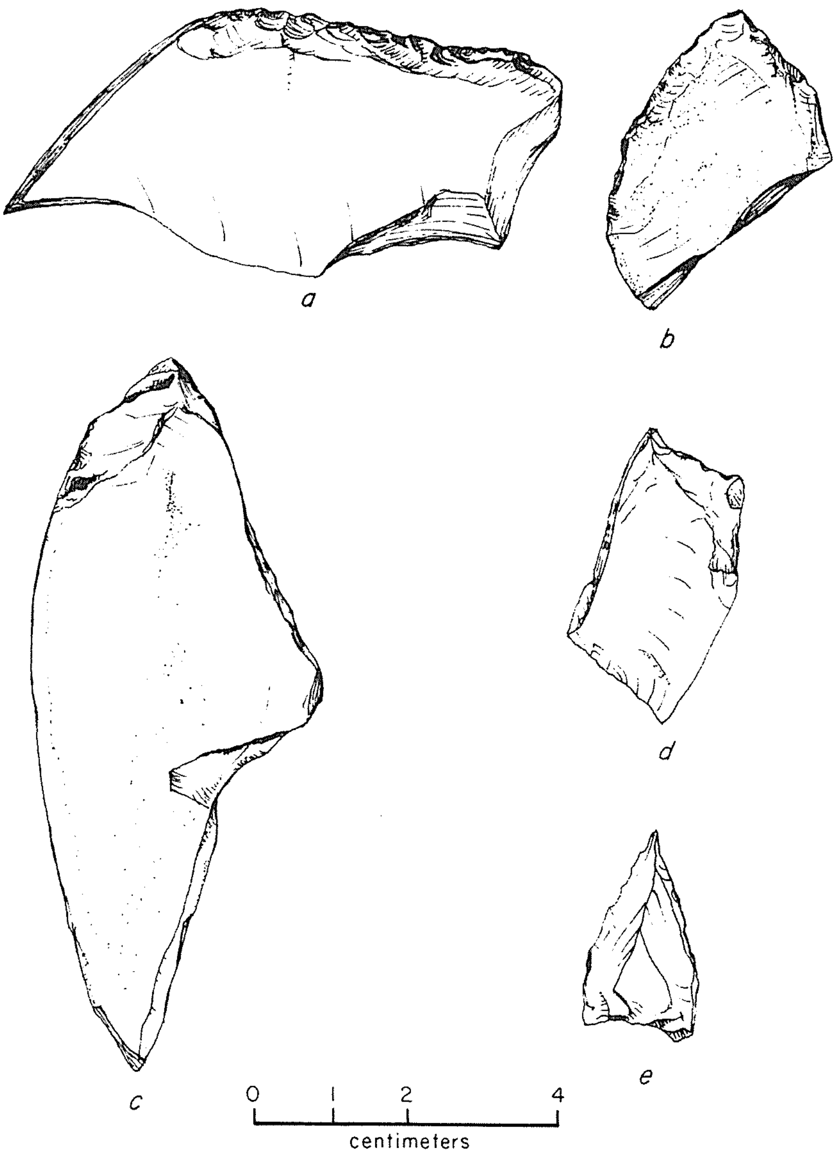


Figure 8: Shell artifacts; modified *Macrocallista nimbosa* from 41AS16: a, Group A; b, Group B; c, Group E; d, Group H; e, Group J.

tentatively interpreted as oyster knives (they were inserted between the oyster valves after the valves were pried open with one of the whelk shuckers and were used to detach the animal from one valve to extract the meat). The largest category of sunray venus artifacts is 47 small triangular pieces. Some of these apparently are the broken ends of the presumed oyster knives (Figure 8, d), whereas others may be shell projectile points (Figure 8, e) and other tools.

One feature revealed in the excavations was a cluster of whelk shells in an area of burned oyster shells near the bottom of the upper shell horizon of the clay dune in Area 1. Associated with the feature were various other shells, bone fragments, and burned clay lumps. The association of the unburned whelk shells is difficult to interpret, but the burned oyster shells and burned clay lumps seem to indicate the presence of a hearth. Two other pitlike features were investigated, one in Area 1 and one in Area 4. Both were thought at first to be possible burial or storage pits but were found later to be animal burrows.

The unmodified faunal remains consist of shells and bones. Oysters account for more than 75 percent of the more than 183 kg of shell. The 13 remaining species are dominated by lightning whelks (about 3 percent) and Atlantic bay scallops (about 2 percent). Other groups comprise no more than about 1 percent each of the total. Except for apple murex, which is a continental shelf species, all the species represented are common in bay environments (Table 1). Most of the species prefer low-salinity bays, but some, such as the horse oyster, prefer high-salinity habitats. The economic species are oyster, whelk, scallop, sunray venus clam, and conch. The hooked mussels and cross-barred venus clams are common on oyster reefs, and their introduction to the site probably was incidental to oyster exploitation.

The snail shells recovered represent common terrestrial and aquatic species expected in the region. These are dominated by the South Texas tree snail, *Rabdotus alternatus* (Tables 2, 3).

The nearly 5,000 bone fragments (Table 4) represent an array of aquatic, terrestrial, and avian species whose habitats are consistent with the site's location

Table 1. Names and Habitats of Mollusc Shells at 41AS16

Latin Name[1]	Common Name[1]	Habitat[2]
Fasciolaria lilium	Banded tulip shell	Inlet–influenced[1]
Pleuroploca gigantea	Florida horse conch	Inlet–influenced[1]
Busycon spiratum	Pear whelk	Inlet–influenced[1]
B. contrarium[3]	Lightning whelk	Bay margins[3]
Murex pomum	Apple murex	Intermediate continental shelf (or shallow water)[3]
Anadara transverso	Transverse ark	Inlet–influenced[3]
Ischadium recurvum	Hooked mussel	Low–salinity oyster reef
Argopecten amplicostatus	Atlantic bay scallop	Open sound or lagoon margin
Crassostrea virginica	Eastern oyster	Low–salinity oyster reef
Ostrea equestris	Horse oyster	High–salinity oyster reef
Rangia cuneata	Common *Rangia*	River–influenced, low salinity
Macrocallista nimbosa	Sunray venus	Inletinfluenced[1]
Chitone cancellata	Cross-barred venus	Open sound orlagoon margin
Mercenaria campechiensis texana	Texas quahog	Open sound or lagoon margin

[1] Andrews 1981
[2] Parker 1960
[3] Abbott 1968

Table 2. Snail Species Recovered from Quarter-inch Screen Samples, Unit 1, Area 1

Species	Zone 5/6	4	3	2
Littorina irrorata	3	3	11	8
Helicina orbiculata	0	7	6	8
Truncatella pulchella[1]	–	–	–	–
Succinea sp.[1]	–	–	–	–
Helicodiscus singleyanus[1]	–	–	–	–
Rabdotus alternatus	0	213	69	16
Thysanophora horni[1]	–	–	–	–
Polygyra texasiana	0	7	11	8
Praticolella berlandieriana	0	56	5	5

[1] Shells of this species are too small to be retained on the quarter–inch screen.

Table 3. Snail Species Recovered from Sixteenth-inch Screen Samples, Unit 1, Area 1

Species	Zone 5/6	4		3		2	
		Ad	Im	Ad	Im	Ad	Im
Littorina irrorata	0	0		0		0	
Helicina orbiculata	0	38	22	27	7	37	17
Truncatella pulchella	0	2	2	0		1	0
Succinea sp.	0	0	2	0	1	0	3
Helicodiscus singleyanus	0	1	0	0		2	0
Rabdotus alternatus	0	15	47	39	5	48	21
Thysanophora horni	0	4	1	4	0	0	
Polygyra texasiana	0	47	27	33	8	20	13
Praticolella berlandieriana	0	46	17	52	5	58	15

Ad–Adult
Im–Immature

on the coastal littoral (Table 5). Fish bones are the most numerous, including ray, gar, and a variety of advanced rayfins such as sea catfish, porgy, croaker, and burrfish. Notable among these are sheepshead, seatrout, redfish, and black drum. With the exception of the sheepshead, which prefers a nearshore open gulf habitat, all the species inhabit bays during some part of the year. Those useful for seasonlity purposes include cownose ray, redfish, black drum, and striped burrfish, all of which are most common during the spring and summer months.

An analysis of the 15 black drum otoliths recovered generally indicates late spring-early summer harvest (Appendix), but some variation is suggested by the vertical distribution of the otoliths. The two specimens from the winnowed shell suggest late winter-early spring harvest, but the three from the shell-poor clay dune deposits suggest late winter to early summer. The 10 from the upper shell horizon

Table 4. Summary of Faunal Remains Recovered from Excavation Units (Raw Frequencies)

	Area 1 (Units 1, 2, 6) Zone				Areas 3 & 4 (Units 3, 5) Zone			
Common name	5/6	4	3	2	5/6	4	3	Total
Unidentified	436	1,669	112	116	513	93	12	2,951
Ray	2	5	–	–	1	–	–	8
Gar/bowfin	–	–	–	–	12	4	–	16
Rayfin	69	722	65	29	141	65	10	1,101
Frog/toad	–	7	–	–	–	4	–	11
Turtle	26	47	–	2	39	14	4	132
Lizard	–	1	–	–	–	–	–	1
Snake	7	66	7	4	48	3	1	136
Alligator	–	1	–	–	–	–	–	1
Bird	3	5	3	–	34	10	1	56
Unidentified mammal	6	148	7	15	43	8	–	227
Shrew	–	–	–	–	1	–	–	1
Skunk	–	–	–	–	–	1	–	1
Javelina	–	1	–	–	–	–	–	1
Deer	3	16	4	–	6	–	–	29
Bison	–	–	–	–	–	1	–	1
Dolphin	1	–	–	–	–	–	–	1
Rat	–	10	1	–	8	–	–	19
Gopher	–	1	–	–	–	–	–	1
Rabbit	–	10	1	2	3	–	–	16

of the clay dune indicate a continuation of the late winter-early summer pattern, but one specimen appears to have been harvested during the summer. The sizes of the fish can be estimated from their age; only four of the otoliths are from fish more than four years old. The fish probably weighed about 1 kg.

Turtles and snakes are the predominant reptiles, but one alligator bone and a few lizard bones were found. Unfortunately, none of the bird bones are identifiable to species, but a variety of sizes appears to be represented. Similarly, most of the mammal bones are too fragmentary for species identification, but deer dominates the identifiable bones. One specimen each of javelina, bison, and dolphin are represented in the collection. Roughly equal amounts of bone were found in the winnowed shell and shell-poor zone of the clay dune. The greatest quantity came from the upper shell horizon of the clay dune; the second–greatest quantity came from the loessic sediments.

NATURAL HISTORY

Sediments and soils at the Swan Lake site indicate that the depositional environment has changed significantly during the late Pleistocene and Holocene. At about 20,000 B.P., the Swan Lake site was an upland area 150 meters above sea level and more than 100 km inland. Today, it is a coastal lowland essentially at sea level. The following sequence of paleoenvironments is interpreted from the strata exposed in trenches and soil cores.

Table 5. Composite Faunal List and Preferred Texas Habitats

Scientific Name	Common Name	Preferred Habitats
Chondrichthyes	Sharks, rays, skates	
Batoidea	Rays, skates,	
Rhinoptera bonasus	Cownose ray	Nearshore, estuarine (warm months)
Osteichthyes	Bony fish	
Holostei	Gar, bowfin	
Lepisosteus sp.	Gar	Freshwater, estuarine, nearshore
Teleostei	Advanced rayfin fish	
Ariidae	Sea catfish	
Arius felis	Sea catfish	Estuarine, nearshore
Bagre marinus	Gafftopsail catfish	Estuarine, nearshore
Sparidae	Porgies	
Archosargus probatocephalus	Sheepshead	Nearshore
Scianidae	Croakers	
Bairdiella chrysura	Silver perch	Estuarine
Cynoscion sp.	Seatrout	Estuarine, inner shelf
Scianops ocellata	Redfish	Estuarine, inner shelf
Pogonias cromis	Black drum	Estuarine
Diodontidae	Porcupinefish, burrfish	
Chilomycterus schoepfi	Striped burrfish	Estuarine, nearshore
Diodon sp.	Balloonfish	Estuarine, inner shelf
Amphibia	Frog, salamander	
Anura	Frog, toad	Freshwater, terrestrial, arboreal
Reptilia Reptiles		
Chelonia	Turtles	Freshwater, estuarine, marine, terrestrial
Sauria	Lizards	Terrestrial, arborial
Ophidia	Snakes	Freshwater, estuarine, terrestrial, arboreal
Crocodilia		
Crocodylidae	Crocodiles, alligators	Freshwater, estuarine
Aves	Birds	
Mammalia	Mammals	
Soricomorpha	Shrews, moles	
Cryptotis parva	Least shrew	Fields with dense ground cover
Carnivora	Carnivores	
Mustelidae	Weasels, skunks	
Mephitis mephitus	Striped skunk	Brushy or wooded areas
Artiodactyla	Even-toed hoof animals	
Dicotyles tejacu	Collared peccary	Brushy semidesert with prickly pear
common		
Odocoileus virginianus	White-tailed deer	Woody or brushy areas and coastal
	marshes	
Bison bison	Bison	Prairie, woodlands
Cetacea	Whales	
Tursiops truncatus	Atlantic bottlenose dolphin	Nearshore, inner shelf, estuaries
Rodentia	Rodents	
Neotoma floridana	Eastern woodrat	Woodlands
N. Micropus	Southern Plains woodrat	Semiarid brushy areas
Sigmodon hispidus	Hispid cotton rat	Grasslands, brushy areas
Geomys sp.	Pocket gophers	Sandy soils
Lagomorpha	Rabbits, hares	
Sylvilagus aquaticus	Swamp rabbit	Swamps and coastal marshes
S. floridanus	Eastern cottontail	Brushy areas and grasslands
Lepus californicus	Black-tailed jackrabbit	Prairie and scrublands

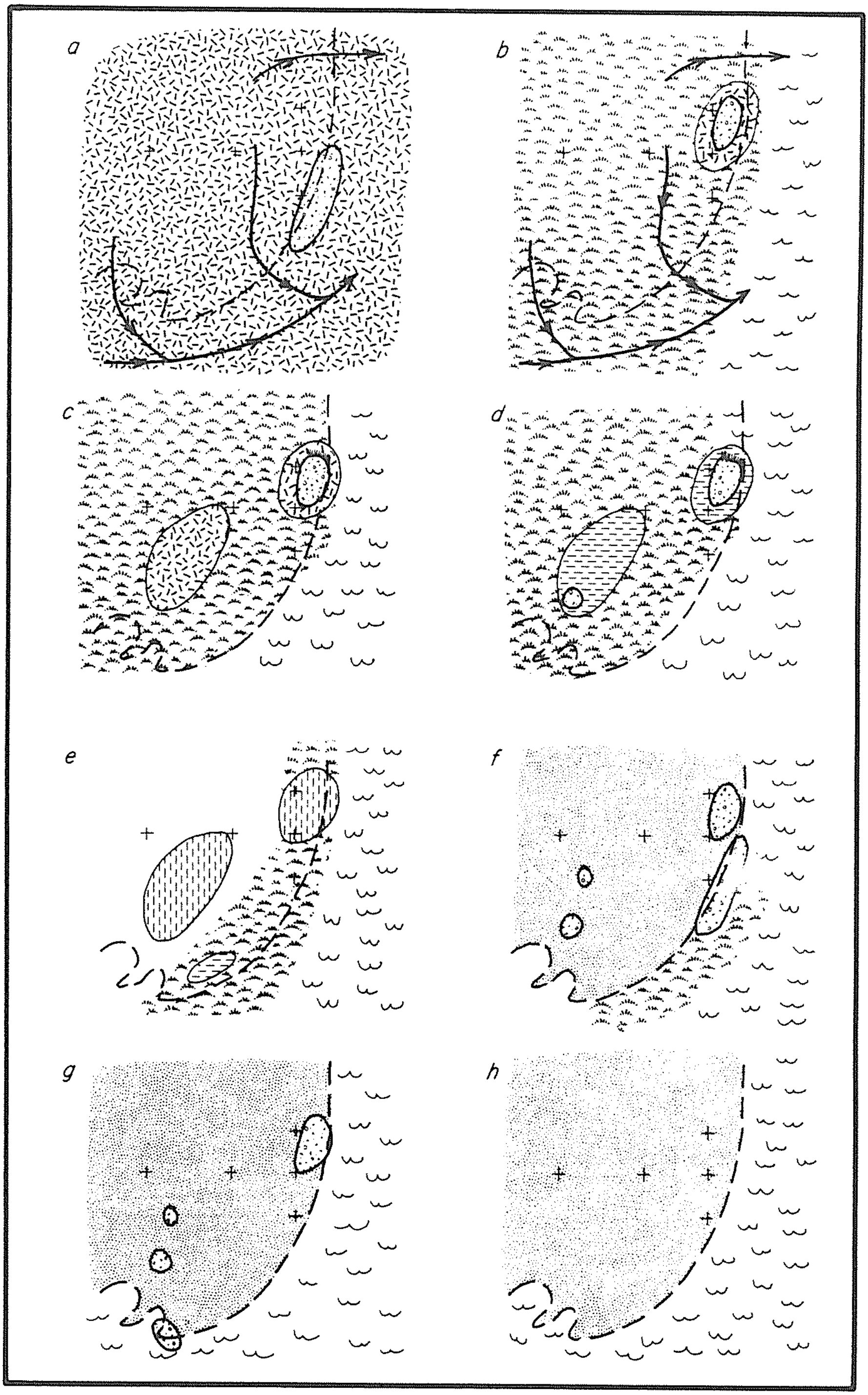
Late Pleistocene to Early Holocene

During a period of low sea level at the end of the Pleistocene and the beginning of the Holocene, streams cut a drainage network into the exposed and weathered Beaumont Formation. At the Swan Lake site, a minor valley opened southward between the two Beaumont knolls (Figure 9, a). This valley joined a larger, eastward-opening valley (now occupied by Swan Lake) south of the site. This valley in turn entered the deeper ancestral Aransas River valley, which had been incised from 10 to 20 meters below present sea level under Copano Bay (Wright 1980).

Holocene Highstand (Early)

Sea level rose rapidly during the early Holocene, bringing the coastline closer to the site. Estimates of when marine waters entered present-day Copano Bay depend on both the depth of stream incision and the sea level curve used for the calculation. Taking 20 meters as the maximum depth of incision (Wright 1980) and the sea level curve of Frazier (1974), marine waters would have first entered Copano Bay about 9000 to 10,000 B.P. Because the valleys near the Swan Lake site were not deeply incised, saline water reached these areas later. By about 5000 B.P., sea level was so high that storm waters inundated the area (Figure 9, b). A lens composed of cultural debris, storm-winnowed marine shells, and shell hash was deflated onto the Beaumont Formation on the eastern knoll at about this time. The storm-winnowed shell lens in Area 1 records the first extensive occupation at the Swan Lake site, preceded only by brief occupation of Area 2 by one or more groups of hunters before 5000 B.P.

Figure 9: Paleoenvironmental and cultural sequence at the Swan Lake site, 41AS16
a. Small streams drain the weathered and eroded Beaumont Formation during the late Pleistocene and early Holocene; early Archaic camp in Area 2 ca. 6000 B.P.
b. When sea level nears its present level, middle Archaic occupation occurs in Area 1, leaving a mass of oyster shells and other cultural debris at about 5000 to 4500 B.P.
c. At the beginning of the highstand, ca. 4500 B.P., wind–tidal flats develop, storms winnow and deflate shell/cultural materials in Area 1 onto Beaumont Formation surface, and a low shell berm develops along shoreline on northeast edge of Area 1.
d. During the highstand, the wind–tidal flat provides sediment for clay dune growth; occupations occur in Areas 1 and 4 at about 4000 to 3500 B.P.; shell berm on northeast edge of Area 1 continues to develop.
e. After the highstand, sea level retreats to near modern levels; abandonment of wind–tidal flats causes deposition to cease on the clay dunes and allows soil formation to begin; clay dune depostion begins at lower elevation at about 3000 B.P.
f. Wind blown loesslike sediments blanket Swan Lake Site; occupations continue in Areas 1 through 4, about 2500 to 1000 B.P.
g. Loesslike sediments continue to accumulate across Swan Lake site; later occupations in Areas 1, 3, 4, and 5, at about 1000 to 300 B.P.
h. Loesslike sediments continue to accumulate across Swan Lake site; Areas 2 and 5 deflate as modern shoreline develops, beginning about 300 B.P.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At the end of this rise in sea level, a wind-tidal flat was established at about 1.8 meters elevation between the two knolls at the site (Figure 9, c). If the wind-tidal flat was active, sea level probably was 0.9 to 1.2 meters higher than at present. This highstand is also suggested by a possible beach ridge, composed of reworked shells from the winnowed shell layer, on the northeast edge of the eastern knoll.

Holocene Highstand (Late)

After the tidal flat was established, alternate periods of wetting and drying caused by frontal passage or other infrequent atmospheric events, produced the sediment that formed two clay dunes at the Swan Lake site (Figure 9, d). (Clay dunes form downwind of and adjacent to ephemeral water bodies [Price 1958], the dunes receiving eolian sediment when the adjacent water body dries up.) At the Swan Lake site, the western Beaumont knoll collected sediment from the tidal flat between the knolls. The source of sediment for the eastern knoll probably was also a tidal flat; however, bay-margin erosion has removed it. Erosion of the eastern clay dune has deflated cultural debris from the dunes onto the Swan Lake shore. The presence of cultural material in the clay dunes implies that occupation occurred during dune formation and, therefore, during the Holocene highstand. This occupation probably began by 4500 B.P. and ended by 3000 B.P.

Post–Holocene Highstand

After sea level fell to near its present level, the tidal flats adjacent to the clay dunes were abandoned, and no sediment was available to continue dune accretion. A soil began to form on the abandoned dunes (Figure 9, e), and, although it is difficult to estimate how long they were exposed to weathering, it was long enough for a soil profile to develop and for calichification to begin. Radiocarbon dates on soil fractions from the western clay dune (Tx-5594, 2270±60 B.P., uncorrected) (S. Valastro, Jr., personal communication, October 1986) indicate that dune growth ceased by about 2500 B.P., so it appears that sea level must have fallen by that time.

The final Holocene event at the Swan Lake site is the ongoing deposition of a loesslike sheet of silt over the inactive wind-tidal flat and clay dunes (Figure 9, f-h). Loessic deposition coincided with the most recent occupation of the site sometime after 1500 B.P.

CULTURAL HISTORY

The data recovered from the Swan Lake site support modest conclusions on three aspects of its history. These are site function, local settlement/subsistence model, and regional implications. It seems clear that the site was primarily a fishing camp. The masses of shells are evidence that shellfishing was especially important to the inhabitants, and large quantities of fish bones attest to the importance of this food resource. The site afforded ready access to the food resources in Copano Bay and Swan Lake and also provided limited access to terrestrial resources; the limited availability of these resources is reflected in the site's contents.

Primary activities on the site were food preparation and consumption. Other activities, such as formal stone tool manufacture, were kept to a minimum, and greater emphasis was placed on tools of convenience. The size of the group inhabiting the site at any one time probably was small, perhaps no more than 25 or 30 people. The range of activities was appropriate to small family groups and apparently did not include a specialized endeavor such as an all male fishing station. Based on the limited seasonality data, it is presumed that occupation occurred primarily during the late winter to early summer or, roughly, from March through June or July.

From these interpretations, it is possible to construct the beginnings of a local settlement/subsistence model. The Swan Lake site represents one seasonally-specific component of this model. Previous investigations along the south shore of Copano Bay (summarized in Prewitt, Lisk, and Howard 1987:15-25) have revealed several very large and dense shell midden sites and many more smaller sites on the order of the Swan Lake site. Seasonality studies are scarce, but the apparent use of this site as a spring-summer fishing camp indicates that seasonal transhumance, [See Ricklis, herein, *Ed.*] with its attendant social implications, was an integral aspect of the prehistoric use of the area.

It is suggested that the littoral zone around Copano Bay was inhabited by small groups of fishermen that moved periodically on a seasonal basis or whenever the resources at a given locality were depleted, or were perceived to be depleted. These small groups probably joined to form maximum bands at some time between late summer and early winter. Larger shell midden sites around Copano Bay, such as Kent-Crane (Campbell 1952), are assumed to represent periods of the year when the groups congregated into maximum bands—the time when goods were exchanged, marriages were arranged, and myriad other social rites and activities were conducted.

Little is known of the early historic aboriginal groups in this area, but Campbell and Campbell (1981:12-13) place the Quitoles in the region extending from Copano Bay southward toward Nueces Bay. The Quitoles are thought to have stayed near the bay all year, and they, together with three other nearby coastal groups, apparently did not participate in the well-known summertime treks into the prickly pear fields of southern Texas. These observations, although sketchy, tend to support the archeological conclusions.

The regional implications of the Swan Lake site are not yet clear. Most striking is the absence of tools such as shell adzes that are commonly associated with the Aransas focus. The site simply does not conform well to current perceptions of the local Archaic. The later use of the site seems to agree with extant data describing the Rockport focus, although the materials at the Swan Lake site do not reflect the full range of the currently defined archeological unit. The implications are that the few excavations conducted in the Copano Bay-Live Oak Peninsula area have not included the functional range of sites and that considerable work is needed before a regional framework can be established with confidence.

CONCLUSIONS

Several major conclusions are drawn from the investigations at the Swan Lake Site:

1) Temporal affiliations begin with the early Archaic period and extend into the Late Prehistoric period. The material culture assemblage can be assigned to the Aransas focus (Archaic) and Rockport focus (Late Prehistoric) but does not include a great many items associated with either of the defined units. The site was occupied intermittently from about 5000 to 6000 B. P. until about 300 or 400 B.P.

2) The site was used by small family groups. Limited seasonality data gathered from black drum otoliths and the migratory patterns of cownose rays, red drums, black drums, and striped burrfish indicate spring to early summer harvest. Other terrestrial and aquatic species such as deer, bison, javelina(?), alligator, and dolphin were harvested on an opportunistic basis;

3) Tools of convenience made from whelk shells and sunray venus clam shells dominate the material culture assemblage. These represent a suite of simple but effective tools for exploitation of fish and oysters.

4) Wind-tidal flats surrounding the knolls comprising the site provided a source for eolian sediments that formed clay dunes on the knolls. To make these flats active, sea level on the Texas Coastal Bend would have to have been 0.9 to 1.2 meters higher than at present. Stratified cultural materials within the dunes and radiocarbon dates on dune soils indicate that this highstand occurred between about 4500 B.P. and 2500 B.P.;

5) During and after the highstand, the site functioned as a fishing camp that provided the occupants access to fish and shellfish from the shallow waters of Copano Bay and Swan Lake. The use of the site as a fishing camp reflects one aspect of a local settlement/subsistence system oriented toward exploitation of littoral resources;

6) Extensive excavations around Copano Bay are required to reexamine the composition of the local chronological constructs and to explore the validity of the settlement/subsistence model suggested by the data from the Swan Lake site.

ACKNOWLEDGMENTS

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APPENDIX

Observations on Seasonality of Selected Fish Remains from 41AS16

Elton R. Prewitt

INTRODUCTION

Two aspects of seasonality can be determined from the fish remains recovered from the Swan Lake site. The first relies on observation of the annuli of the otoliths of certain species (Casteel 1976:31–35); the second relies on biological observations of the habits of certain species (Hoese and Moore 1977; Texas Parks and Wildlife Department 1984). The present observations are limited to four species of fish: *Rhinoptera bonasus* (cownose ray), *Scianops ocellata* (red drum), *Pogonias cromis* (black drum), and *Chilomycterus schoepfi* (striped burrfish).

OTOLITH ANALYSIS

Fifteen otoliths from 41AS16 are identified as *Pogonias cromis* (black drum). Previous research along the Texas Coastal Bend (Smith 1983) has demonstrated that the otoliths of this species are appropriate for analysis of seasonality as described by Casteel (1976). According to Casteel (1976:31), this technique has been known and used since the late nineteenth century. Otoliths, or ear stones, are thought to be part of the system that controls equilibrium and hearing and are composed of calcium carbonate in the form of aragonite (Casteel 1976:18-20). The calcuim carbonates are deposited as alternating light and dark bands surrounding a nucleus, forming annuli. The age of the fish is determined by counting the annuli, and the season of death is estimated from the termination width of the outer ring. Errors in these estimates can, of course, be introduced through variations in water temperature and other factors, but these have not been considered in this preliminary study.

Procedures

The procedures described by Smith (1983:479) are cumbersome and risky. A modified system using equipment adapted to working with whelk shells was used in this study. The equipment consists of a bench-mounted motor with a flexible shaft and a series of attachments, including cutoff wheels, sanding drums, and felt polishing wheels. A focal exhaust system is required to control dust generated during the procedure (a dust mask is a less effective alternative). Additional preparation materials include 400-grit sandpaper, jewelers rouge, modeling clay, toothbrush, liquid soap, and water.

The procedure for slicing an otolith along its long axis is simple. Place the otolith on a small block of modeling clay, flat or concave face down, then set the clay adjacent to the exhaust system. Attach an extra-fine cutoff wheel to the flexible shaft and cut the otolith along the desired axis. The cutoff wheel is most effective between 1,500 and 2,000 rpm and will slice the otolith quickly at these speeds. The modeling clay minimizes incidental breakage and partially dissipates the intense heat generated by the cutoff wheel. The dust generated is removed by the exhaust system.

The larger D-shaped part of the otolith is used for the remainder of the preparation and analysis; the smaller piece (which breaks frequently during slicing) should be returned to a vial or other receptacle with proper catalog information. Smooth the cut facet of the otolith with an extra-fine smoothing drum inserted into the flexible shaft and operated at about 1,500 rpm. Again, intense heat and dust are generated. For final smoothing, place the 400-grit sandpaper on a flat surface and rub the cut facet across it a few times. The otolith is now ready for polishing.

Smear a small amount of jewelers rouge on the circumference of the felt polishing wheel after inserting it in the flexible shaft. The exhaust system should be turned off to keep its force from sucking the otolith out of the hands (jewelers rouge becomes very slick when heated). At about 1,500 to 2,000 rpm, gently polish the cut facet of the otolith. Intense heat again will be generated. After polishing, remove excess rouge by scrubbing the otolith gently with a toothbrush, liquid soap, and water. It is now prepared for examination under a microscope.

The sample described here was examined at 30x and 64x magnification under a binocular microscope using reflected light. The procedures described by Smith (1983) were used to identify the nucleus and the annuli. Dark (translucent) rings are assumed to be rapid spring and summer growth, and white (opaque) rings are assumed to be slower fall and winter growth. This appears to contradict Casteel's (1976:32) comments, but his discussion of the confusion surrounding translucent and opaque is itself confusing.

Results

All of the specimens are from Area 1, and 14 are from the first two excavation units. The fish are not overly large for *P. cromis*, which commonly weigh 11 to 13 kg (5 to 6 pounds), but can reach as much as 132 kg (60 pounds), in the bays and even 330 kg (150 pounds) (and as much as 91 cm in length) in the open sea. Rather, the age range of between less than one and eight years indicates a normal bay population. Only 4 of the 15 otoliths indicate that the fish were more than four years old.

The results of the determination of the apparent season of death supplied by the 15 otoliths (Table 6) are dramatic. Thirteen of the otoliths are centered around the spring season, with seven indicating late winter/early spring and six indicating late spring/early summer. This suggests strongly that the fish were harvested more or less during the spring. Summer and winter seasons are indicated by only one specimen each.

Table 6. Seasonality Distributions of *Pagonius cromis* Otoliths

Area 1 Zone	Winter	Late Winter/ Early Spring	Late Spring/ Early Summer	Summer	Total
5/6	–	–	–	–	0
4	–	5	4	1	10
3	–	1	2	–	3
2	1	1	–	–	2
Total	1	7	6	1	15

BIOLOGICAL OBSERVATIONS

Less precise indications are gained from observations of the seasonal habits of some species of fish. From observation of habitat and seasonality of four species found at the Swan Lake site (Table 7), the general inference is that these fish are most common, or are most easily caught, during the period from late winter through the spring and summer.

Table 7. Seasonality Data, Selected Fish Species[1]

Species	Habitat	Seasonality
Rhinoptera bonasus (Cownose ray)	Silty bays; browse across mud/sand flats in schools	Especially common in May and during the summer; migrate out of bays at onset of cold weather.
Sciaenops ocellata (Red drum or redfish)	Shallow bays; adults solitary	Especially common in summer; migrate out in fall, return in spring; smaller fish stay in bays all year; spring run is popular time for modern harvest.
Pogonius cromis (Black drum)	Bays; adults feed in large schools, often in very shallow water	Common all year but usually spawn in Gulf during late winter or early spring; easily caught in channels during spawning runs.
Chilomycterus schoepfi (Striped burrfish)	Bays	Especially common in summer.

[1] Sources: Hoese and Moore (1977); Texas Parks and Wildlife Dept. (1984)

CONCLUSIONS

The otolith analysis and the biological observations for four selected species of fish at the Swan Lake site provide complementary data suggesting that at least these species were harvested during a limited time of the year. It is reasonable to conclude that fishing, by whatever means, was a routine activity during the late winter through the early summer. Obviously, this could include the period from March through July, but it was most likely the period from April through June.

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A Visual Key for the Identification of Otoliths

Laurie S. Zimmerman, D. Gentry Steele, and Joffre D. Meyer

ABSTRACT

Examination of fish remains from Texas Gulf Coastal sites can provide valuable information concerning both subsistence patterns of aboriginal populations and paleoenvironments. Although otoliths, or ear–stones, are one of the most commonly preserved fish elements, they are uncommonly recovered or analyzed. To encourage and facilitate future studies, this paper provides a visual key for the identification of otoliths from common Texas Gulf Coastal fish, and provides descriptions of each fish's gross features, ecology, characteristic otolith, and reported occurrence in the archeological record. A method for estimating fish size is also presented.

INTRODUCTION

The study of fish remains from Texas Gulf Coastal sites can provide valuable information regarding seasonality, subsistence, and paleoenvironmental inferences (Casteel 1976). One of the most commonly preserved elements of fish useful for specific identification is the otolith, or ear–stone. Although otoliths are a commonly preserved element of fish found in the archeological sites, they are typically underrepresented in the archeological literature for two reasons—their small size and the limited literature available concerning their structure and classification.

Olsen (1968) also noted these problems in the analysis of fish remains, stating that

1. A review of the published literature documented the paucity of material.
2. Investigators report finding fish without indicating which element or elements were recovered.
3. Many investigators are unfamiliar with the elements of a fish, so they may overlook small elements such as otoliths during excavation.
4. A lack of reference material; the keys that do exist are complicated.

Several factors account for the fact that otoliths in particular are underrecorded in archeological sites. They include inadequacies in research design and in collecting, recovering, and reporting techniques. Research design can be a vital factor in recovery of information from an archeological site. From 1870 to 1950, when the field of zooarcheology was in its formative period (Robison 1978), emphasis was not placed on recovery of faunal remains from archeological sites. Instead, material culture was the focus of most investigations. This is reflected in the literature published during the early period of zooarcheology. It may look as if fish were not used as a resource by aboriginal populations in some Gulf Coastal areas, but that appearance only reflects the fact that the research designs of many early excavations did not focus on the analysis of subsistence strategies.

A second factor influencing data on otoliths is recovery techniques. Otoliths are not commonly recovered because of their small size; the usual screen size for archeological excavations is quarter–inch (Hester 1980, Hester et al. 1975). Casteel (1972) and DeMarcay and Steele (1986), however, point out that many small fish remains as well as other faunal remains pass through a quarter–inch mesh. In one study, Fitch (1969) has even documented a 100 percent loss of fish otoliths by sieving through a quarter–inch mesh screen, so it is clearly essential to fine–screen archeological sites in order to recover otoliths. A review of the literature shows that a variety of recovery techniques have been used on the Texas Gulf Coast sites. The methodology varied from making only surface collections to using a backhoe, to actually fine–screening the site. With the first two techniques, the otoliths probably would not be recovered, except fortuitously.

The last factor is the actual documentation of information in the literature. Eight sites could not be fully integrated into this study because of ambiguity in the reported data. In some cases, it was noted that fish bones, or just fish, were recovered (Campbell 1956, Hole and Wilkinson 1973, Patterson and Ford 1974). In other instances, the species was listed, but no other information was provided, such as identification of the specific element of the fish (Aten 1983, Dillehay 1975, Gilmore 1974, Hester 1975). Although it is important that the occurrence of fish was noted at these sites, the importance of implementing precise recording practices should be stressed as well.

In spite of these difficulties, fish otoliths have been recovered and reported from sites along the Texas Gulf Coast, and 11 common Texas Gulf Coastal fish were included in this investigation (Table 1), but it is important to point out that *Lutjanus campechanus, Bairdiella chrysura,* and *Paralichthys lethostigma* have not been reported in any of the Gulf Coastal sites in this survey. More than 100 site reports were examined, and 32 of these documented the presence of fish remains. Otoliths were recovered at 24/32 sites (Table 2, Figure 1). Examination of the tables makes it apparent that most of the archeological sites yielding otoliths are in Nueces and

Table 1. Species of Texas Gulf Coastal Fish

Species	Common Name
Ictalurus furcatus	Blue catfish
Lutjanus campechanus	Red snapper
Bairdiella chrysura	Silver perch
Cynoscion arenarius	Sand seatrout
Cynoscion nebulosus	Spotted seatrout
Micropogonius undulatus	Atlantic croaker
Pogonius cromis	Black drum
Sciaenops ocellata	Channel bass
Archosargus probatocephalus	Sheepshead
Paralichthys lethostigma	Southern flounder
Arius felis	Sea catfish

Kleberg counties, but this is a reflection of the work of several scholars who are interested specifically in the prehistoric use of marine resources (Breuer 1957, Carlson, Steele, and Bruno 1982, Hester 1971, Smith 1984, Steele and Mokry 1983). For example, Carlson, Steele, and Bruno (1982), Hester (1971), Smith (1984), and Steele and Mokry (1983) have completed extensive studies in which seasonality determinations were based on examination of the otoliths recovered. In addition, Breuer (1957) had determined that the black drum had been an important food resource at the Loyola Beach site, based on the large number of otoliths recovered. Therefore, these studies, which focused on the use of prehistoric resources, were greatly enhanced by examination of the otoliths, documenting a more accurate picture of the subsistence strategies of these aboriginal populations.

To encourage the type of studies that are being undertaken now, this paper

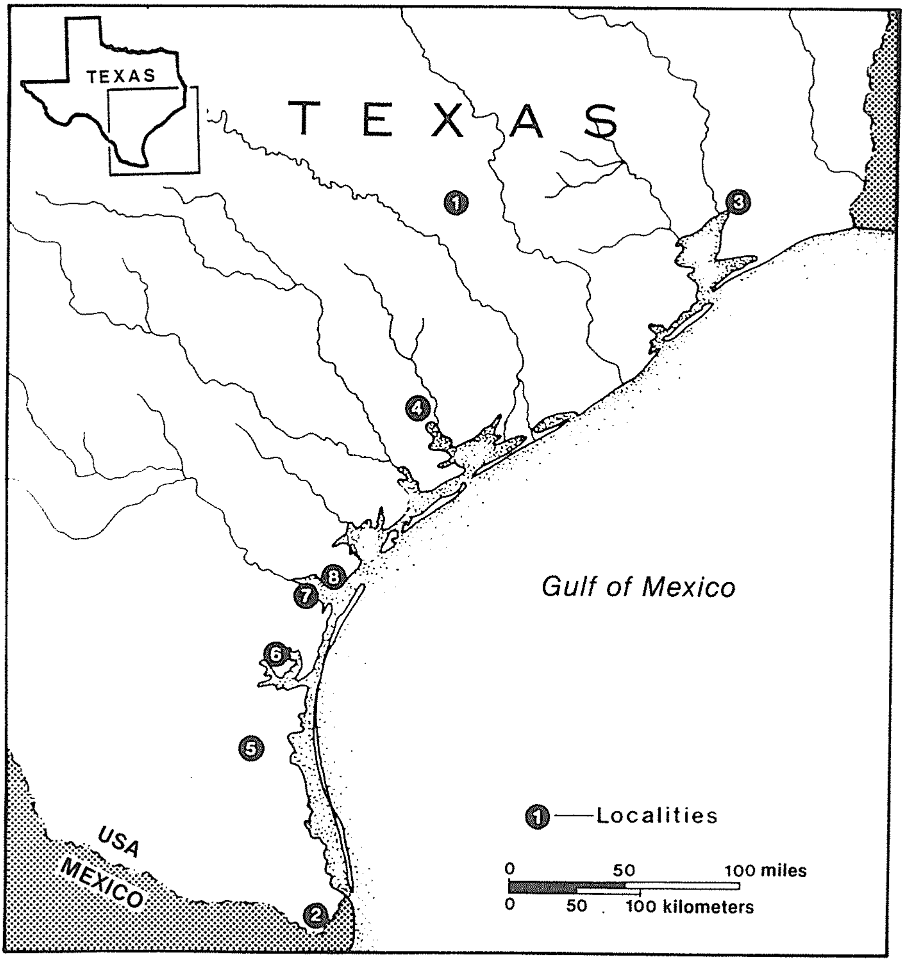

Figure 1. Map of the Gulf Coast of Texas, showing the archeological sites sampled for this study (see Table 2).

Table 2. Texas Sites From Which Otoliths Have Been Recovered

Map No.	County	Site	Source
1	Austin	41AU36, 37, 38	Hall 1981
2	Cameron	41CF29	Prewitt 1974
3	Chambers	41CH110[1], 172[1]	Gilmore 1974 Dillehay 1975
4	Jackson	41JK41, 91, 147	McGuff 1978
5	Kenedy	41KN3	Hester 1969
6	Kleberg	41KL13, 22, 30, 33, 37, 71, 74	Hester 1971
7	Nueces	41NU101, 102, 103, 185, 221	Carlson et al. 1982 Steele & Mokry 1983 Ricklis 1986
8	San Patricio	41SP27[1], 43	Ricklis 1986 Story 1968

[1] It was not stated whether otoliths were recovered from these sites.

provides a visual key for the identification of otoliths from common Texas Gulf Coastal fish and documents their occurrence in the archeological record and the relationship between fish length and otolith length. For each of the species included (Table 1), ecological information and a brief description are provided.

MORPHOLOGY OF OTOLITHS

Otoliths are the ear–stones situated within the inner ears of higher bony fish and cartilaginous fish; they float in a liquid called endolymph that fills a chamber behind the cranium. The piezoelectric properties they possess enhance the fish's equilibrium and hearing (Casteel 1976:18).

Carlstrom (1963:441) recognized two basic forms of otoliths—statoconia and statoliths. Statoconia are the small particles composed of calcium phosphate found in the Cyclostomata (cyclostomates), Chondrichthyes (cartilaginous fish), and the Chondrostei (chondrosteans) (Casteel 1976:19). Statoliths are the large solitary ear–stones found in all of the Teleostei, or higher bony fish, except for the sturgeon. They are composed principally of aragonite and conchiolin and forms of calcium carbonate (Casteel 1976:19, 20).

Most of the Actinoptergians (ray–finned fish) and nearly all Teleosteans (teleosts) have three pairs of statoliths (Nolf 1985:6). There are three types of statoliths—the sagitta (arrow), the lapillus (small stone), and the asteriscus (star) (Casteel 1976:20). Although all three types are present in each fish, the sagitta otolith is generally the largest of the three, particularly in the Sciaenidae family, fish that are common to Texas coastal waters.

In general, the otolith has an inner and an outer face. The outer face can be either concave or flat and consists of a series of bumps and ridges. The edges of the outer surface may be crenulated. Concentric growth rings are visible on the outer face, surrounding the core area. The most distinctive patterns, which characterize the

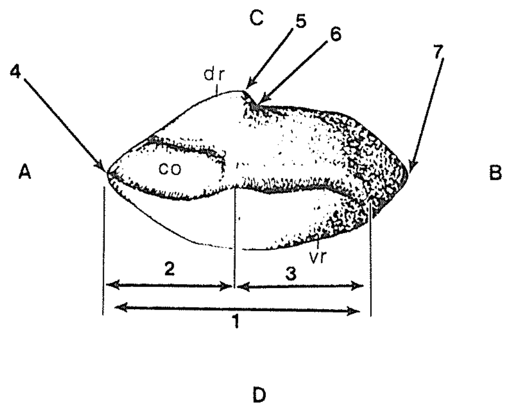

Figure 2. Diagrammatic representation of an inner right sagitta otolith, *Lutjanus campechanus:* 1, sulcus; 2, ostium; 3, cauda; 4, rostrum; 5, antirostrum; 6, postrostrum; 7, pararostrum; CO, colliculum; dr, dorsal rim; vr, ventral rim; A–D, orientation: A, anterior; B, posterior; C, dorsal; D, ventral.

specific level (Figure 2), are on the inner face. The *sulcus,* a deep groove on the inner face, occurs in each of the three types of otoliths. It is divided into two parts—the *ostium,* or wider anterior region, and the *cauda,* the narrow taillike posterior section. The cauda bends toward the ventral margin (Frizzel and Dante 1965). The *colliculum* is the area within the sulcal groove. The *rostrum* and *antirostrum* are present in otoliths with slanted anterior ends. The rostrum is the anteriormost point on the otolith, and borders the ventral margin. The antirostrum is roughly 40° behind the rostrum and is on the dorsal margin. In this sample, the Sparidae, Bothidae, and Lutjanidae families have rostra and antirostra.

The *postrostrum* and *pararostrum* are present in otoliths with slanted posterior ends. The postrostrum is the posteriormost projection and is near the ventral margin. The pararostrum is about 20° dorsal to the postrostrum. An *excisura,* or notch, may be present at either the anterior or posterior end, separating the postrostrum from the pararostrum or the rostrum from the antirostrum (Messieh 1972, see Figure 2).

Four primary margins describe the orientation of a sagitta otolith, anterior, posterior, ventral, and dorsal. The ostium is always anterior, and the cauda is in the posterior part and bends toward the ventral margin, so the dorsal margin is the one the cauda points away from. To side otoliths in the family Sciaenidae, the otolith should be oriented with the rostrum at the bottom. The cauda of the sulcus will point in the direction of the side from which the otolith comes (Simons 1981).

Of the three types of otoliths, lapillus otoliths are the least distinctive in shape; only the sulcal and antisulcal ends are identified. The sulcus usually is not well developed (Figure 3). The Ictaluridae and Ariidae catfish families are unique in that they have large lapilli.

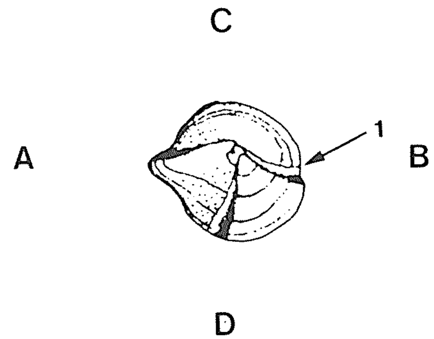

Figure 3. Diagrammatic representation of an outer right lapillus otolith: 1, sulcus; A, sulcal end; B, antisulcal end; C, upper margin; D, lower margin.

IDENTIFICATION OF SPECIES

This section provides diagrammatic representations and descriptions of the otoliths and fish found in archeological sites along the Gulf Coast of Texas.

Table 3 summarizes the dimensions and localities of the Gulf Coastal Fish that were included in this study.

Order: Ostariophysi
Family: Ictaluridae
Genus: *Ictalurus*
Species: *Ictalurus furcatus* (Lesueur)
Common name: Blue catfish

Note: Since there are very few differences between *Ictalurus furcatus* and *Arius felis*, only one set of drawings (Figure 4, *Arius felis*) is given for both species. The differences are explained in the text.

Body: The body is light to slate blue, without scales. It has eight barbels on the lower jaw and 30 to 50 anal rays. The blue catfish can be distinguished from the channel catfish because the former has a greater number of anal rays and does not have spots on the body. The blue catfish typically reaches 45.5 cm in length, and weighs between 0.23 and 0.25 kg (Hoese and Moore 1977).

Habitat: The blue catfish is common in low salinity habitats, although in winter it will head for open bay waters. Blue catfish breed when the water temperature reaches 21.1° to 23.8°C. The diet of the blue catfish consists of insects, crayfish, mussels, fish, plants, and carrion. Its distribution extends from the Mississippi Valley to Mexico (Hoese and Moore 1977).

Otoliths: The lapillus, the most distinctive otolith in the Ictaluridae and the Ariidae, is heart–shaped (Figure 4). The inner face is concave and the outer face is almost flat. The upper margin has a protuberance projecting outward. The sulcus extends in a half circle, 180°, along the sulcal end. It is a narrow groove in the inner surface of the lapillus. There are no crenulations along the sulcal end. The flat outer surface is fairly smooth, with no crenulations (Figure 3).

Table 3. Dimensions and Localities of Gulf Coastal Fish Included in this Study

Location	Catalog No.	Otolith Length (cm)	Otolith Length (cm)	Fish Length (cm)
	Ictalurus furcatus			
—	TAMU 6–35	1.73	1.530	–
	Lutjanus campechanus			
—	TAMU 6–12	2.945	1.670	–
Gulf of Mexico	TAMU 6–43	1.175	0.690	–
Gulf of Mexico	TAMU 6–44	1.145	0.740	–
	Bairdiella chrysura			
Baffin Bay	TAMU 6–25	0.605	0.830	–
	Cynoscion arenarius			
Corpus Christi Bay	TAMU 6–23	1.860	0.770	–
	Cynoscion nebulosus			
Port Aransas	TAMU 6-59	1.415	0.610	30.5
Port Aransas	TAMU 6-69	1.565	0.620	30.5
Port Aransas	TAMU 6–61	1.575	0.620	35.2
Port Aransas	TAMU 6–71	1.580	0.645	35.5
Port Aransas	TAMU 6–32	1.595	0.695	36.8
Port Aransas	TAMU 6–58	1.605	0.620	36.8
Port Aransas	TAMU 6-67	1.620	0.646	36.8
Port Aransas	TAMU 6-57[1]	1.630	0.675	36.8
Port Aransas	TAMU 6–68	1.650	0.650	39.0
Port Aransas	TAMU 6–60	1.660	0.677	39.0
Port Aransas	TAMU 6–63[1]	1.670	0.640	37.0
Port Aransas	TAMU 6–56[1]	1.675	0.655	35.0
Port Aransas	TAMU 6–66	1.685	0.710	30.0
Port Aransas	TAMU 6–62	1.795	0.673	43.2
Port Aransas	TAMU 6-65	1.830	0.730	41.0
Port Aransas	TAMU 6–70	1.845	0.655	40.5
Port Aransas	TAMU 6-34	1.900	0.725	40.7
Port Aransas	TAMU 6–64	1.955	0.730	42.2
Baffin Bay	TAMU 6-22	2.500	0.735	41.8
	Micropogonias undulatus			
Aransas Bay	TAMU 6–15	1.125	0.910	–
Aransas Bay	TAMU 6–20	1.210	0.950	–
Aransas Bay	TAMU 6–21	1.285	0.930	–
Corpus Christi	TAMU 6–19	1.380	1.145	–
	Pogonias cromis			
Corpus Christi Bay	TAMU 6–27	1.335	1.650	–
	Sciaenops ocellata			
Oso Creek	TAMU 6–26	1.480	0.830	–
—	TAMU 6–6	2.015	0.950	–
—	TAMU 6–6	2.210	1.150	–
	Archosargus probatocephalus			
Corpus Christi Bay	TAMU 6–28[1]	1.090	0.650	–
	***Paralichthys* sp.**			
Texas Gulf	TAMU 6–7	0.855	0.490	–
	Paralichthys lethostigma			
Corpus Christi Bay	TAMU 6–24	0.870	0.575	–
	Arius felis			
Aransas Bay	TAMU 6–29	0.725	0.605	–
Mustang Island	TAMU 6–10	0.940	0.805	–
Corpus Christi Bay	TAMU 6–18	1.08	0.925	–

[1] Measurements were taken on left otolith.

Archeological Sites: The genus *Ictalurus* has been reported from sites 41CH110 and 172; 41JK147 and 91; and 41AU36, 37, and 38 (Table 2). In sites 41CH 172 and 41CH110 it is not stated whether otoliths were collected but only that the genus *Ictolurus* was present.

Order: Siluriformes
Family: Ariidae
Genus: *Arius*
Species: *Arius felis* (Linnaeus)
Common name: Sea catfish, Hardhead

Body: *Arius felis,* the hardhead, is a scaleless fish with large spines on the dorsal and pectoral lines (Figure 4). The body is blue on the sides, with a white venter.

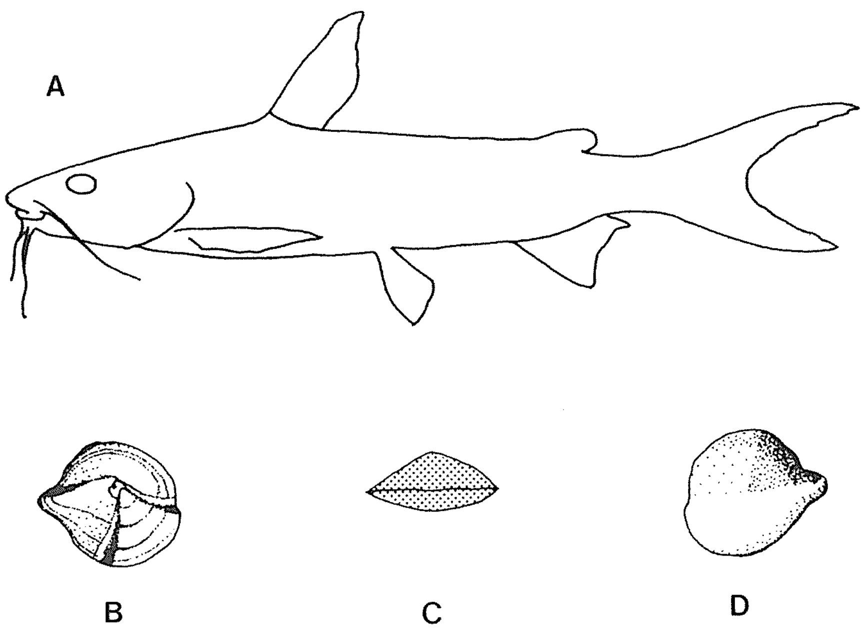

Figure 4. Outline sketch of *Arius felis* (A) and drawing of right lapillus otolith (B–D): B, outer face; C, ventral view; D, inner face; length 1.15 cm; width .97 cm.

There are six barbels on the lower chin. Most hardheads weigh less than 0.45 kg, and typically reach a length of 61.0 cm (Compton 1975, Hoese and Moore 1977).

Habitat: Adult hardheads eat almost anything. The young will eat mucus, scales, or ectoparasites by scraping the sides of other fish; adults will eat rotten fish or whatever is available. They are most abundant in bays and the shallow part of the Gulf during the summer months when they spawn. The males carry the fertilized eggs in their mouths until they hatch. The distribution of the hardhead extends from Massachusetts to Mexico (Compton 1975, Gough 1979, Hoese and Moore 1977).

Otoliths: The lapillus is enlarged in both the Ariidae and the Ictaluridae (Figure 4; Table 3). The lapillus is round and dome shaped with a flat bottom. The outer surface is flat, fine grained, with no crenulations. There is a small cylindrical protuberance at the upper margin of the lapillus with a tiny notch on the antisulcal end. *Arius felis* is smaller than *Ictalurus furcatus* and has a less distinctive sulcus.
Archeological Sites: The species *Arius* cf. *felis* has been reported from sites 41NU102 and 103 (Figure 1; Table 2).

Order: Perciformes
Family: Lutjanidae
Genus: *Lutjanus*
Species: *Lutjanus campechanus* (Poey)
Common name: Red snapper

Body: The red snapper is marked by a reddish hue, with alternating dark and light vertical bands (Figure 5) and a dorsal area that is darker than the light-colored belly. The dorsal and caudal fins are dark; there can be a diffused black spot above the lateral line, near the caudal fin. The red snapper weighs between 0.45 kg and 1.8 kg, but can reach 13.6 to 15.9 kg. Red snappers are 25.4 cm long by the first year

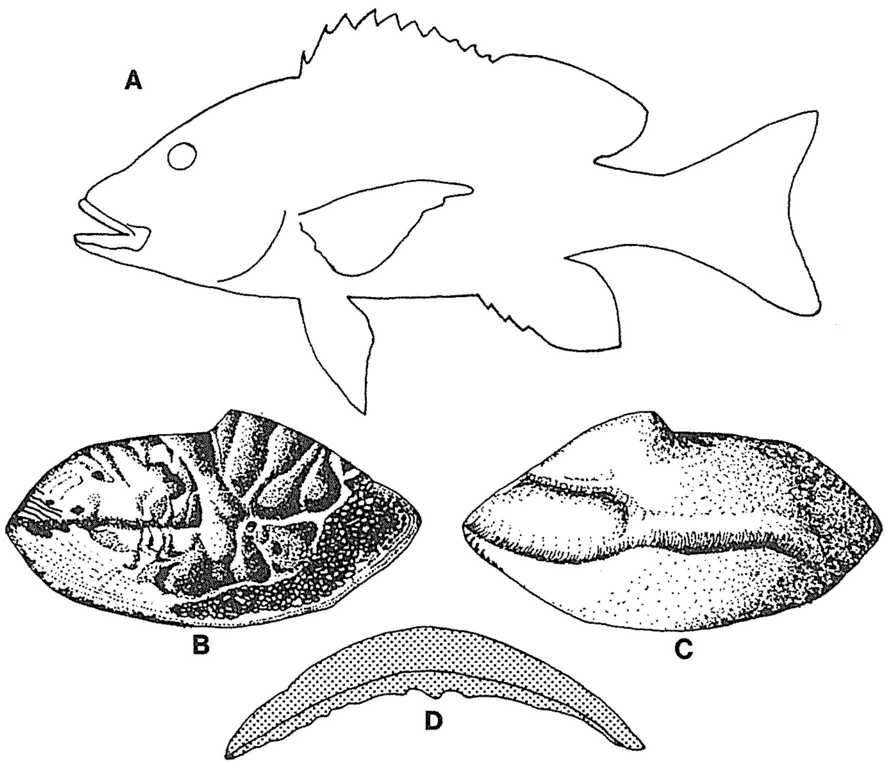

Figure 5. Outline sketch of Lutjanus *campechanus* (A) and drawing of right sagitta otolith (B–D): B, outer face; C, ventral view; D, inner face; length 2.930 cm, width 730 cm.

and probably grow 7.62 cm per year until age four. They are found in the Gulf of Mexico, on the coasts of Texas, Louisiana, and Yucatan (Bryan 1971, Compton 1973, Hoese and Moore 1977).

Habitat: The red snapper inhabits hard irregular limestone formations that rise above the floor of the Gulf, far from shore. These snapper banks are scattered at depths between 40 and 100 fathoms in the Gulf of Mexico. Very young fish have been caught on muddy and sandy bottoms in the Gulf. Spawning on the Texas coast lasts from early June through the middle of September (Bryan 1971, Compton 1973, Klepper 1966, Stevens 1969).

Otoliths: The sagitta otolith, though very large, is similar in structure to *Archosargus probatocephalus*, the sheepshead (Figure 5; Table 3). The thick anterior end slants at a 40° angle forming a rostrum and an antirostrum. The ventral edge is nearly straight. A notch on the dorsal margin, below the point where the ostium and cauda join, has a pinhole structure unique to the red snapper in this sample of fish. The posterior end is slanted, giving it a postrostrum and pararostrum. The ostium is deepest on the dorsal margin and is less pronounced on the ventral margin, extending to the anterior part. The cauda is very pronounced; it does not reach the ventral margin. Small crenulations on the anterior and posterior parts are visible on both the inner and outer faces. On the outer face, there is a pronounced rib formed by the sulcal groove, and, in addition, small transverse ribs run perpendicular to the central rib.

Archeological Sites: This genus has not been reported from the Texas Gulf Coast.

Order: Perciformes
Family: Sciaenidae
Genus: *Bairdiella*
Species: *Bairdiella chrysura* (Lacepede)
Common name: Silver perch

Body: The body is light silvery with yellow to silvery yellow fins. The lateral line is clearly marked (Figure 6). The fish is rather small, reaching only 15.24 to 30.48 cm, and usually weighs less than 0.227 kg (Compton 1976, Hoese and Moore 1977).

Habitat: The silver perch lives in lagoons and bays and can withstand a wide range of salinities. Adults move to the Gulf in the winter and return to the coast to spawn in the spring. Silver perch eat crustaceans, worms, and small fish. The young are usually found in the protective grass beds (Compton 1976, Hoese and Moore 1977).

Otoliths: The sagitta otolith has a unique irregularly triangular shape (Figure 6; Table 3). There is a projection at the corner formed by the posterior and ventral edges when viewed on the inner surface; another projection is visible on the dorsal side. The sulcus is deep and well defined; the ostium is deep and straight. The cauda is short, L–shaped, and curves almost to the ventral margin. There is a groove just below the cauda on the posterior end. The outer surface is slightly irregular. The anterior half has the greatest height (Chao 1978).

Archeological Sites: There are no recorded sites for this genus.

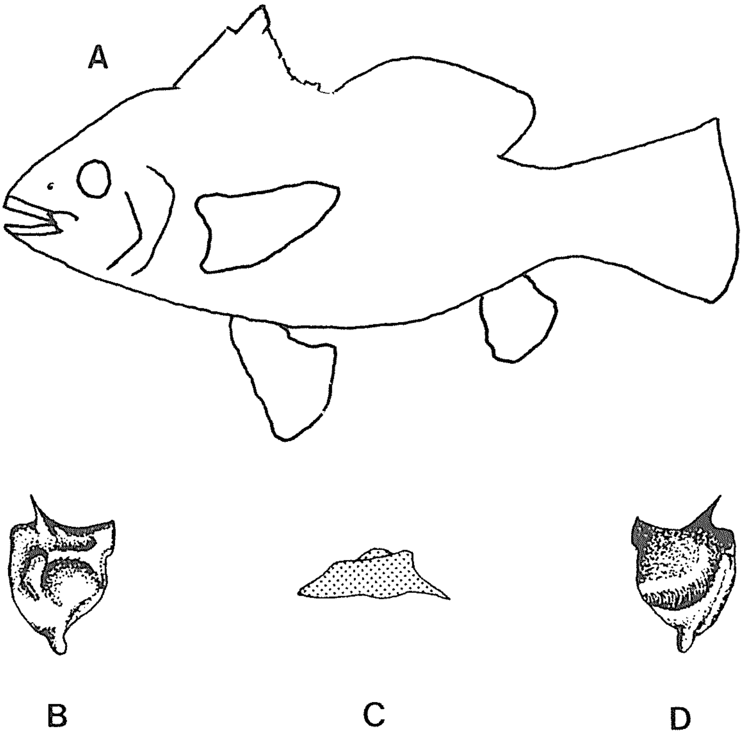

Figure 6. Outline sketch of *Bairdiella chrysura* (A) and drawing of right sagitta otolith (B–D): B, outer face; C, ventral view; D, inner face; length .877 cm, width .630 cm.

Order: Perciformes
Family: Sciaenidae
Genus: *Cynoscion*
Species: *Cynoscion arenarius* Ginsburg
Common names: Sand seatrout, sand trout, white trout

Body: The body of the adult is silvery to blue gray, with a yellow–green back (Figure 7) on which are large irregular spots. The sand trout is usually less than 45.7 cm long and rarely weighs more than 0.45 kg. The young differ from adults in the faint crossbands visible on their backs (Compton 1974, Hoese and Moore 1977, Moffett and McEachron 1976).

Habitat: The sand trout lives in the coastal bays and shallow near–shore Gulf from southern Florida to the Gulf of Campeche. The adults spawn in the deeper channels near the tidal inlets of the bays and remain there until about March to early April, when they are fully grown. Adults also can be found in the shallow bays and will remain throughout the winter if the water temperature does not fall far below 20°C. The young prefer back bays because of the lower salinity and the protection they afford from larger fish. Older fish prefer the primary bays and shallow Gulf waters. The sand seatrout can withstand the rapid temperature and salinity changes of the

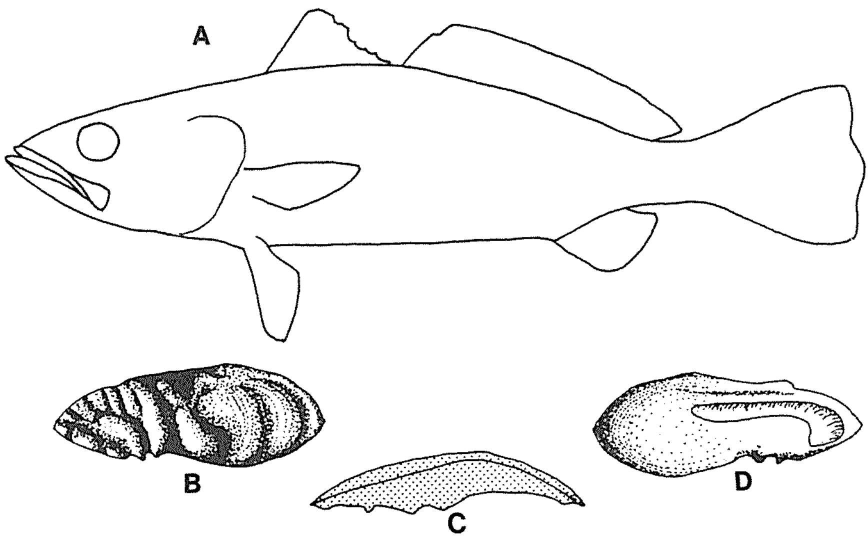

Figure 7. Outline sketch of *Cynoscion arenarius* (A) and drawing of left sagitta otolith (B-D): B, outer face; C, ventral view; D, inner face; length 1.86 cm, width .773 cm.

Texas bays (Compton 1974, Hoese and Moore 1977, Moffett and McEachron 1976).

Otoliths: *Cynoscion arenarius* has an elliptical sagitta otolith (Figure 7; Table 3). The inner side is well developed. The oval–shaped ostium almost reaches the anterior margin. The cauda is noticeable but faint, becoming less distinct toward the ventral margin. There is a poorly developed marginal groove on the dorsal part. The posterior half is slightly thicker than the anterior half. On the inner face, the posterior part has a slightly scalloped appearance. *Cynoscion arenarius,* which does not have well–developed cauda, can be differentiated by that characteristic from *Cynoscion nebulosus,* which does have a well–developed cauda.

Archeological Sites: The genus *Cynoscion* and the species *Cynoscion arenarius* have been reported from 41JK147 and 91; 41NU102 and 103; 41SP43, and 41CH172 (Figure 1; Table 2). The genus *Cynoscion* was reported from sites 41SP43 and 41CH172, but it is not known whether otoliths were recovered.

Order: Perciformes
Family: Sciaenidae
Genus: *Cynoscion*
Species: *Cynoscion nebulosus* (Cuvier)
Common names: Spotted seatrout, Speckled seatrout

Body: The body of the speckled seatrout is silvery with a greenish back (Figure 8; Table 3); the back, dorsal, and caudal fins have many dark spots, and the inside of the mouth is orange. Adult speckled seatrout spawn in the bays; typically, mature fish range between 30.0 and 35.5 cm in lenth and weigh approximately 0.23 to 0.45

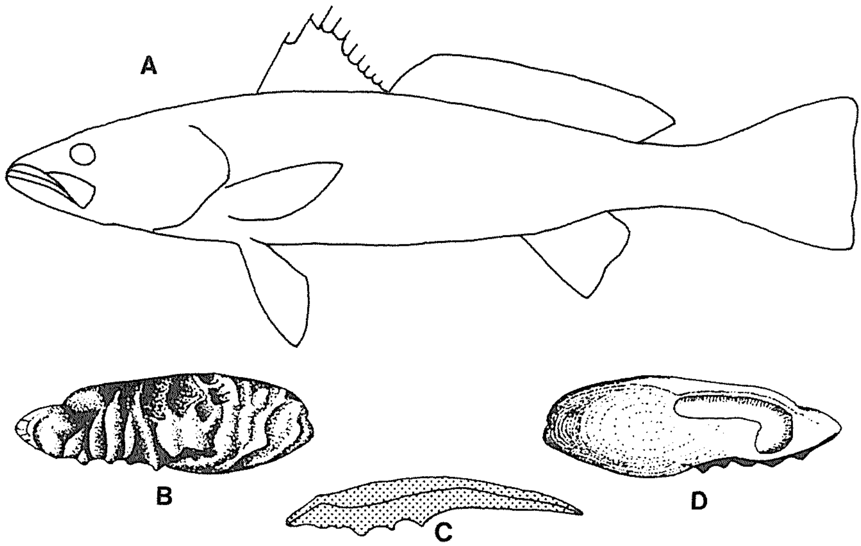

Figure 8. Outline sketch of *Cynoscion nebulosus* (A) and drawing of left sagitta otolith (B–D): B, outer face; C, ventral view; D, inner face; length 2.05 cm, width .71 cm.

kg. Older fish may reach 76 cm in length and 28.7 kg in weight. (Becker 1964; Hoese and Moore 1977). The young have a similar spotted pattern (Hoese and Moore 1977).

Habitat: During their first year, the young usually are found in grass flats. The adults live in deeper areas and sometimes can be sighted over oyster reefs. Adult speckled seatrout spawn in the bays, and reach about 1.22 meters in length (Becker 1964, Hoese and Moore 1977).

Otoliths: *Cynoscion nebulosus* has a narrow elliptical sagitta otolith that is very similar in appearance to the otolith of *Cynoscion arenarius* (Figure 8; Table 3). Distinctive features of *Cynoscion nebulosus* are (1) The cauda bends more but does not reach the dorsal margin, (2) The anterior half is narrower than in *Cynoscion arenarius,* (3) The ventral margin of *Cynoscion nebulosus* is straighter, but the edge is more jagged, (4) There are more crenulations on the outer surface, (5) The dorsal margin bends inward more at the midpoint in *Cynoscion nebulosus,* and (6) The posterior half of the otolith in *Cynoscion nebulosus* is thicker than the anterior half, pointed rather than rounded, and lacks the toothlike serrations of the posterior end of *Cynoscion arenarius.*

Archeological Sites: The genus *Cynoscion* and the species *Cynoscion nebulosus* have been reported from 41JK91 and 47, 41NU221, 102, and 103; 41KL13, and 41CH172 (Figure 1; Table 2). The genus *Cynoscion* was present at site 41CH172, but it was not stated that otoliths were recovered.

Order: Perciformes
Family: Sciaenidae
Genus: *Micropogonius*
Species: *Micropogonius undulatus* (Linnaeus)
Common name: Atlantic croaker

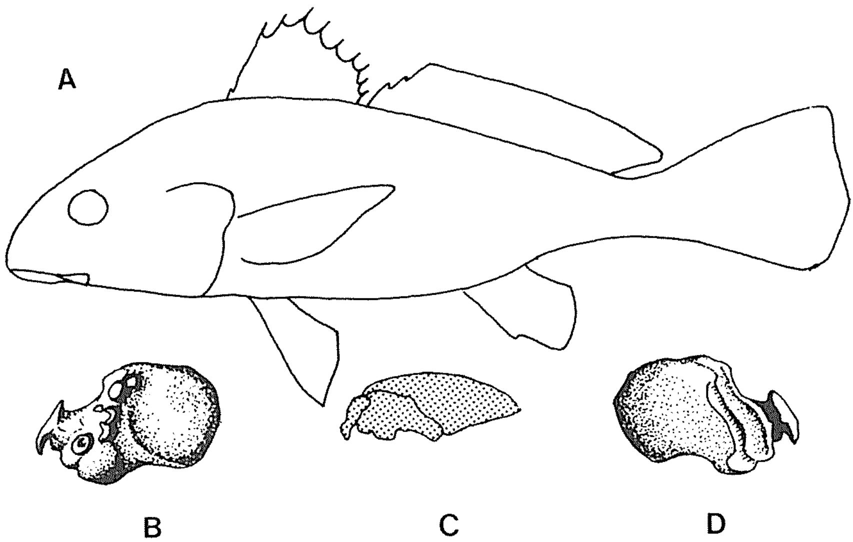

Figure 9. Outline sketch of *Micropogonius undulatus* (A) and drawing of sagitta otolith (B–D): B, outer face; C, ventral view; D, inner face; length 1.275 cm, width .86 cm.

Body: The Atlantic croaker, silvery when young, has a brassy yellow hue and irregular brown streaks as an adult (Figure 9). Adults weigh from 0.11 to 0.23 kg, and, occasionally, as much as 2.3 kg. The typical body length ranges between 24.0 cm and 30.5 cm (Compton 1974, Hoese and Moore 1977).

Habitat: The Atlantic croaker can be found in bays and on the Gulf margin. In the summer, the young live in the deeper parts of the bays, but depart by fall. Atlantic croakers are winter spawners. Their distribution extends from Cape Cod to Central Mexico (Compton 1974, Hoese and Moore 1977).

Otoliths: The sagitta otolith of the Atlantic croaker has a unique shieldlike form (Figure 9; Table 3). On the outer surface is a hooklike phalange on the dorsal margin. The large ovoid ostium is faint and does not reach the anterior margin. The cauda is more pronounced and slants towards the posterior end. The posterior end is thickest, due to the many spurs, or humps, projecting from the outer surface close to the dorsal margin (Chao 1978).

Archeological Sites: The species *Micropogonius undulatus* has been reported from 41NU102, 103, and 221; and at 41SP43 (Figure 1; Table 2). At site 41SP43 only the occurrence of the genus *Micropogonius* was noted.

Order: Perciformes
Family: Sciaenidae
Genus: *Pogonius*
Species: *Pogonius cromis* (Linnaeus)
Common name: Black drum

Body: The black drum is the largest sciaenid in the Gulf of Mexico, weighing as much as 68.04 kg (Figure 10). The sides of the silvery body are covered with broad,

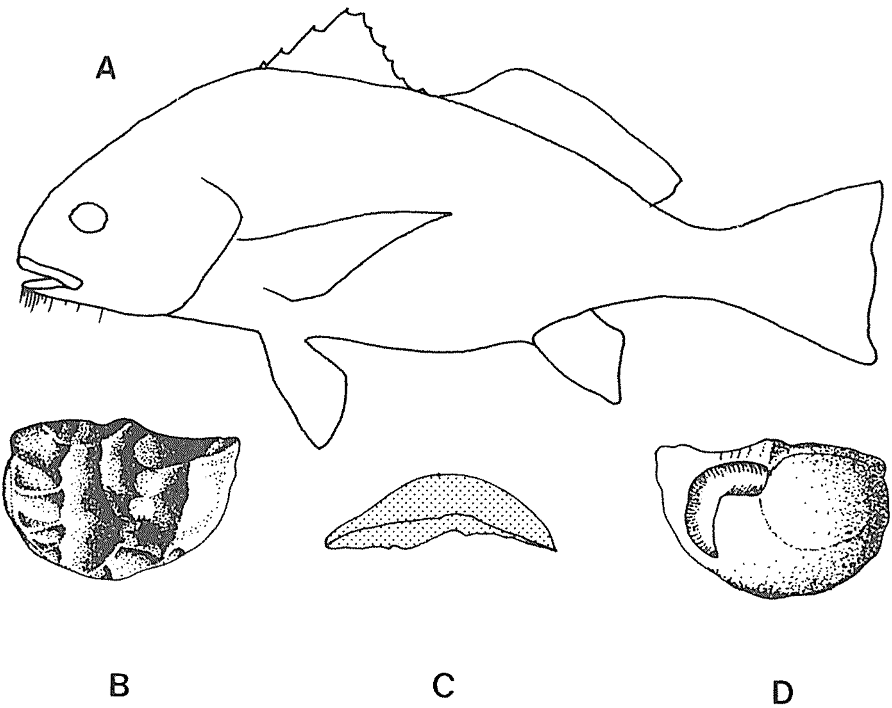

Figure 10. Outline sketch of *Pogonius cromis* (A) and drawing of left sagitta otolith (B–D): B, outer face; C, ventral view; D, inner face; length 1.375 cm, width 1.70 cm.

dark bands. In larger fish the banding becomes obscured so the body appears darker. The underside of the lower jaw is covered with large barbels. Typically, black drum range in length from 40.6 to 50.8 cm and weigh from 6.6 kg to 8.8 kg. Large specimens may weigh as much as 35.4 kg. The black drum is found from Massachusetts to Argentina, but it is more abundant off the South Texas coast (Breuer 1977, Cook 1974, Compton 1975, Hoese and Moore 1977).

Habitat: This species frequents shallow bays and lagoons. the large grinding molars in its throat aid in chewing shells of mollusks. The black drum spawns in both winter and spring; its annual spawning run into the bays is from late December through April (Breuer 1977, Cook 1974, Compton 1975, Nuckles 1967, Simmons 1962).

Otoliths: The sagitta otolith of the black drum is semicircular, or D–shaped, thin, and has a large sulcus (Figure 10; Table 3). The ventral margin is evenly curved and convex; the dorsal margin is fairly straight. There is a projection on the dorsal margin near the point where the ostium and cauda are joined. The large, roundish ostium does not reach the anterior end. The J–shaped cauda has a pointed distal end that does not reach the ventral margin. The outer surface has crenulations and a distinct core area. The posterior half is slightly thicker. The highest part is in the center, giving the sagitta a domelike yet concave appearance in lateral view. There is a faint marginal groove between the dorsal margin and the sulcus (Chao 1978).

Archeological Sites: The genus *Pogonias* and the species *Pogonias cromis* have been reported from 41CF29; 41SP27 and 43; 41JK41; 41KL22, 33, 71, 74, 37, 30, and 13; 41KN3; 41CH110 and 29; and 41NU221, 185, 101, 102, and 103 (Figure 1; Table 2). It was not stated that otoliths were recovered from sties 41SP27, 41CH110, and 41NU185.

Order: Perciformes
Family: Sciaenidae
Genus: *Sciaenops*
Species: *Sciaenops ocellata* (Linnaeus)
Common names: Channel bass, Red drum, Redfish

Body: The body of the redfish is silvery when young, turning coppery brown or reddish as it matures (Figure 11). There usually is a single large black spot above the lateral line in front of the caudal fin, but some redfish have additional spots

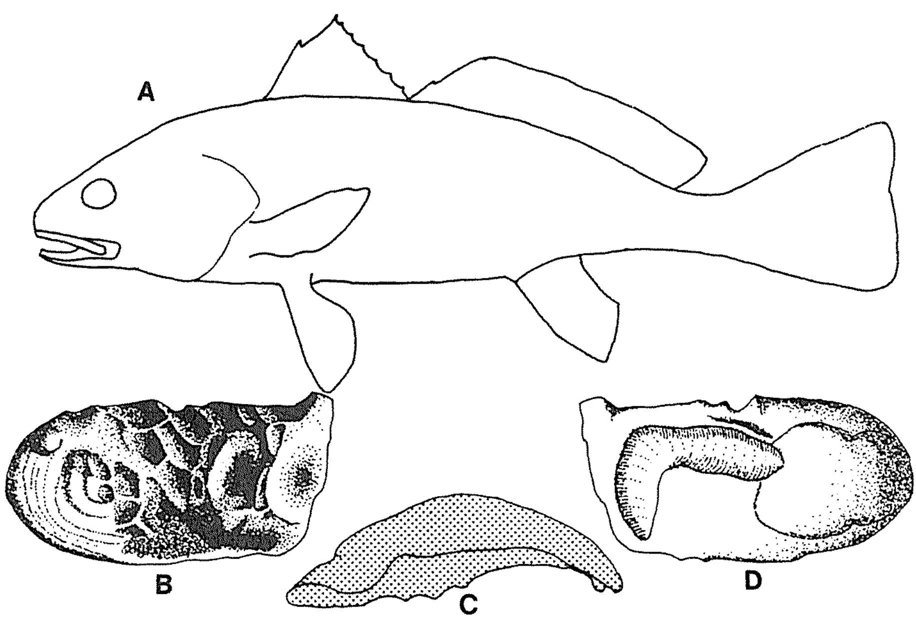

Figure 11. Outline sketch of *Sciaenops ocellata* (A) and drawing of right sagitta otolith (B–D): B, outer face; C, ventral view; D, inner face; length 2.25 cm, width 1.10 cm.

(Hoese and Moore 1977). Red drum are among the fastest growing fish. By one year, they reach 27.9 cm and 0.45 kg, by two years, 55.8 cm and 1.59 kg; by three years, they may reach 61.0 cm and 3.6 kg. Mature fish may weigh in excess of 22.7 kg (Simmons 1962; Simmons 1965; Simmons 1976).

Habitat: The redfish is predominantly a bottom feeder, commonly engaging in an activity called tailing, in which the fish, in a head–down position, searches the substrate for small crabs, fish, and shrimp. The adults are largely solitary, living in shallow water habitats such as bays, but they also move in schools. In fact, redfish migrate in large numbers to the Gulf in the fall as temperatures decline and return to the bays and inlets in the spring. During the fall and winter, the redfish spawn just off the shore along the bay inlets before moving out to the Gulf (Simmons 1962, Simmons 1965, Simmons 1976).

Otoliths: The sagitta of the redfish is thick and rectangular, with a distinct sulcus (Figure 11; Table 3). The ostium of the sulcus is pear shaped and not well pronounced; its expanded part reaches the anterior margin of the sagitta. The cauda is J shaped, with a narrow distal end that approaches the ventral margin. The dorsal margin of the otolith is slightly crenulate, whereas the ventral margin is curved and convex. The outer surface has both ridges and crenulations. The cauda is slightly deeper than the ostium. In lateral view it is convex. The posterior is the thickest part of the sagitta otolith (Chao 1978).

Archeological Sites: The species *Sciaenops ocellata* has been reported from 41SP43; 41KL33 and 13; 41NU101, 102, and 103; and 41CH172 (Figure 1; Table 2). The species *Sciaenops ocellata* was reported from site 41CH172, but it was not stated that otoliths were recovered.

Order: Perciformes
Family: Sparidae
Genus: *Archosargus*
Species: *Archosargus probatocephalus* (Walbaum)
Common name: Sheepshead

Body: The body of the sheepshead is gray, greenish yellow, or bronze, with seven dark vertical stripes (Figure 12); the belly is white. Coloration fades with age. The body is flattened sideways, and there is a long dorsal fin. The tail is not deeply forked and has rounded edges that separate the sheepshead from other members of the family Sparidae. The name sheepshead was derived from its buck–toothed appearance. The front incisors are broad and flat, and adjacent to these are peglike canines. Next to the canines are globular and molarlike cheek–teeth. The average weight is 0.9072 to 1.814 kg. Typical length of sheepshead range between 35.6 cm and 45.7 cm. Some fish, however, attain a maximum weight of 13.61 kg and 76.2 cm in length (Hoese and Moore 1977; Pearsall 1966; Simmons 1962).

Habitat: The sheepshead are bottom feeders that are attracted to substrates covered with barnacles or inhabited by crustaceans. Their diets change in the hottest part of the summer to algae. They are commonly found in bays over shell reefs. From late winter to early spring the sheepshead move in schools back to the shallow water

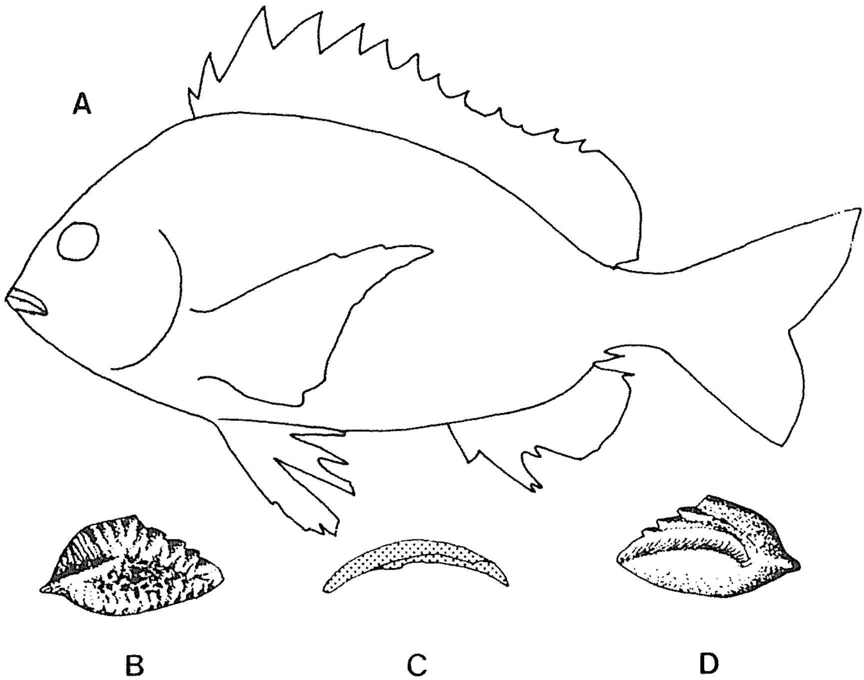

Figure 12. Outline sketch of *Archosargus probatocephalus* (A) and drawing of sagitta otolith (B–D): B, outer face; C, ventral view; C, inner face; length 1.105 cm, width .653 cm.

bays to spawn (Hoese and Moore 1977, Pearsall 1966, Simmons 1962, Swann 1964).

Otoliths: The sagitta otolith is small but similar in basic structure to *Lutjanus campechanus,* the red snapper (Figure 12; Table 3). The anterior margin slants at a 40° angle, creating a rostrum and antirostrum. The anterior margin is thin and highly serrated, unlike the red snapper. The dorsal margin has a very slight slant. The ostium reaches the anterior margin, and the cauda is straight with a slight bend toward the ventral margin. The outer face shows an axis formed by the sulcal groove. The side view is concave. The posterior end also is slanted, giving that margin a pararostrum and a postrostrum. Serrations are visible on both the dorsal and ventral sides. There is a marginal groove on the dorsal side adjacent to the sulcus.

Archeological Sites: The species *Archosargus probatocephalus* has been reported from 41CH172 and 41JK91 (Figure 1; Table 2). It was not stated whether otoliths were recovered at 41CH172.

Order: Pleuronectiformes
Family: Bothidae
Genus: *Paralichthys*
Species: *Paralichthys lethostigma* (Jordan and Gilbert)
Common name: Southern flounder

Body: The dorsal surface of the southern flounder is dark olive to light brown; the ventral surface is white (Figure 13); the the dorsal surface is capable of changing color upon stimulation. The eyes and coloration are on the left side; the blind side is pale. There are light tan spots on the fins. Newly hatched fish are symmetrical, with one eye on each side of the head, but after the fish reaches a critical size, one eye migrates, and the pigment disappears from the blind side. Typically, female southern flounder range from 30.5 cm to 40.6 cm and weigh from 0.45 kg to 0.68 kg. Males rarely exceed 30.5 cm. Large specimens may reach 71.0 cm and weigh 5.9 kg (Compton 1976, Hoese and Moore 1977, Simmons 1962, Simmons 1964, Stokes 1975).

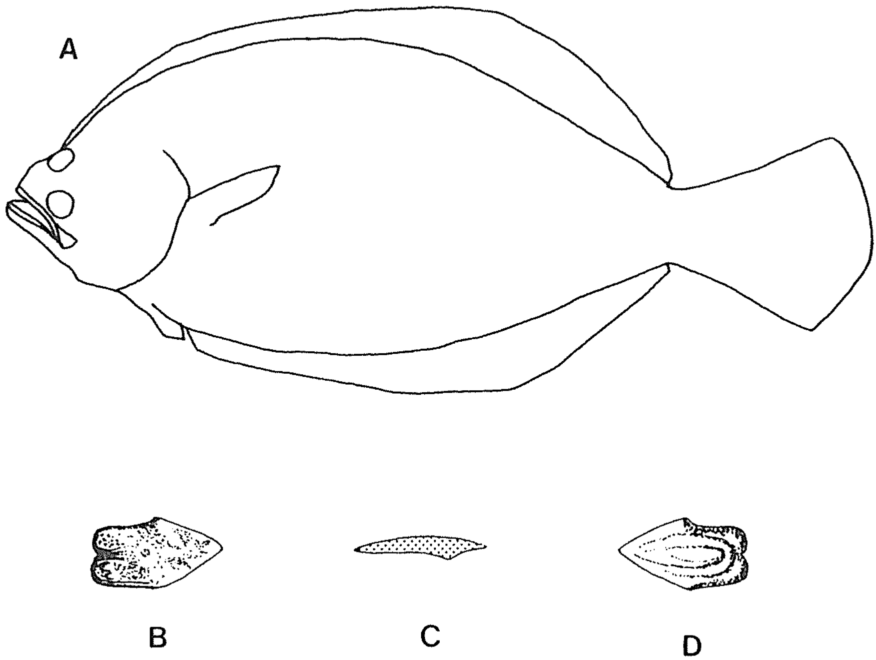

Figure 13. Outline sketch of *Paralichthys lethostigma* (A) and drawing of sagitta otolith (B–D): B, outer face; C, ventral view; D, inner face; length .826 cm, width .473 cm.

Habitat: Southern flounders prefers loose substrate so they can bury themselves in order to catch small fish, squid, shrimp, and other crustaceans. The young are found in shallow bays. The usual season of abundance extends from early spring into November or December. In the fall, the adults leave the bays to spawn; severe cold will cause a mass migration for spawning from the shallow bays into the Gulf.

Warmer conditions tend to cause these large flounders to disperse over a greater period of time. Southern flounder are commonly found from North Carolina to Florida and from Florida to northern Mexico (Compton 1976, Hoese and Moore 1977, Simmons 1962, Simmons 1964, Stokes 1975).

Otoliths: The sagitta otolith is extremely small, flat, and almost symmetrical along the Y axis (Figure 13; Table 3). The anterior margin forms a 40° angle and is slightly jagged. There is a rostrum and an antirostrum. A notch or excisura at the base of the posterior margin separates the postrostrum and pararostrum. The posterior margin is straight. The sulcus is narrow and not differentiated into an ostium and cauda. The outer side has prominent growth rings.

Archeological Sites: This genus has not been reported from sites on the Texas Gulf Coast.

ESTIMATING SIZE OF FISH

Estimation of fish size is important when dealing with archeological remains for three reasons. First, the size of a fish can suggest its importance as a subsistence item. Second, some inferences may be made about the techniques used in obtaining fish, especially in the absence of cultural remains. For instance, small fish probably were trapped, netted, or poisoned, whereas large fish probably were speared or hooked. Finally, some ecological information can be gleaned from fish remains. By associating skeletal elements with specific levels, it is possible to infer habitats based on the ecology of modern fish. Reitz, Quitmeyer, Hale, Scudder, and Wing (1987:306) have noted that small individuals of a particular species may have been caught in an estuarine nursery, whereas those of larger species may have been caught offshore, so fish size can provide valuable insights.

In several investigations the relationship between otolith length and fish size (Casteel 1976, Eziuzo 1963, Fitch and Brownell 1968, and Reitz et al. 1987) has been examined, and it has been determined that an allometric relationship exists between bone and body mass (Reitz et al. 1987). This is biologically more sound than work of some previous investigators who suggest that there is a linear relationship. Those who support a linear relationship assume that shell or bone dimensions increase in a constant ratio with body mass (Reitz et al. 1987), but this is not the case.

Fish grow continuously throughout their lives, but the growth rate is not constant; after sexual maturity the rate decreases. Environmental changes, too, can affect the growth rates of fish. Casteel (1974:572, 1976:65, 66) has shown that the growth rate of fish is directly related to temperature variations, with increases in temperature promoting increased growth. These visible increments in growth in the otoliths are biological evidence supporting an allometric relationship between otolith size and fish size.

A second important fact is that in many cases where a linear relationship is considered, an *average–size* criterion must be established for each species of fish, and factors such as age, sexual dimorphism, and temperature variations—which can cause extreme discrepancies in size within species—are not taken into account.

Casteel (1976) has summarized and compared five methods of estimating fish size from skeletal elements. These methods are the single regression, double regression, proportional, White's Technique, and Cook and Treganza's technique; the two most accurate are the single and double regression (see Reitz et al. 1987).

In order to investigate this issue, nineteen otoliths from *Cynoscion nebulosus* were measured from the postrostrum to the rostrum (Table 3). These measurements were compared to the actual fish length, using a simple regression, and the following equation was derived: $\log Y = \log a + b(\log X)$. Log Y is the length of the fish, b is the slope of the line, a is the y–intercept, and log X is the length of the otolith. This equation can predict total length for *Cynoscion nebulosus* for which the actual length is unknown by substituting the otolith length into the equation. Similarly, fish weight can be estimated from otolith length by deriving an equation from a known population of fish. The results of this investigation indicate that a relationship, albeit not a strong one, does exist (Figure 14). The correlation coefficient was .778. These findings are similar to those of Reitz, Quitmyer, Hale, Scudder, and Wing (1987). The sample that was used for this study did not include any juvenile fish, and, in addition, most of the adults were in the same size range, so the lack of variation within the sample can explain why the correlation was not strong. Regression techniques are adequate for estimating gross fish size (either fish length or fish weight), but the technique produces only an estimate.

A study by Eziuzo (1963) and Fitch and Brownell (1968) uses a two–step process. The length of the fish is estimated from the length of the otolith, using the

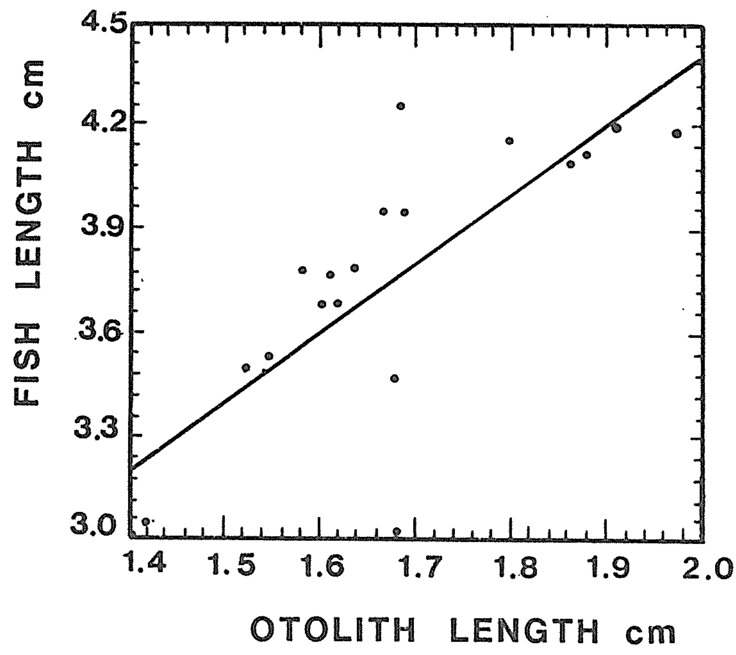

Figure 14. Simple regression plot illustrating the relationship between otolith length and fish length for nineteen specimens of *Cynoscion nebulosus*.

double regression method, and the weight of the fish is predicted from this estimated length. In this study, however, the length of the fish is already known, so the second step would be to examine the data in order to determine the fish weight based on the fish length.

As a general guide, Table 3, which documents fish size and otolith length of the specimens used in this study, can be consulted.

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Rangia Cuneata as a Seasonal Indicator for Coastal Archeological Sites in Texas

David L. Carlson

ABSTRACT

Rangia cuneata, a brackish water clam, is commonly found in archeological sites along the coast of Texas and Louisiana. Because of its abundance and because of the obvious growth rings on the surface of its valves, *Rangia* has been a focus of seasonality studies over the last ten years. Recently, Lawrence Aten (1981) proposed a method of identifying site seasonality using *Rangia* valves.

Aten's dated collections are used to develop a model of *Rangia* growth patterns by using cubic splines to smooth and interpolate the known samples. A FORTRAN program is used to fit archeological samples to the model and provide a graphic display of the quality of the fit. Sixty–four published *Rangia* seasonality determinations are evaluated using this procedure. The analysis of archeological samples using this technique confirms previous researchers' conclusions that *Rangia* were used along the Texas coast primarily as a spring resource.

INTRODUCTION

The brackish water clam, *Rangia cuneata,* is common on archeological sites along the coast of Louisiana and Texas. Along the central Gulf Coast of Texas, extensive shell middens of *Rangia* like the one at the Dow–Cleaver site (41BO35) document the use of large quantities of these clams for food (Aten 1971). At Dow–Cleaver, piles of circular "floors" of *Rangia* appear to have been deliberately constructed for living areas. Although there is some disagreement about whether *Rangia cuneata* was a staple (Dillehay 1975c) or a minor supplement (Byrd 1976), its abundance at many sites suggests that the species was systematically collected as a food resource.

Rangia cuneata occupy brackish water habitats in estuaries and bays along the coast, surviving in environments ranging in salinity between 0 and 33 parts per thousand (Bedford 1972). They are most abundant in the low diversity habitat zone between freshwater and saltwater environments, where they reach their greatest population densities (Bedford 1972:99). Ecological studies suggest that the preference of the species for low salinity environments is a result of heavy predation and competition in more saline habitats (O'Heeron 1966).

The success of *Rangia* in brackish habitats, where salinity can change suddenly and dramatically, is primarily a result of its success at osmoregulation. At salinities above 10 parts per thousand, *Rangia* are isosmotic. At lower salinities, however, *Rangia* rapidly begin to osmoregulate and control their internal salinity at a significantly higher level than the surrounding medium (Bedford 1972:99). This ability buffers the species against sudden salinity shocks and insures that shell morphology is more likely to be a function of animal growth cycles than of transient environmental effects.

Perhaps as a result of their ability to survive under adverse environmental conditions, *Rangia cuneata* are reported from the Potomac River on the Atlantic Coast to Avarado, Mexico on the Gulf (Tarver 1971). The species has been in Louisiana for at least the last 9000 years, and some 5 million cubic yards of dead shell are dredged in that state every year (Tarver 1971).

Rangia are relatively easy to gather since they reach their highest densities in shallow water adjacent to sources of fresh– or saltwater (Tarver and Dugas 1973). In Lakes Pontchartrain and Maurepas in Louisiana, densities can reach 820 individuals 16mm or larger in a single square meter. In the Neches River in Texas, concentrations of 250 individuals per square meter have been reported (Tarver and Dugas 1973).

Because of their abundance and because of the obvious growth rings on the surface of their valves, *Rangia cuneata* have been a focus of seasonality studies over the last 10 years (Aten 1972, 1981; Dillehay 1974, 1975a, 1975b; Skelton 1978). By studying the indentations on the surface of *Rangia* shells, Aten devised a technique for classifying samples of 50 or more shells by growth stages and then fitting the resulting distribution to a series of modern samples (Aten 1981).

The use of growth increments in bivalve shells to determine environmental conditions has been the subject of considerable study in recent years. Bivalve growth patterns that reflect subdaily, daily, bidaily, fortnightly, lunar month, and annual growth episodes have been identified (Kennish 1980).

Interruptions in growth can be related to freeze, heat, and thermal shock, abrasion, spawning, neap tides, and storms (Kennish 1980). By microscopic observation of shell microstructure, it is often possible to distinguish various environmental shocks and other events in the life of an individual bivalve (Tevesz and Carter 1980).

This report explores the use of *Rangia cuneata* for estimating seasonality on archeological sites on the Texas coast. An extension of the techniques originally proposed by Lawrence Aten (1981) is described and applied to a series of 64 archeological samples.

SEASONALITY IN *RANGIA CUNEATA*

In 1981, Aten published a method for determining seasonality from collections of *Rangia cuneata* (Aten 1981). The technique involves examining the exterior surfaces of the shells for annual rings. Once the annual rings are located, the degree of growth beyond the last period of growth interruption is estimated. Application of the procedure involves using estimates of age/size relationships in *Rangia cuneata* so that interruptions caused by thermal shock or storm tides are not mistakenly identified as annual rings. The width of the ring preceding the last is used as a measure of the amount of growth expected in the last ring. If the growth in the last ring is less than one–third of what is expected, the valve is classified as in the *Early* stage. If it is more than one–third, but less than two–thirds, it is classified as *Middle*, and if it is more than two–thirds, it is classified as *Late*. If the last growth episode appears to be complete, and the valve is currently in an arrested period of growth, it is classified as *Interrupted;* if the rings cannot be clearly identified, the valve is classified as *Indeterminate*. Since the evaluation of any single valve is subject to error, Aten recommends that samples of at least 50 valves of one side (i.e. all left or all right valves) be used. Blind tests involving Aten and Dillehay and Aten and the author indicate that independent assessments of single samples are comparable.

Once estimates have been made for a sample of valves (preferably at least 50), the distribution of the sample is compared to empirical distributions made by Aten from modern collections along the Texas coast.

The samples vary in size from 14 to 50 individuals. Aten combines these samples into half–month periods. Dated samples are available for 18 of the 24 half–month periods in the year.

Seasonality estimates are made by picking the empirical distribution that most closely matches the sample. The method has been criticized on various grounds; one criticism is that the surface morphology of bivalves in general cannot be used to identify annual cycles reliably (Monks 1981, Claassen 1982). Study of thin sections or acetate peels of thick sections certainly are more reliable methods than observation of surface morphology or estimating the age or season of a single individual, but the cost and time involved in analyzing sections of each specimen greatly limit the number of specimens that can be examined. Although study of surface morphology is less precise, the errors in that method may average out if sample sizes are large enough. Examination of surface annual rings has been used in at least one ecological study to produce demographic life tables for *Rangia* (Fairbanks 1963).

Another criticism has been that the determination of seasonality from surface morphology overestimates the expected growth in the last year by comparing it to the penultimate growth ring, since growth rates slow as the individuals become older. This imprecision would be more important if the exact width of the ring were involved in the estimate. Since only the nearest third is estimated and since the reduction in growth rates is relatively small from one year to the next, the effect is likely to be negligible. More importantly, the same inaccuracy occurs in the empirical data. Since both the sample and the empirical data may underestimate the "true" proportion of Late stage clams, there is no systematic bias in the prediction as suggested by Monks (1981). To resolve this problem, steps have been taken to systematize the fitting procedure and to provide a graphic display of the *goodness of fit* between the unknown sample and the dated samples.

The dated samples collected by Aten represent several localities along the coast. For this reason, they are viewed best as an approximation of the average trends of growth for *Rangia*. Examining the plots for the different growth categories emphasizes this fact. Each growth category should be characterized by a single peak. Secondary, smaller peaks probably reflect sampling fluctuations or unique conditions (see Aten 1981, Figure 4).

What is needed is a smooth curve that follows the rise, peak, and decline of each growth category through the years but ignores the smaller fluctuations. Several techniques are available for smoothing "noisy" data. These techniques also permit estimates of the expected proportions in the six half–month periods for which there are no samples. One technique would be to fit nonlinear curves to the data, for example, polynomial functions by least squares or by iterative techniques designed for nonlinear regression. Another would be to smooth the data using the exploratory data techniques described by Hartwig and Dearing (1979) and others. The first approach would have the possible disadvantage of smoothing the data too much. The latter approach would make estimates for the gaps somewhat more difficult, and the degree of smoothing could not be easily controlled.

A third approach, which overcomes these deficiencies, is to use cubic splines, which are simply a series of separate cubic polynomials fitted to the intervals

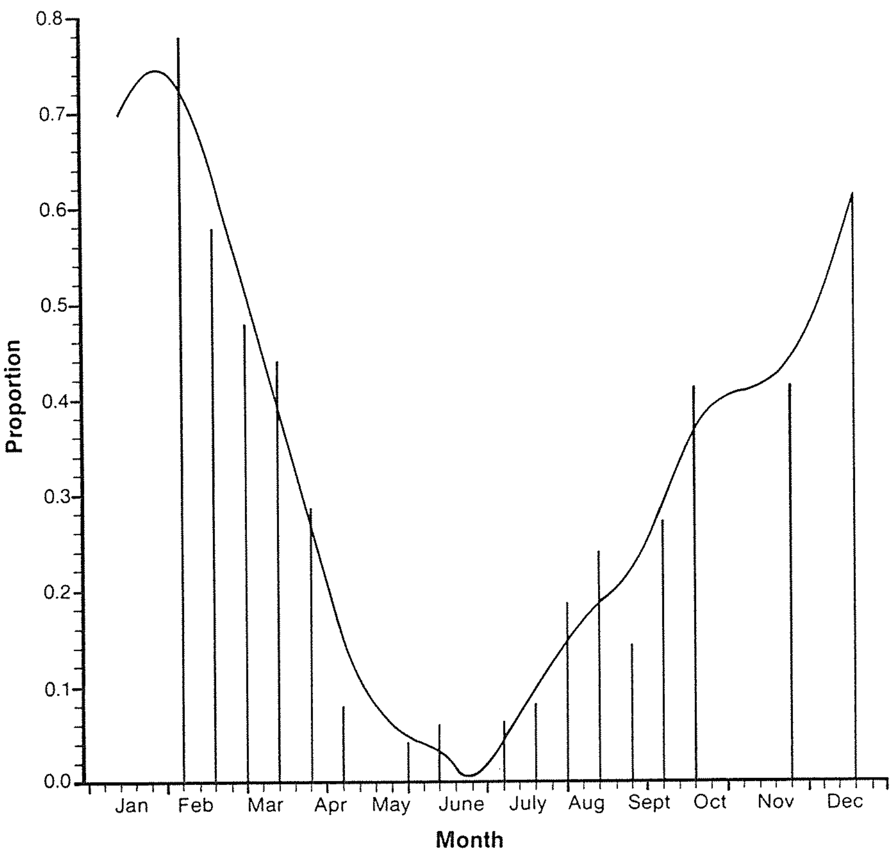

Figure 1. Spline curve fit to Aten's modern data on the proportion of *Rangia* values in the Interrupted stage. Vertical lines show the observed proportions; the smooth curve is the cubic spline approximation.

Table 1. Expected Proportions for each *Rangia* Growth Stage

Half–Month	Inter–rupted	Early	Middle	Late	Un–certain
Mid–Jan	.6941	.0425	.0051	.1586	.0997
Late Jan	.7398	.0864	.0123	.1035	.0580
Mid–Feb	.7177	.1464	.0215	.0541	.0603
Late Feb	.6193	.2209	.0329	.0196	.1073
Mid–March	.5015	.3017	.0474	.0220	.1274
Late March	.3851	.3770	.0776	.0230	.1373
Mid–April	.2601	.4313	.1394	.0329	.1363
Late April	.1473	.4406	.2320	.0522	.1276
Mid–May	.0782	.3911	.3368	.0818	.1121
Late May	.0451	.3012	.4378	.1236	.0923
Mid–June	.0289	.2007	.5102	.1787	.0815
Late June	.0065	.1261	.4972	.2447	.1255
Mid–July	.0482	.0827	.3905	.3156	.1630
Late July	.0962	.0591	.2633	.3804	.2010
Mid-Aug	.1467	.0504	.1860	.4260	.1909
Late Aug	.1857	.0391	.1652	.4501	.1599
Mid–Sept	.2196	.0232	.1638	.4556	.1378
Late Sept	.2892	.0131	.1476	.4415	.1086
Mid–Oct	.3637	.0103	.1057	.4172	.1031
Late Oct	.3968	.0079	.0821	.3888	.1244
Mid–Nov	.4092	.0044	.0748	.3557	.1559
Late Nov	.4391	.0000	.0663	.3160	.1786
Mid–Dec	.5129	.0015	.0436	.2684	.1736
Late Dec	.6088	.0147	.0063	.2150	.1552

between dated samples. A cubic spline is continuous and has continuous first and second derivatives. This latter condition assures that the curve will have a smooth overall appearance. The spline function can be used to smooth noisy data values and to interpolate between known points (Reinsch 1967, Wold 1974).

In order to smooth the dated samples published by Aten, a FORTRAN program was written using a subroutine provided in the International Mathematics and Statistics Library (1980) for smoothing by cubic splines. The subroutine requires the user to provide a smoothing parameter, which is used to fit the curve. In fitting the function, each sample was weighted by the number of valves in the sample so the curve would fit large samples more closely than small ones. A large value was selected for the smoothing parameter by examining the data, and this value was progressively reduced to zero. At this point, the spline curve fits the data exactly (i.e., no smoothing is done). The results were inspected at each increase of the smoothing parameter, and the smallest value was selected that produced a curve that rose monotonically to a single peak and then declined monotonically. Curves were calculated independently for Interrupted (Figure 1), Early, Middle, and Late growth stages. The expected proportions for each half–month period in the year were calculated for each growth category (Table 1). The uncertain category was computed by summing the four growth stages and subtracting the result from 1.0. Table 1, then, represents a model of a full year's expected *Rangia* growth that is

Mid–Jan	0.55090	***
Late Jan	0.61324	***
Mid–Feb	0.59308	***
Late Feb	0.48934	***
Mid–Mar	0.38325	**************************************
Late Mar	0.30755	*******************************
Mid–Apr	0.23551	************************
Late Apr	0.16637	*****************
Mid–May	0.10081	**********
Late May	0.05127	*****
Mid–June	0.03022	***
Late June	0.01810	**
Mid–July	0.00654	*
Late July	0.03496	***
Mid–Aug	0.07935	********
Late Aug	0.10661	***********
Mid–Sept	0.12192	************
Late Sept	0.15230	***************
Mid–Oct	0.20436	********************
Late Oct	0.23052	***********************
Mid–Nov	0.23604	************************
Late Nov	0.25710	**************************
Mid–Dec	0.32828	*********************************
Late Dec	0.44777	***

Rangia counts (N=32):	2	4	12	8	6
Proportions (% of total):	0.0625	0.1250	0.3750	0.2500	0.1875
Expected:	0.0482	0.0827	0.3905	0.3156	0.1630

Figure 2. Aten's mid–July *Rangia* sample compared to the model. The length of the line of astersks/stars shows how well (short) or poorly (long) the sample fits each period. The best fit is mid–July. The error sum of square is 0.006537. The mean squared error is 0.239391 with variance 0.033999.

based on the dated samples.

If the calibrated data really reflect the seasonal growth patterns of *Rangia cuneata,* they should be correlated with environmental factors known to affect *Rangia* growth. Data on air temperature (Aten 1981) and water temperature (Texas Parks and Wildlife Department 1963, 1964, 1965, 1966, 1967, 1968, 1969/70, 1972, 1973) in the Galveston Bay area were examined and found to be highly correlated (r=+.9912). *Rangia* in the Early, Middle, or Late stages can be considered to be growing, so the sum of these categories should be correlated with temperature. The correlation between air temperature and the proportion of *Rangia* in the Early, Middle, or Late stage is +.9254. In addition, Aten (1981:195) notes that growth in

Table 2. Summary of Goodness of Fit Between the Model and the Dated *Rangia* Samples

		Error Sums of Squares			
Sample Size	No.	Minimum	Maximum	Mean	Standard Deviation
X < 50	4	.0007	.0428	. 0157	.0187
50< X < 100	8	.0009	.0121	.0061	.0038
X > 100	6	.0006	.0069	.0027	.0028

Mid–Jan	0.28260	************************************
Late Jan	0.31775	********************************
Mid–Feb	0.29123	*****************************
Late Feb	0.20582	*********************
Mid–Mar	0.12606	*************
Late Mar	0.08438	********
Mid–Apr	0.06902	*******
Late Apr	0.07801	********
Mid–May	0.09659	**********
Late May	0.12818	*************
Mid–June	0.17335	*****************
Late June	0.18637	*******************
Mid–July	0.12868	************
Late July	0.09433	*********
Mid–Aug	0.09173	*********
Late Aug	0.10022	**********
Mid–Sept	0.10740	***********
Late Sept	0.10827	***********
Mid–Oct	0.11564	************
Late Oct	0.11943	************
Mid–Nov	0.11702	************
Late Nov	0.12342	************
Mid–Dec	0.15632	****************
Late Dec	0.22003	**********************

Rangia counts (N=200):	48	52	32	46	22
Proportions (% of total):	0.2400	0.2600	0.1600	0.2300	0.1100
Expected:	0.2601	0.4313	0.1394	0.0329	0.1363

Figure 3. Aten's late April and mid–October samples combined to illustrate a poor fit to the *Rangia* seasonality model. The best fit is mid–April. The error sum of squares is 0.069020. The mean squared error is 0.146743 with variance 0.004675.

proportion of growing *Rangia* should come in June (mean temperature 81.5°). In July and August, when the mean temperature increases to 83°F, the proportion of growing *Rangia* declines. These data strongly suggest that the major growth cycles of the species have been captured in the model.

In order to match undated samples to the model, a second FORTRAN computer program was written. This program compares the sample proportions with each of the model predictions. For each of the 24 comparisons a goodness–of–fit measure is calculated that involves summing the differences between the observed and expected proportions for the four growth periods (the unknown category is not used in fitting the sample to model). The half–month period with smallest error sum of squares is selected as the best fit. For each sample, the program displays the error sum of squares for each half–month period and draws a histogram that reflects the degree of fit or lack of fit over the whole year. A sample that fits the model will have a valley in the histogram that indicates a close fit with that half–month or group of half–months. A deep, narrow valley indicates a close fit with a single half–month, whereas a broad, gradual valley indicates a poorer fit with any particular half–month but a general fit with a particular season.

To judge the accuracy of the model and the fitting program, the 18 dated samples were submitted for seasonality estimates. Thirteen of the samples were estimated to the exact half–month of their collection. The remaining five samples were placed in an adjacent half–month interval. All of the samples then, were classified within a half–month of their true dates. All of the "errors" occurred in the late summer and early fall months when growth is slowing and most of the valves are in the Late or Interrupted stage. In addition, the valleys tend to be broader in the late summer and fall, indicating that changes are taking place more gradually and that, therefore, it is more difficult to distinguish between adjacent periods. Aten's mid-July collection is illustrated as an example of a close fit between the model data and a modern collection (Figure 2). The results of the test also provide some data on how well good samples can be expected to fit the model (Table 2). Archeological samples cannot be expected to fit the model as closely as the data from which the model was generated do, but very poor fits should be regarded with suspicion.

Mid–Jan	0.47043	***
Late Jan	0.48667	***
Mid–Feb	0.42872	***
Late Feb	0.30102	******************************
Mid–Mar	0.18511	*******************
Late Mar	0.10368	**********
Mid–Apr	0.04475	****
Late Apr	0.01420	*
Mid–May	0.01013	*
Late May	0.03657	****
Mid–Jun	0.09310	*********
Late Jun	0.13897	**************
Mid–July	0.14652	***************
Late July	0.17885	******************
Mid–Aug	0.22114	**********************
Late Aug	0.15094	*************************
Mid–Sept	0.26838	***************************
Late Sept	0.28240	****************************
Mid–Oct	0.30648	*******************************
Late Oct	0.31391	*******************************
Mid–Nov	0.30606	*******************************
Late Nov	0.30831	*******************************
Mid–Dec	0.34467	**********************************
Late Dec	0.41568	**

Rangia counts (N=295):	47	102	88	23	35
Proportions (% of total):	0.1593	0.3458	0.2983	0.0780	0.1186
Expected:	0.0782	0.3911	0.3368	0.0818	0.1121

Figure 4. A composite sample created by combining all of Aten's spring samples, which illustrates a close fit to the *Rangia* seasonality model. The best fit is mid–May. The error sum of squares is 0.010133. The mean squared error is 0.235696 with variance 0.019410.

Table 3. Seasonality Determinations for Published *Rangia* Samples

Site	Level (L) Zone (Z) Surface (S)	Estimate	Date
41CH32	L 1	Late April	A.D. 1550?[2]
	L 2	Late May	A.D. 1400[2]
	L 3	Poor fit	A.D. 1000–1400[2]
	L 4	Late May	A.D. 500–1000[2]
	L 5	Poor fit	A.D. 100–500[2]
41CH46	L 1	Late April	After A.D. 1100[2]
	L 2	Late April	A.D. 600–1100[2]
	L 3	Poor fit	A.D. 500–1000[2]
	L 4	Late April	A.D. 100–600[2]
41CH47	L 1	Late April	A.D. 800?[2]
	L 2	Mid–May	A.D. 700?[2]
	L 3	Late May	A.D. 400–600?[2]
	L 4	Poor fit	A.D. 100–500[2]
	L 5	Late May	Late Archaic[2]
41CH110	Z 1	Late July	A.D. 1160–1760[1]
		Mid–July	A.D. 1160–1760[1]
	Z 3	Mid–May	A.D. 1160–1760[1]
		Late July	A.D. 1160–1760[1]
	Z 4	Mid–May	A.D. 1160–1760[1]
		Late May	A.D. 1160–1760[1]
		Mid–July	A.D. 1160–1760[1]
		3–Poor fit	A.D. 1160–1760[1]
41CH172	L 1	Late April	A.D. 100–500[2]
	L 2	Mid–May	A.D. 100–500[2]
	L 3	Mid–May	A.D. 100–500[2]
	L 4	Poor fit	Archaic[2]
	L 5	Poor fit	Archaic[2]
	L 6	Mid–July	Archaic[2]
	L 7	Mid–June	Archaic[2]
	L 8	Mid–July	Archaic[2]
41MG19	S	Mid–May	Late Prehistoric[3]
41MG25	S	Mid–May	?[3]
41MG29	S	Late May	?[3]
41JK7	0–.5'	Mid–May	Late Prehistoric[3]
		Late April	Late Prehistoric[3]
		Poor fit	Late Prehistoric[3]
		Late April	Late Prehistoric[3]
	.5–1'	Mid–April	Late Prehistoric[3]
		Late April	Late Prehistoric[3]
41JK41	Test	Late April	Late Prehistoric[3]
41JK91	Upper Cluster	Poor fit	Late Prehistoric[3]
		Poor fit	Late Prehistoric[3]
		Late April	Late Prehistoric[3]
	Middle Cluster	Poor fit	Archaic/ Late Prehistoric[3]
		Late April	Archaic/ Late Prehistoric[3]
	Lower Cluster	Late April	Archaic[3]
		Late April	Archaic[3]

continued

Table 3, continued

41JK110	S	Mid–May	?[3]
41JK113	S	Mid–May	?[3]
41JK114	S	Late April	Late Prehistoric[3]
	S	Mid–July	Late Prehistoric[3]
41JK118	S	Late June	Late Prehistoric[3]
41JK120	S	Late May	?[3]
41JK125	S	Late May	Late Prehistoric[3]
	S	Mid–May	Late Prehistoric[3]
41JK128	S	Mid–May	Late Prehistoric[3]
41JK129	S	Late June	Late Prehistoric[3]
41JK147	Test	Late April	Late Prehistoric[3]
41CL35	S	Mid–July	?[3]
41CL37	S	Late June	Archaic[3]
	S	Mid–July	Archaic[3]

[1] Dillehay 1974
[2] Dillehay 1975b
[3] Skelton 1978

```
Mid–Jan     0.56606   *********************************************************
Late Jan    0.57683   **********************************************************
Mid–Feb     0.50531   ***************************************************
Late Feb    0.35587   ************************************
Mid–Mar     0.21709   **********************
Late Mar    0.11454   ***********
Mid–Apr     0.03922   ****
Late Apr    0.00282
Mid–May     0.00759   *
Late May    0.05307   *****
Mid–Jun     0.13101   *************
Late Jun    0.18969   *******************
Mid–July    0.20578   *********************
Late July   0.24258   ************************
Mid–Aug     0.28864   *****************************
Late Aug    0.32355   ********************************
Mid–Sept    0.34669   ***********************************
Late Sept   0.36693   *************************************
Mid–Oct     0.39477   ***************************************
Late Oct    0.40316   ****************************************
Mid–Nov     0.39533   ****************************************
Late Nov    0.39891   ****************************************
Mid–Dec     0.43826   ********************************************
Late Dec    0.51117   ***************************************************
```

Rangia counts (N=51):	6	22	14	3	6
Proportions (percent of total):	0.1176	0.4314	0.2745	0.0588	0.1176
Expected:	0.1473	0.4406	0.2320	0.0522	0.1279

Figure 5. A sample from archeological site 41JK7 illustrating a close fit to the Rangia seasonality model. The best fit is late April. The error sum of squares is 0.002815. The mean squared error is 0.2924785 with variance 0.029107.

Next, a series of mixed samples was created by combining dated samples from different seasons. The purpose of these experiments was to see if, for example, by mixing spring and fall collections, the program would erroneously estimate a summer or winter collection. The results (Figure 3) showed that a bimodal distribution is created by mixing samples from disparate seasons, which is readily identified as a poor fit to the model; no half-month period fits well. An added advantage to the program, then, is that mixed or otherwise inappropriate samples can be readily identified and eliminated.

A second series of experiments was run simulating collection over a single season. In these tests, all of the dated samples from a single season were combined (Figure 4). The best estimate is consistently within the range of the known sample dates. The valleys appear to be somewhat broader than for single samples, however, the difference is subtle. This suggests that samples representing a particular season and samples representing a single collection episode cannot be distinguished from one another. For example, combining all of the spring collections produces a composite sample that fits the Late April and Mid-May model values (Figure 4). This suggests too that the accuracy of this technique for seasonality estimates may be as good as ±1 1/2 months. Considering the simplicity of the technique and the level of our current understanding of seasonal exploitation by prehistoric populations, this level of accuracy is impressive.

Next, a series of 64 published archeological samples of *Rangia,* from Chambers County on the upper Texas coast to Calhoun County on the central Texas coast, was analyzed (Table 3). Thirteen of the samples provided relatively poor fits to any of the half-month periods; 51 samples fit one of the model periods. The sample from the Anaqua site (41JK7) (Story 1968) is illustrated as an example of a good fit (Figure 5). The analysis shows that the estimates range between mid-April and late July, a four-month period spanning spring and early summer. Despite differences in location along the coast and time period, it is clear that the the use of *Rangia* by the prehistoric inhabitants of the coast was highly seasonal (Table 4). This confirms

Table 4. Summary of Archeological Seasonality Determinations

Half-Month Period	No.	Percent
Mid-April	1	1.6
Late April	16	25.0
Mid-May	12	18.8
Late May	9	14.1
Mic-June	1	1.6
Late June	3	4.7
Mid-July	7	10.9
Late July	2	3.1
Poor fit	13	20.3
TOTAL	64	100.1

the results of Aten, (1979), Dillehay (1974, 1975b), and Skelton (1978). Some of the sites listed in Table 3 probably were occupied only for a single season. Others, however, are larger, multicomponent occupations of specific areas. The tight clustering of *Rangia* seasonality determinations suggests a highly scheduled subsistence pattern involving movements along the coast and, perhaps, inland as well.

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Utilization of Marine Mollusks by Inhabitants of the Texas Coast

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ABSTRACT

Along the Texas Coast, marine mollusks were used by the aboriginal populations both as a significant food resource and as a source of raw material for the manufacture of tools and ornaments. The utilization of this resource varies along the coast, and this variation is correlated with differences in marine habitats and the availability of lithic resources. Along the upper Texas coast the common rangia and the eastern oyster were the major mollusks used as food; along the central and southern coast a greater variety of marine species were utilized. More tools and ornaments were manufactured from mollusks along the central and southern parts of the coast.

INTRODUCTION

Many Texas coastal archeological sites can be recognized by the shell refuse littering the area, yet the aboriginal use of these marine resources was one of the last questions seriously examined by archeologists working in the state. The early period of archeological research concentrated on finding evidence of prehistoric occupation, establishing the cultural sequences, tracing historic groups back through time, and understanding Texas's role in the origin of Mesoamerican cultures and their diffusion into the Mississippi Valley. This phase of archeological research has been well reviewed by Aten (1979, 1983), Campbell (1960), Dillehay (1975), Hester(1980a), and Patterson (1979a, 1979b).

This early research did not focus on analyses of subsistence patterns, such as utilization of marine resources, but it did establish the importance of marine resources to dwellers of the Texas coast. The concentration of shell midden sites along the upper Texas coast was first documented by Sayles (1935), whereas the significance of the marine resources to peoples of the central and southern coast of Texas was first documented by Martin (1929, 1930) and Sayles (1935). In a more systematic fashion, Campbell's research on the central coast of Texas emphasized the importance of shell as a resource for production of tools (1947,1952,1956, 1958a, and 1958b), whereas MacNeish's work emphasized the shell industry of the south (1947).

Only in the last two decades have archeologists systematically pursued questions concerning the use of marine resources by Indians of the Texas coast. For the upper Texas coast, Ambler's excavations in the Trinity River delta (1973) and Dillehay's report (1975) on prehistoric patterns of subsistence in the lower Trinity Bay area are landmark research efforts. For the central coast of Texas the work of

Story (1968) in the Corpus Christi Bay area is especially noteworthy for its ecological orientation. Her work was followed shortly by research conducted by Hester (1969a, 1971b) and Fritz (1975). In these studies, the first serious consideration of the faunal remains and human subsistence patterns was presented, as well as traditional research on the artifacts made of bone and shell. Since these studies appeared, Aten (1979, 1983), Carlson, Steele, and Bruno (1982), Day, Laurens–Day, and Prewitt (1981),Smith (1983a, 1983b), and Steele and Mokry (1985) have continued to pursue environmentally oriented questions. Janota's study of the shell ornaments of the central and upper Texas coast (1980) and Mokry's examination of whelk shell adze technology (1980) are two studies that specifically examine one aspect of aboriginal use of marine resources

What is lacking for the Texas coast is a review of the aboriginal use of marine resources for the entire region focused on recognition of regional patterns and explaining the reasons for these patterns. This paper is an initial review that concentrates on aboriginal use of mollusks as food and for the production of tools and ornaments. It is restricted to the mollusks because insufficient data is available to warrant inclusion of other marine resources such as salt and fish. The emphasis is on analysis of geographic variation in the use of species, since data are too limited to support analysis of temporal and seasonal use of mollusks. However, the literature on these topics will be discussed where it is pertinent.

SITES AND MATERIALS

This review of aboriginal use of marine mollusks is based on material recovered from 111 sites and the Anderson Collection, the most extensive collection of mollusks recovered from archeological sites in the Rio Grande delta region, made by A. E. Anderson during the first half of the century. After Anderson's death, the collection was lent to The University of Texas at Austin (Prewitt 1974a). Tabulation of the mollusks in the Anderson Collection is based on a brief paper of Anderson's (1932) and on the author's examination of material from that collection that is housed in the Texas Archeological Research Laboratory in Austin.

To facilitate regional comparisons, materials from the sites have been clustered into 15 separate localities along the coast (Figure 1, Table 1).

Identifications made by the original analysts generally have been accepted, but species identifications of shells originally identified as oyster or whelk are tentative.

Since all sites were not sampled originally in the same fashion, precautions should be taken in evaluating the data (Table 2). No distinction is made on Table 1 between one or a thousand specimens since frequencies are not available for the various species at all sites. Certain taxa, such as *Rangia, Crassostrea*, or *Busycon*, are quite frequent, but species such as *Diodra cayenensis* or *Cerithidea pliculosa* are never very frequent. In these cases, subjective evaluations of species frequency are presented, but in cases where specimens of species appear in apparent equal frequency, no frequency comparisons are made. Too, absence of a species from a locality may be significant, as is the absence of *Rangia cuneata* from southern coastal sites, but the absence from a locality of species that show up only rarely in

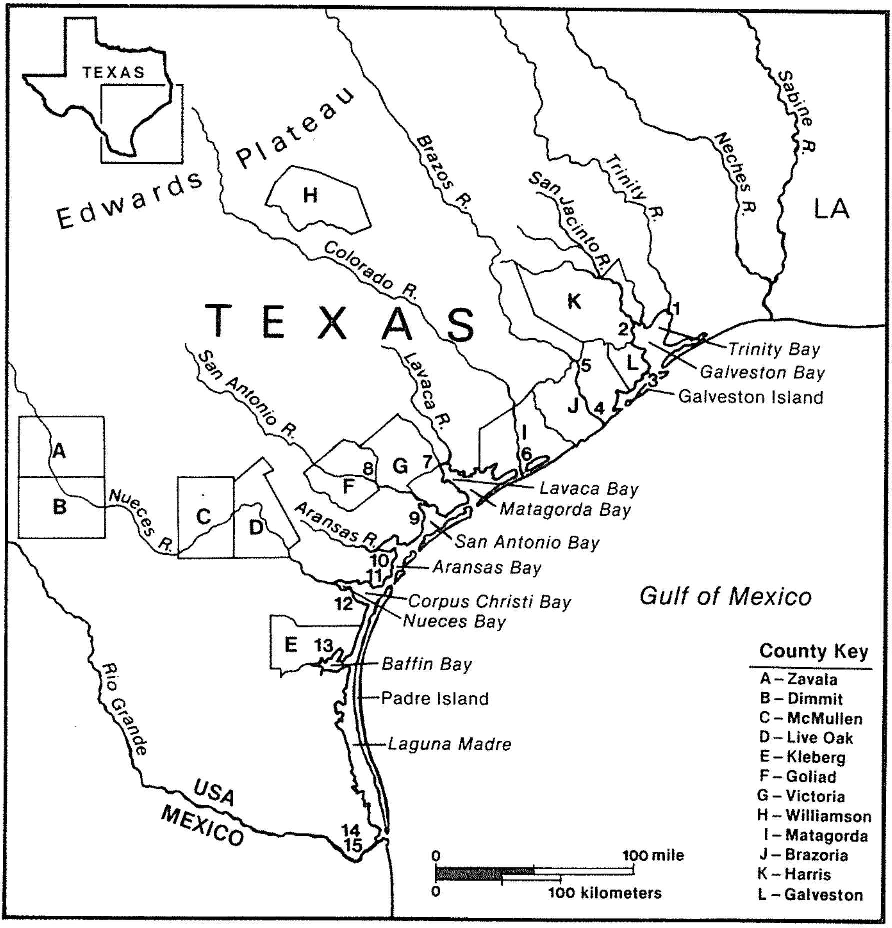

Figure 1. Map of the Coastal Bend of Texas showing the 15 localities from which sites were sampled.

all sites may simply be a result of sampling error.

Variation in mollusk use through time, and seasonal variation in the use of mollusks are discussed only briefly because little data are available on them. One exception concerns seasonal utilization of rangia, which is discussed by Carlson (1988).

FACTORS AFFECTING DISTRIBUTION AND USE OF MOLLUSKS

Three major factors that affect the distribution of mollusks along the Texas coast are (1) the structure of the coastline itself, (2) the amount of rainfall in the region and the amount of runoff into the bays, and (3) the scarcity of lithic materials along the Gulf Coast.

The most distinctive features of the Texas coastline are the many embayments that flood the mouths of the rivers, and the peninsulas and barrier islands that parallel

Table 1. Sites from 15 Localities Along the Gulf Coast of Texas Containing Material Examined or Cited

Map No.	County	Coastal Area	Sites	Source
1	Chambers	Trinity Bay	41CH1, 16, 20, 24, 31–33, 36, 40, 46, 47, 52, 80, 88, 98, 106, 110, 137, 169, 172	Ambler 1973, Aten 1983, Dillehay 1975, Gilmore 1974, Shafer 1966
2	Harris	Galveston Bay	41HR50, 56, 61, 80, 81, 85	Aten et al. 1976, Aten 1983
3	Galveston	Galveston Bay and	41GV1, 5, 41BO2	Aten 1965, Campbell 1957
	Brazoria	Gulf of Mexico		Hole and Wilkinson 1973
4	Brazoria	Gulf of Mexico	41BO4, 11–13, 35, 41, 50, 126	Aten 1971, 1983, Dering & Ayers 1977, Hamilton 1988, Hollingsworth 1981, This study
5	Wharton	Matagorda Bay	41WH8	Hudgins 1984
6	Matagorda	Matagorda Bay	41MG8–25, 29	Fritz 1975
7	Jackson	Lavaca Bay	41JK7, 41, 47, 91, 110–120, 122, 124–130, 132–142, 144,	Fritz 1975, McGuff 1978, Story 1968
8	Victoria	Lavaca Bay	41VT1	This study
9	Calhoun	Lavaca Bay	41CL8, 9, 21–32, 35, 41, 42, 44	Fritz 1975
10	Aransas	Aransas Bay	41AS1, 3	Campbell 1947, 1952
11	San Patricio	Corpus Christi Bay	41SP43	Story 1968, This study
12	Nueces	Nueces Bay	41NU11, 35, 65, 101, 102–104, 169, 184, 185, 221	Carlson et al. 1982, Steele & Mokry 1985, Riklis & Gunter 1986, Ricklis 1986, This study
		Laguna Madre		Campbell 1956
13	Kleberg	Baffin Bay	41KL13, 71	Hester 1969a, 1971, Smith 1983b
14	Cameron	Laguna Madre and Gulf of Mexico	41CF2, 18 19, 97–102	Collins et al. 1969, Hall & Grombacher 1974, Prewitt, 1974a, This study
	Hidalgo		41HG89	Day et al. 1981
	Willacy		41WY48, 51, 60, 74	Day et al. 1981
15	Cameron	Laguna Madre and Gulf of Mexico	Anderson Collection	Anderson 1932, This study

the coastline, protecting these bays (Figure 1). In the northeast corner of the state, Galveston Bay and Trinity bays are almost completely separated from the Gulf of Mexico by Bolivar Peninsula and Galveston Island (Figure 1, localities 1 to 3). These bays, because of their isolation, together with high annual rainfall and resultant discharge into them, are brackish water bays that support few mollusk species. South of Galveston Bay (near locality 4, Figure 1), a short stretch of the Texas coast directly fronts the Gulf; like the seaward rim of Galveston Island and Bolivar Peninsula, it provided hunters and gatherers access to a marine environment and to fauna more reminiscent of the southern bays than of the adjacent brackish water bays.

The next embayment is Matagorda Bay, with the smaller arms Lavaca Bay, Carancahua Bay, and Tres Palacios Bay flooding the lower reaches of the streams that bear the same names (near localities 6 and 7, Figure 1). Matagorda Bay, like Galveston Bay, is bounded seaward by barrier islands and peninsulas, but less freshwater enters the bay, so Matagorda Bay's mollusk fauna is more reminiscent of the Gulf of Mexico than of Galveston Bay.

Directly south of Matagorda Bay are the narrow San Antonio Bay, the larger sprawling Aransas Bay with smaller embayments Copano and St. Charles bays (near locality 10), and Corpus Christi Bay with smaller Nueces Bay and Cayo del Oso (near localities 11 and 12, Figure 1). All three of these bays, like Matagorda Bay, are sufficiently saline to support a highly varied marine fauna reminiscent of the Gulf of Mexico.

South of Corpus Christi Bay stretches Laguna Madre (localities 14 and 15, Figure 1), separating the mainland from Padre Island, which opens to the Gulf only at its southern and northern tips and has little freshwater entering from the mainland. Consequently, of all Texas bays, the saline Laguna Madre supports a marine fauna most like that of the Gulf of Mexico. Baffin Bay (locality 13) with its sister bays Cayo del Grullo and Alazan Bay, is the only embayment that breaks the main coastline fronting Laguna Madre, flooding one of the most arid stretches of the Texas coast. It is one of the most saline bays along the Gulf, and it appears, in fact, that this bay complex has grown more saline during the period of human occupation (Hester 1971a, 1980a, Smith 1983a, 1983b).

The second factor affecting mollusk distributions and their value to aboriginal populations is the amount of rainfall along the coast, together with the amount of water entering the bays from the rivers. Today, a marked precipitation gradient characterizes the Texas coast. The current annual precipitation means range between 112 cm (44 inches) along the upper coast and 71 cm (28 inches) at the mouth of the Rio Grande (Figure 2).

The upper Texas coast receives the major part of both precipitation and runoff for the state. The Colorado, Brazos, Trinity, Neches, and Sabine Rivers, which enter the upper half of the Texas coast, drain well over half of the entire landmass of Texas. On the other hand, the Lavaca, Guadalupe, San Antonio, Aransas, and Nueces Rivers, short rivers draining only the base of the Edwards Plateau and the south Texas plains, cross the central part of the coast, with discharges far less than those of the rivers of the upper Texas coast. Between the Nueces and the Rio Grande

Table 2. Species of Marine Mollusks Recovered in 15 Localities Along the Gulf Coast of Texas[1]

Species (Common name in parentheses)	Locality 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Aequipecten irradians amplicostatus (Atlantic bay scallop)	S	–	S	B	–	–	S	S	S	S	S	S	S	S	A
Anadara sp. indet. (Ark)	–	–	–	–	S	–	–	–	S	–	–	–	–	–	–
Anadara transversa (Transverse ark)	–	–	–	–	–	–	–	–	–	S	–	–	–	–	–
Atrina serrata (Saw–tooth pen shell)	–	–	–	–	–	–	–	–	–	–	S	–	–	–	–
Brachiodontes sp. indet. (Scorched mussel)	–	–	–	–	–	S	S	–	S	–	–	–	–	–	–
Busycon sp. indet. (Whelk)	A	B	B	B	S	S	B	A	B	B	S	B	A	A	A
Callista nimbosa (Sunray venus)	–	–	–	–	–	A	A	A	S	B	–	B	B	A	A
Cerithida pliculosa (Plicate horn shell)	–	–	–	–	S	S	–	–	S	–	–	S	–	–	A
Chione cancellata (Cross–barred venus)	–	–	–	–	–	–	S	_	S	S	S	–	S	–	–
Crossostrea virginica (Eastern oyster)	S	–	S	S	–	A	B	A	S	B	S	S	S	S	–
Crepidula fornicata (Common Atlantic slipper)	–	–	–	–	–	–	–	–	S	–	S	S	–	–	–
Cyrtopleura costata (Angel wing)	–	–	–	–	–	–	–	–	–	–	–	S	–	–	–
Diodora cayenensis (Keyhole limpet)	–	–	–	–	–	–	–	–	–	S	–	–	–	–	–
Dosinia discus (Disk dosinia)	–	–	A	S	–	–	–	–	–	–	–	–	S	S	A
Fisciolaria lilium (Banded tulip)`	–	–	–	–	–	S	–	S	S	B	S	S	S	–	–
Geukensia demissa (Ribbed mussel)	–	–	–	S	–	–	S	S	–	–	–	–	–	––	
Ischadium recurvum (Hooked mussel)	–	–	–	–	–	–	–	–	–	S	–	–	–	–	–
Laevicardium robustum (Giant Atlantic cockle)	–	–	A	S	S	S	B	–	S	S	S	S	S	S	–
Littorina irrorata (Marsh periwinkle)	–	–	S	–	–	S	–	–	S	S	S	–	–	–	–
Lucinia floridana (Florida lucina)	–	–	–	–	–	–	–	–	–	S	–	–	–	–	–
Mercenaria campechiensis (Southern quahog)	–	–	–	S	–	S	–	S	S	S	–	S	S	S	–
Murex pomum (Apple murex)	–	–	–	–	–	–	–	–	–	S	–	S	S	–	–
Noetia ponderosa (Ponderous ark)	–	–	–	–	–	–	–	–	–	S	–	S	A	A	A
Oliva savana (Lettered olive)	A	–	A	–	A	–	–	A	–	S	–	S	S	A	A
Olivella dealbata (Whitened dwarf olive)	–	–	–	–	–	–	–	–	A	–	–	–	–	–	–
Ostrea equestris															

continued

Table 2, continued

(Horse oyster)	–	–	–	–	–	–	–	–	–	–	–	–	S	–	–
Phalium granulatum (Scotch bonnet)`	–	B	–	–	–	–	–	–	–	–	–	S	–	–	–
Pleurophloca gigantea (Florida horse conch)	–	–	–	–	–	–	–	A	–	A	–	A	–	–	S
Polinices duplicatus (Shark's eye)	–	–	–	S	–	S	–	S	S	S	–	S	S	–	–
Prunum apicina (Common Atlantic marginella)	–	–	–	A	–	–	–	A	–	–	–	–	–	A	A
Rangia cuneata (Common rangia)	B	–	S	S	S	S	B	S	S	–	–	S	–	–	–
Rangia flexuosa (Brown rangia)	–	–	S	–	–	–	–	–	–	–	–	S	–	–	–
Thais haemastoma floridana (Florida rock shell)	–	–	–	S	–	S	S	–	S	–	–	–	–	–	–
Trachycardium sp. indet. (Cockle)	–	–	–	–	–	–	–	–	S	–	–	–	–	–	–

[1] Based on the taxonomic list of Andrews, 1971
S (Shell) unmodified specimens
A (Artifact) modified specimen
B (Both) both unmodified and modified specimens

lies a fourth of the entire Texas coastline, but it is drained by no constantly flowing river.

These conditions were probably less harsh in the past, but the precipitation gradient apparently has existed at least since Cabeza de Vaca's time. Krieger (1956), in his review of the food habits of aboriginals along the Texas coast based on the journals of Cabeza de Vaca, describes three regions: one near Galveston Bay, one inland from Lavaca Bay, and the expanse between the Nueces River and the Rio Grande. Although the relative amounts of rainfall are not given for these regions by Cabeza de Vaca, his descriptions closely fit the conditions for the regions as they are now.

We do not know how far into antiquity these conditions persisted. Hester (1980b) and Smith (1983b) have reviewed changing salinity in Baffin Bay. Based primarily upon the work of Behrens (1963, 1971, and 1972), they report that until 4,000 years ago Baffin Bay supported a varied marine fauna similar to what is found in Aransas and Corpus Christi bays today. Then, with the development of the barrier islands around 5,000 years ago and the gradual reduction in the amount of fresh water discharging into the bay, the bay became too saline to support the varied mollusk fauna.

Ricklis and Gunter (1986) reported recovering only brown rangia in Late Archaic deposits at 41NU184 and 41NU221, but by Late Prehistoric times, both the brown and the common rangia were being harvested at 41NU221. They inferred that this reflected increasingly brackish water conditions in the area of the site as the developing barrier islands slowed the dispersion of the fresh water emptying into

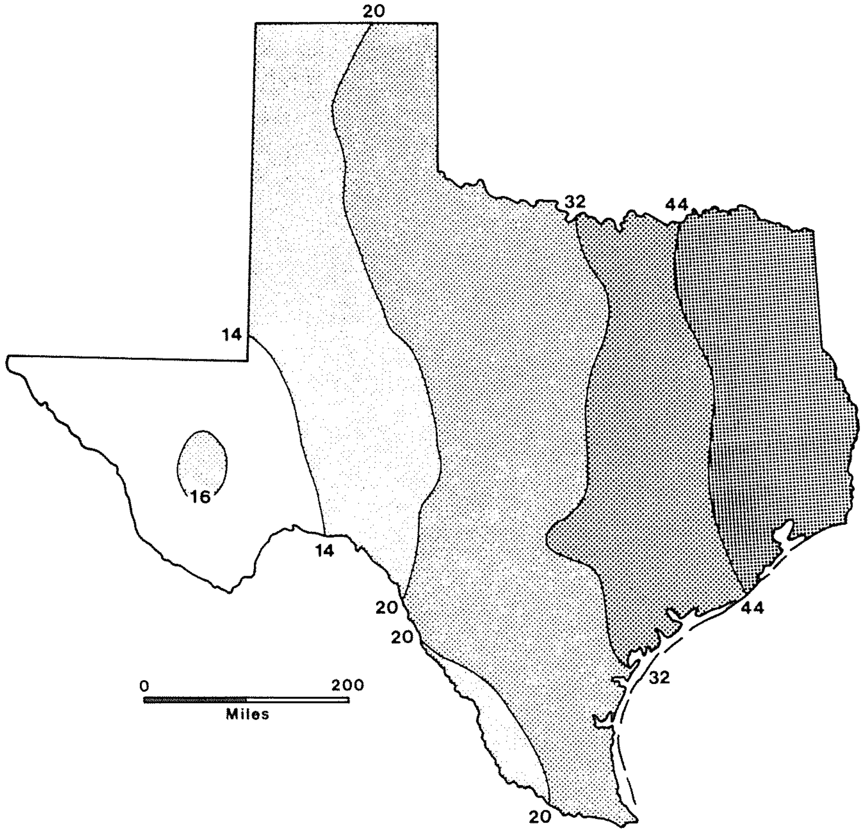

Figure 2. Map of Texas showing the precipitation gradient along the coast. Numbers give the mean annual precipitation recorded in inches along the representative lines.

Corpus Christi Bay from the Nueces River. This is the reverse of the trend postulated for Baffin Bay, where the developing barrier islands, water evaporation, and the lack of a constant fresh water discharge resulted in increasing rather than decreasing salinities.

Aten, Chandler, Wesolowsky, and Malina (1976) reported sequential changes in mollusk fauna recovered at the Harris County Boys' School site similar to those seen in Nueces Bay. Here the changes indicated a shift from an early brackish water fauna dominated by common rangia to a more saline fauna with increasing numbers of oysters, then a final return in the most recent times to a brackish fauna, again dominated by the common rangia. Aten (1983) suggested that these changes reflected the development of the Galveston Bay estuary.

From these three examples it is apparent that conditions along the coastline have changed during the period of human occupation. The creation of the barrier islands was a major change that could have affected conditions in all of the estuarine bays, limiting the exchange of bay waters and those of the open Gulf. This would have resulted in the gradual establishment of either brackish water estuaries such as the upper reaches of Galveston and Nueces bays, or hypersaline estuaries such as Baffin Bay, depending upon the degree of freshwater discharge into the bays.

Availability of marine fauna along the Texas coast could have been affected not only by the establishment of the barrier island system, but also by the changing environmental conditions during the late Quaternary. Aten, in summarizing the climatological data available for the upper Texas coast (1983), points out that with the last recession of the glaciers there was a gradual submergence of the Texas coastline. Between 10,030 and 8490 B.P. river flow was reduced to about what it is today, cloud cover dissipated, and seasonal temperatures became increasingly divergent. Between 8490 and 5060 B.P. the area became markedly more arid and warmer, conditions that supported the formation of caliche deposits; during this period river discharge may have dropped. Since 5060 B.P. there has been a gradual change to present conditions. These broad changes were taking place along the upper Texas coast together with analogous changes along the southern part of the coast, but the exact nature of the changes and their effects upon the mollusk fauna are unknown.

In summary, the Texas coastline today is a complex series of bays nestled behind a protective screen of barrier islands and peninsulas. From the upper Texas coast southward these bays form a graded series of saline environments from the brackish Trinity and Galveston bays to the highly saline Baffin Bay complex. Various aboriginal populations living along the Texas coast then, would not have harvested from a homogeneous marine environment, but rather from a variety of environmental zones with specific foraging opportunities and limitations that probably required adaptation to changes through time.

The third factor to be considered when examining mollusk utilization is the scarcity of locally available lithic material for tools and ornaments. The land bordering the coast is a broad, gently rising plain of late Pleistocene sands and aeolian deposits resting on Holocene clays. These deposits, which extended as far as 145 km (90 miles) inland, are virtually barren of rock or gravel of suitable size for the production of artifacts (Aten 1979, Hester 1980a), except for the upper Texas coast where (Aten 1983) has postulated that gastroliths from crocodilians were locally available lithic raw material (Figure 3). Except for this rather unusual source, aborigines had to look inland for lithic materials.

The nearest chert– and silicified wood–bearing deposits are along a belt about 95 to 145 km (60 to 90 miles) inland that broadly parallels the coastline. Here, silicified wood fragments and stream–worked chert pebbles and cobbles are found on the surface of locally exposed Pliocene and early Pleistocene deposits. Further inland, late Pleistocene stream gravels are exposed along stream beds and abandoned terraces. These gravels, washed down during the last phases of the Pleistocene, contain some large cobbles and appear to have been a useful source for chert. In the eastern part of the state the Manning Formation (Brown 1976) is a more localized source for fused glass, and one of the major sources for chert and precipitated flint is the limestone exposures of the Edwards Plateau. In this region,

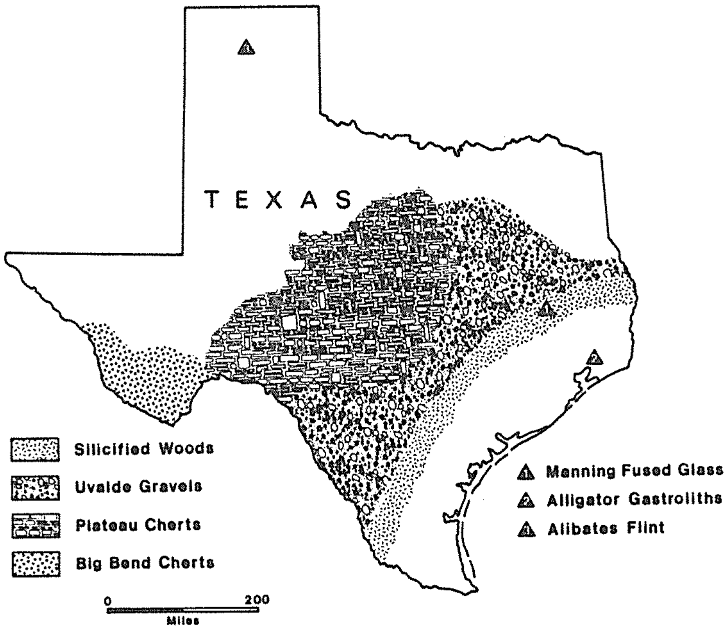

Figure 3. Map of Texas showing sources of lithic raw material that were available to coastal populations. Numbered localities are specific sources. Prepared in consultation with Harry J. Shafer and with information from Aten (1983), Brown (1976), and Hester (1980a).

large chert nodules can be found eroding from some of the limestones; the region undoubtedly was one of the ultimate sources for chert in stream gravels. In the Big Bend region of West Texas are some other important sources for chert, and some of this material has been found downstream along the Rio Grande. One of the most widely recognized sources of lithic raw material, the Alibates Quarry, is in the Panhandle region of Texas, but little or no Alibates flint has been recovered along the coast.

Several authors, including Aten (1971, 1983) and Hester (1980a), have noted these extensive inland lithic sources and the lack of lithic resources along the Texas coast. They have pointed out that there must have been trading relations with inland groups for acquisition of the raw materials needed for lithic tools. Cabeza de Vaca referred to these trading relations when he noted his value to the Indians as a trader carrying conchs and other things inland (Newcomb 1961:70). As a result of the scarcity of lithic deposits along the Texas coast, mollusk shells were widely used as raw material for the manufacture of tools and ornaments.

MOLLUSKS AS A SUBSISTENCE RESOURCE

Food for the hunters and gatherers who lived along the Texas coast may not have been abundant throughout the year. Anyone who has read Cabeza de Vaca's experiences among the aborigines from 1528 to 1536 comes away with a strong feeling that hunger was a common condition to contend with, and that little that lived and could be collected was not eaten. Based primarily on Cabeza de Vaca, Newcomb (1961:39) stated that the Coahuiltecans living in the central and south coastal regions of Texas had available the fewest usable resources of any Texas Indian group. For the coastally located Karankawa Indians Newcomb (1961:66-67) stated that

> it is difficult, in fact, not to think of Karankawas as harvesting a little here, then hastening to another spot to reap another minuscule harvest, and on to a third place, and so on continuously, seldom starving but never having a truly bountiful or fully dependable subsistence either. They were no more able to overlook a potential food source than were the Coahuiltecans.

Krieger's summary of the food habits of Texas coastal Indians, gleaned from his translation of the journals of Cabeza de Vaca (1956), also presents a grim picture of the subsistence base for hunters and gatherers along the coast. For the central part of the coast Krieger (1956:52) stated that there apparently were only two seasons of comparative plenty, one in the fall when the pecans were ripe and available in the river bottoms and one in the summer when the Indians journeyed inland to harvest the fruit of the prickly-pears. For the southern part of the Texas coast starvation was the year–round rule except for the season when the tunas and young stems ripened(Krieger 1956:55).

Whether this rather harsh outlook for subsistence reflected conditions present only for a short period of the sixteenth century or only the biased view of Cabeza de Vaca, food hardly could have gone unclaimed and uneaten, and any mollusks, either alive or with hermit crabs in the abandoned shells, found in sites could have served as food. Therefore, most of the 34 species of mollusks recovered from the 15 locations probably served as food. Beyond this broad level of generalization are some patterns of utilization.

Of the 34 species recovered and identified, 22 were recovered in more than one locality and 13 were found in five or more localities. Comparison of the number of species found in each locality indicates that fewer species were utilized along the upper Texas coast, whereas a more varied mollusk fauna was utilized as food along the central and southern parts of the coast (Figure 4). This variation from locality to locality may be a result of sampling error rather than a reflection of reality, but other lines of evidence suggest that fewer species were important in the subsistence pattern of Indians of the upper Texas coast. Virtually all researchers working in this area have found that most shell middens were composed predominantly of rangia, with fewer middens composed predominantly of eastern oyster (Ambler 1973, Aten 1965, 1971, 1979, 1983, Campbell 1957, Dering and Ayers 1977, Dillehay 1975, Gilmore 1974, Hole and Wilkinson 1973, Hollingsworth 1981, and Shafer 1966). Ambler (1973) in particular has discussed how the rangia populations, because of their abundance in the slow–moving brackish waters, could be easily harvested to serve as a staple resource during most of the year. On the other hand, mollusk samples recovered from sites along the central part of the coastline are far more varied in species, and usually several species such as eastern oyster, southern quahog, and specimens of the whelk are equally common. Exceptions to this generalization on the upper coast of Texas may be sites with ready access to the Gulf of Mexico's more varied mollusk fauna (Localities 3 and 4). Aten (1983), in listing eight species of marine mollusks recovered from 41BO4 (Locality 4), noted the large number of species recovered at this site compared to other upper Texas coast sites he had sampled. He also noted that the site was within 5.5 km of the Gulf of Mexico.

There may be regional differences in the numbers of species harvested, but five species appear to have been utilized consistently along the entire coastline: the Atlantic bay scallop, the whelk, the eastern oyster, the giant Atlantic cockle, and the lettered olive. Of these, the scallop, whelk, and oyster are found frequently enough in one or more sites to indicate that they were indeed eaten consistently and were harvested frequently enough to be of significant value. The giant Atlantic cockle and the lettered olive, on the other hand, may have been of more value as tools or ornaments than as food. Neither of these species occurs with high enough frequency in any sample examined by the author to suggest that they could have been a major mollusk food resource. The fact that shells found in sites are usually modified casts further suspicion of use of the lettered olive as food.

The value of the giant Atlantic cockle as a substantial food resource is even more questionable. According to Andrews (1971), this species is found at the

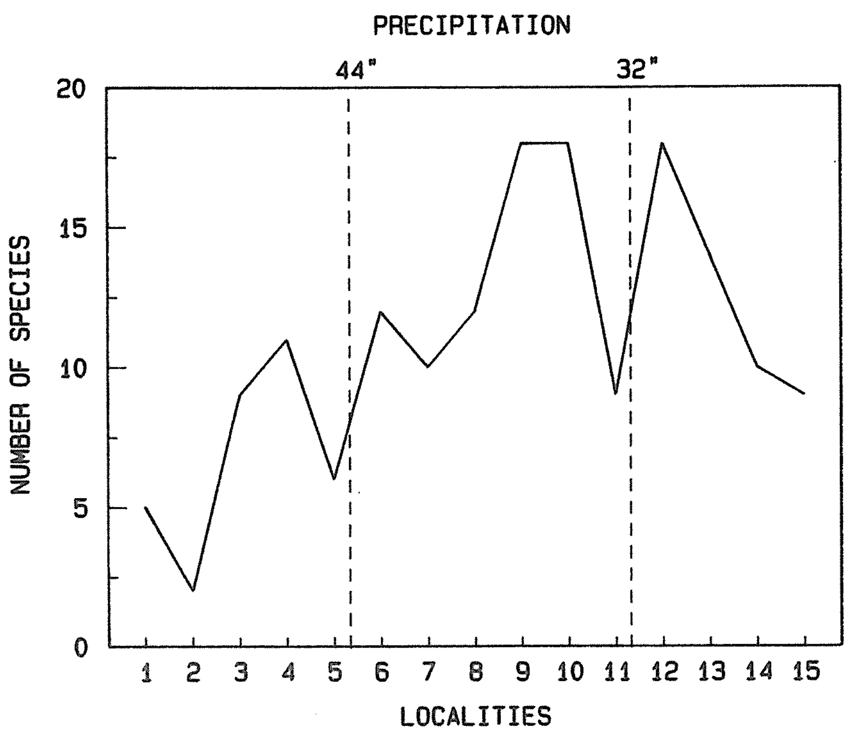

Figure 4. Graph showing the number of species of mollusks reported at the 15 localities on Figure 1.

mouths of the bays and offshore from the barrier islands, so it is probable that this species was harvested at ocean front sites not yet discovered, or that the occasional shells found in the sites were acquired through trade.

It is possible to document not only differences in the numbers of species harvested from locality to locality, but also the relative importance of specific species in different localities. One of the most dramatic regional variations is found in the distribution and relative importance of the two species of rangia. The common rangia dominates the shell middens in Trinity and Galveston bays. Here, many of the middens are composed almost exclusively of this species, and they are so abundant and so large that they have been used as a shell resource for present day construction purposes (Ambler 1973; Shafer 1966). In the central coastal bays of Matagorda, San Antonio, and Aransas, the common rangia occurs much less frequently, and in Corpus Christi Bay is found only at sites along the upper reaches of Oso Creek and the lower reaches of the Nueces River. South of Corpus Christi Bay the common rangia has not been documented. The brown rangia, on the other hand, is recovered most frequently in the Corpus Christi Bay area, particularly in Archaic horizons. These distributional differences for the rangia species reflect the presence of more brackish bays suitable for the common rangia to the north along the upper Texas coast and saline bays suitable for the brown rangia to the south

One note of interest concerning the possible method of processing of rangia can also be made. At site 41BO35, Hollingsworth (1981) reported dwelling platforms composed of uniformly small specimens of the common rangia, and Hollingsworth and Polan (personal communication 1983) stated that many were still articulated, unbroken, and unburned. He tentatively interpreted this as evidence that the Indians were boiling the rangia before eating them, rather than shucking them alive and using the shells as flooring.

The common rangia and the ubiquitous eastern oyster were the apparent main mollusk fare along the upper Texas coast, but a different group of mollusks seems to have been a more significant food resource along the central and southern parts of the coast. From Matagorda Bay southward, the eastern oyster, Atlantic bay scallop, southern quahog, sunray venus, and whelks dominate the shell middens. Of these, the eastern oyster, Atlantic bay scallop, and southern quahog can be found in the bays today, and they can be harvested by techniques similar to those used for the common rangia. Of these three, the eastern oyster seems to be the most frequent in these bays.

Evaluating the sunray venus as a food resource is more difficult. Today, although this species is virtually absent from the bays (Andrews 1971; personal experience), fossil specimens eroded out of submerged muds wash up frequently along the bayshores. In some sites around Aransas and Corpus Christi bays, shell fragments of the sunray venus have been recovered, so the bays may have supported live colonies of this species in the recent past that may have been harvested for their food value. However, shells of this species were commonly modified and used for a variety of tools, so it is possible that only the shells of this species were collected. It is the author's opinion, however, that shells and fragments of shells in sites along Oso Creek occur at sufficiently high frequencies to suggest that live colonies may have been harvested (Steele and Mokry 1985). Hester (1971a) also reported the sunray venus as one of the most abundant mollusks at sites around Baffin Bay, further suggesting the possible use of the species as a food resource, but Smith (1983b) proposed that only fossil shells were harvested around Baffin Bay.

The whelk also is a difficult species to evaluate. For the purposes of this paper, all species of *Busycon* are lumped into the single taxonomic category since, in many sites, the only parts of the shell found are modified fragments of the body whorl or columella, and these cannot always be identified to species. But not all whelk shells recovered from central and southern coastal sites have been modified into artifacts, so they probably served as food as well (Steele and Mokry 1985). Additionally, at sites along Oso Creek near Corpus Christi Bay, whelk shells of a wide variety of sizes were recovered, indicating that the aborigines were not selecting specific sizes for manufacturing material. Some shells have a hole punched through the body whorl opposite the aperture, a common method used today to remove the body of the gastropod. The whelk's lower frequencies in sites along the upper Texas coast suggests that it was either less important as a food resource there, or that the shells were collected and utilized for artifact production only, serving little value as a food resource. Hollingsworth and Polan (personal communication, 1983) reported only five or six whelks from site 41BO35 in Brazoria County (Locality 2), two of these had segments cut from the body whorl.

All species probably were harvested when possible for food; *Busycon perversum* is the species most commonly recovered in the shallow flats of the bays, and it is this species that is most commonly recovered from the sites near Oso Bay (Steele and Mokry 1985). Unlike the bivalves described above, whelks are carnivores that forage over the flats where they can be caught on bait (Andrews 1971). Also, abandoned shells of whelks are taken over by hermit crabs, which can in turn be harvested for food. So whelks and hermit crabs are scattered more sporadically over the bays, and, although baited traps could have been used, they would have required wider foraging by the aborigines.

The last species to be considered separately as a food resource is the horse oyster, noted only for Baffin Bay, where it has proven to be of dietary significance. However, this species has provided the only substantial data for a temporal change in the use of mollusks along the Texas coast. Smith (1983a, 1983b) points out that the horse oyster is most frequent in the late prehistoric sites along Baffin Bay, and suggests that this frequency was the inadvertent result of the increasing salinity of Baffin Bay. The increasing salinity of the bay destroyed the bay as a habitat for most species, except for the horse oyster, which prefers these saline conditions. So the change in the frequency of this species in archeological sites probably reflects a change in availability of species, rather than a change in dietary preferences. Hester (1980b) also has addressed the problem of changing salinity in Baffin Bay, suggesting that as the bay became hypersaline, the aborigines ate fewer mollusks.

Although commonly harvested species appeared to have been consistently significant food resources, some species may have been collected opportunistically, brought to the site unintentionally, or may have entered by other means. Species of the genus *Crepidula*, for instance, could have been brought to the site attached to oysters, shark's eyes, whelks, or other intentionally harvested mollusks, but however acquired, they may have been eaten. Two other species, the marsh periwinkle *(Litorina irrorata)* and plicate horn shell *(Cerithidea pliculosa)* feed over the mud flats of the bays during low tide and could have been harvested unintentionally with marsh grasses. They could have been brought to sites also by birds, but their small size and low frequency in sites clearly indicate that they were of only minor importance.

In summary, the Atlantic bay scallop and the eastern oyster undoubtedly were used along the entire coastline. The whelks, the giant Atlantic cockle, and the lettered olive also are found in sites along the entire coastline, but their value as food is less well documented. It is also possible to see regional variations in the number of species harvested; more species were harvested in the southern bays and fewer species in the northern bays, and some species were of only regional subsistence value. The common rangia proved to be of great significance along the upper Texas coast and of less and less value southward. On the other hand, the southern quahog and sunray venus proved to be of greater regional significance in the central and southern parts of the coast. The whelk was shown to be eaten along the central and southern coast, and possibly along the upper coast as well, and finally, the horse oyster was documented as of local significance only in Baffin Bay.

Some questions about seasonal and temporal variations in harvest time cannot be answered in a simple presence–or–absence distribution chart. Among the Texas coastal species, only the common rangia has been the subject of seasonality studies. By determining that shell growth is correlated with seasons, and thereby determining what growth phase the shellfish was in at death, Aten (1981, 1983) has estimated that the common rangia was harvested mainly in the early summer along the upper Texas coast; common rangia recovered from sites along Corpus Christi Bay apparently were harvested earlier, from late April to late May (Carlson 1988, Ricklis 1986).

One reason why there is so little data on temporal variation of subsistence patterns is that the Texas coastline has undergone gradual flooding since the end of the Pleistocene, which has inundated earlier shorelines and sites. As a result, most sites that are known represent only Middle and Late Archaic and Late Prehistoric times; no Paleo–Indian shell midden sites have been documented along the Texas coast. This problem of identifying earlier coastal sites and analyzing temporal variation in coastal adaptations is not unique to Texas. All reviewers of North American coastal archeology have noted the flooding of the coastline, but they do not agree on the effects this has had on adaptations of populations to coastal environments (Clark and Workman 1983, DePratter 1983, Gagliano 1983, Sanger 1983, Stewart and Custer 1983). Stewart and Custer (1983) believe the flooding of the coastline has resulted in increasing use of marine resources by coastal populations, whereas DePratter (1983) believes there has been little increase during the last 4,500 years in the utilization of marine resources along the southeastern Atlantic coast. For the Gulf Coast, Gagliano (1983) documented the use of coastal resources back through the Late Archaic, but did not specifically address the issue of whether increasing use of resources could be documented.

In addition to the flooding of the coastal margin, archeologists along the Texas coast must also deal with the problem of the relatively slow rate of soil deposition, particularly in the central and southern parts of the coast, which has resulted in mixing of the faunal debris in what multicomponent sites there are. Both Corbin's (1974, 1976) reviews of the Texas Archaic and cultural sequence of the central coast and Patterson's reviews of the upper Texas coast (1979a and 1979b, 1985) have summarized the literature pertaining to cultural sequence, but neither found evidence documenting changing subsistence patterns through time.

As already mentioned, exceptions to the lack of evidence for temporal variation are found in the adaptation to shifting resources in Baffin Bay (Smith 1983a, 1983), Nueces Bay (Ricklis and Gunter 1986), and Galveston Bay (Aten et al. 1976). In Baffin Bay the shift was to increased reliance on the horse oyster; in Nueces Bay the shift was from brown rangia to a combination of brown and common rangia; in Galveston Bay the shift was from the common rangia to the eastern oyster, followed by a return to greater use of common rangia.

MOLLUSKS AS RAW MATERIAL FOR TOOLS AND ORNAMENTS

In addition to serving as food, mollusks, through their shells, served also as raw material for the manufacture of artifacts. In discussing shell artifacts the topics considered are (1) the species used and the types of artifacts produced, (2) methods of preparing artifacts, (3) regional variations in the manufacture and use of shell artifacts, and (4) evidence of the trade of these shells and artifacts inland. Researchers particularly interested in these topics should consult Anderson (1932), Campbell (1947, 1952, 1956, 1958a and 1958b), Hall (1981), Hester (1969a, 1969b, 1971a, 1971b, 1980a), Janota (1980), Mokry (1980), Steele and Mokry (1985), and Story (1968).

Both utilitarian and ornamental artifacts were made by Texas coastal Indians. Shells used for tools and other utilitarian needs are the whelks, sunray venus, eastern oyster, banded tulip, horse conch, and common rangia. Discarded shells have been reported in house platforms; Aten (1971) and Hollingsworth (1981) reported platforms composed of the common rangia at 41BO35 in the upper Texas coastal area. There, many of the platforms appeared to be composed of uniformly small shells of the common rangia, suggesting that small shells were the preferred platform material (Hollingsworth 1981). To the south, along the coast, Campbell (1947) has reported circular shell areas at the Archaic site 41AS1 that may have served as floors of temporary shelters, but here the circular areas were composed of a variety of shells. Common rangia shells that show signs of having been heated and possibly were being used in cooking have also been reported by Gilmore (1974).

Shells such as the giant Atlantic cockle also can be used as containers with little or no modification. This cockle is one of the largest bivalves found along the Texas coast; other shells and objects have been found stored in valves of this species at burial sites around Corpus Christi Bay (Hester and Corbin 1975). McGuff (1978:219) reported one giant Atlantic cockle valve with red pigment on the interior recovered from a site north of Lavaca bay. In addition, broken but otherwise unmodified valves of this species have been recovered from virtually every location along the coast, but they never occur there in sufficient numbers to suggest that aborigines used this species extensively as food, indicating that the valves were used as vessels or for other purposes.

In the instances just described, the shells were used without modification, as building material, convenient material for cooking, or as vessels. In most other instances the shells were consciously modified. Whelk shells with the body whorl removed have been recovered from the Corpus Christi Bay area; the shells are battered, suggesting use as billets or hammers (Steele and Mokry 1985) (Figure 5, A). Similar whelk shell hammers have been reported from sites along Aransas Bay (Campbell 1947, 1952).

Other functional tools made from whelk shells are adzes (Figure 6, E) made from prepared sections of the body whorl recovered from many sites along Aransas Bay, Corpus Christi Bay, and Laguna Madre (e.g. Campbell 1947, 1952, 1956, Hester 1969a, Steele and Mokry 1985, Story 1968). There are some specimens in the Anderson collection, and one specimen has been recovered more than 100 km inland at 41LK67 (Brown et al. 1982). The finding of whelk shell columellae with the whorls removed at central Texas sites indicates that they were being made locally, and Mokry (1980) has described probable techniques of manufacture of adzes from the shells. It is worth noting that Eaton (1974) reported techniques for making similar adzes from *Strombus* shells from sites along the Yucatan coast, indicating that the techniques for manufacturing tools and ornaments from body whorls of large marine gastropods were well known along the entire coastline of the Gulf of Mexico

Hollingsworth and Polan (personal communication 1983) also reported recovery of two whelk shells with sections of the body whorls cut away from site 41BO35 (Locality 2) on the upper Texas coast. The removed material could have been used for tools such as the adzes described above or for ornaments; however, Hollingsworth and Polan believe the segments were being used in the manufacture of ornaments. No body whorl adzes were recovered at 41BO35.

Small ovoid shell discs made from body whorls of shells have also been reported by Campbell (1956), Corbin (1963), and Story (1968) from the central Texas coast. Story (1968) has also reported a similar shaped ceramic sherd from the Ingleside Cove site. These discs are only about 1.5 cm in diameter, smoothed along the margins, and unperforated. Their function has yet to be determined.

Awls made from the columella of the whelk are found frequently in sites along the central and southern parts of the coast; they have been reported from the Matagorda Bay area (Fritz 1975; this paper), Aransas Bay (Campbell 1947, 1952), and Corpus Christi Bay (Steele and Mokry 1985, Story 1968). All of these awls have a ground point at the siphonal end of the columella; the spiral part of the shell may or may not have been removed (Figure 5, A–E). Some of the smaller whelk columella awls also may have been made from banded tulip shells. It should be kept in mind, however, that beach–rolled fragments of columellae and the columellae left after body whorls have been removed can resemble manufactured and used columella awls, making it difficult to determine which, if any, of the columellae were specifically prepared for this purpose and which are tools that had no

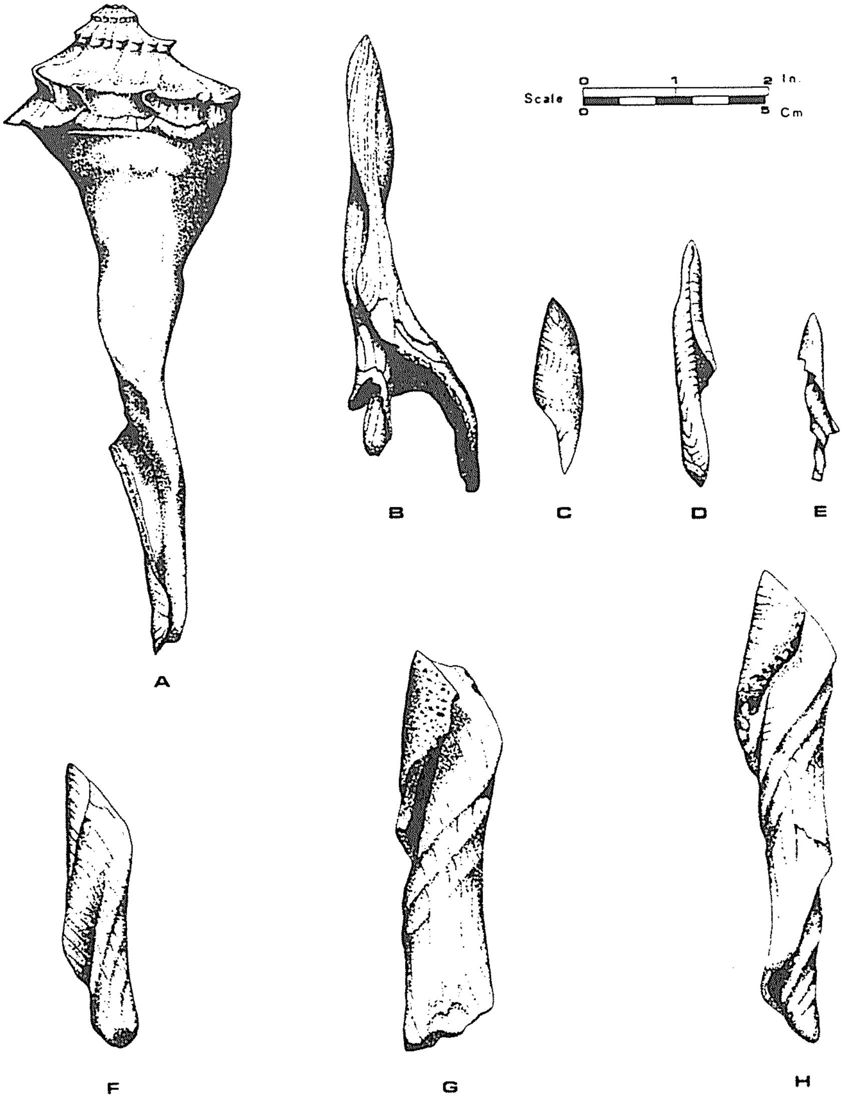

Figure 5. Drawings of tools made from the columellae of whelks and conchs recovered from sites near Cayo del Oso, off Corpus Christi Bay. A, a whelk used as a billet or hammer; B–E, awls made from columellae of whelks; F–H, gouges made from columellae of the Florida horse conch. From Steele and Mokry 1985.

intentional modification.

Another gougelike tool made from the columella of the Florida horse conch has been reported from Aransas and Corpus Christi bays (Campbell 1947, 1952, Corbin 1963, Steele and Mokry 1985) and the Anderson Collection (personal observation). They differ from the columella awls made from the whelk in that the columella are much stouter, and the siphonal ends are ground obliquely, rather than to a point (Figure 5, F–H). No horse conch shells have been recovered from sites examined by the author, but there is one of unknown provenance in the Anderson Collection. James E. Corbin (personal communication), however, has seen horse conch shells in site refuse along Ingleside Cove. This miniscule amount of material, added to the fact that this species is more an inhabitant of the Gulf than of bays, may indicate that the adzes were made only occasionally or were not made at the bay sites commonly sampled.

Shells were also used as net weights. Campbell (1958b), basing his idea upon a Florida analogy, suggested that perforated shells from sites along Aransas Bay were net weights. Since publication of Campbell's paper, perforated oyster shells have been reported at sites along Trinity Bay (Aten 1979), along Matagorda Bay (Fritz 1975), at Corpus Christi (Story 1968), and in the Anderson Collection. Rangia shells punched from the inside outward seem to have been put to similar use, and have been reported by Ambler (1973), Aten (1983), and Shafer (1966).

Shells from three species commonly have been used as raw material for making cutting instruments. Aten (1979, 1983) reported cutting implements made from valves of the eastern oyster recovered from Brazoria County (Locality 4) that usually were made from the upper valve and were worn or battered along the margins. The rough exterior of the shell was also commonly smoothed. McGuff (1978) reported these tools farther south along the Lavaca River (Locality 7). Aten (1983) noted this limited distribution of shell knives from Matagorda Bay to the western margin of Galveston Bay and indicated that it may or may not reflect prehistoric territorial boundaries.

Although rangia shells are common in middens on the upper Texas coast and in some sites on the central Texas coast, their shaping into cutting tools is rarely reported. Hamilton (1988) suggested that broken rangia shells at 41BO13 may have been used as cutting implements, and McGuff (1978) reported rangia shells with ground and chipped margins from 41JK91.

The eastern oyster and possibly the rangia apparently were the preferred material for the production of shell cutting implements along part of the central and upper Texas coast, but aborigines from most of the central and southern parts of the coast used sunray venus and disk Dosinia valves. The sunray venus has the smoothest shell with the finest microstructure of the larger bivalves along the Texas coast, making it possible to use the chipping and pressure flaking techniques used for flint tools to produce chipped shell tools from the sunray venus shells (Figure 6, A–D). Tools of chipped shell also have been reported by McGuff (1978) from the Lavaca Bay area, by Campbell (1952) from the Aransas Bay area, and by Hester (1971a, 1971b, 1980a) and Smith (1983b) from the Baffin Bay area, and there are some in the Anderson Collection. Chipped shell arrowpoints have been reported

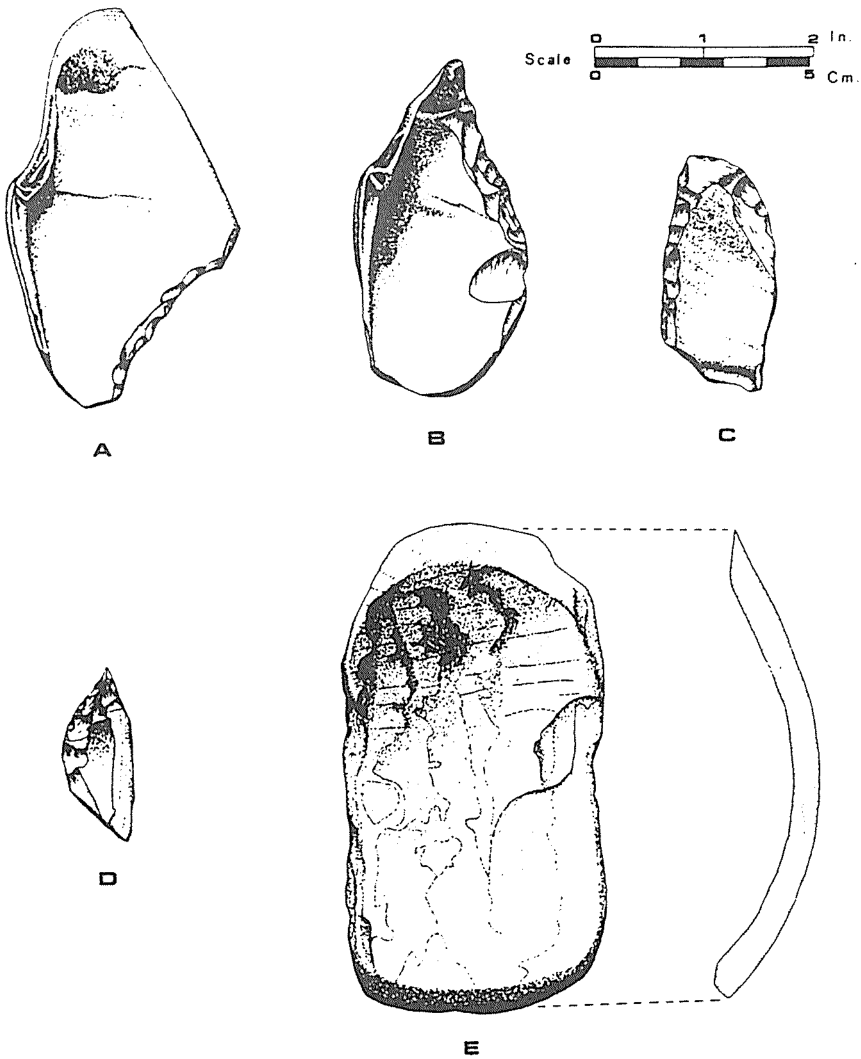

Figure 6. Drawings of tools made from sunray venus shells (A–D) and the body whorl of the whelk (E) from sites near Corpus Christi Bay. A and B, valves with the unbo and unmodified hinge area attached (possibly to make the tool more comfortable to hold) and part of the ventral edge of the shell intentionally flaked to pro-duce a cutting or scraping edge; C and D, flakes from the valves of the sunray venus with more than one edge finely flaked; E, adze with a ground bit made from the body whorl of a whelk. From Steele and Mokry 1985.

from the Rio Grande delta area (Anderson 1932), Baffin Bay (Highly 1980), and the Corpus Christi Bay area (Steele and Mokry 1985). A disk Dosinia has been found in the Rio Grande delta area with a chipped ventral margin (Anderson Collection, Hester 1980a).

Cylindrical projectile points made from the columella of large gastropods, probably whelks, have been reported by MacNeish (1947) from the Rio Grande delta area, and are represented in the Anderson Collection (Hester 1980a), but the type has not been reported elsewhere along the coast. The points are made from short sections of columella that are rounded into a smooth cylindrical shape and ground at one end to a rounded point.

The use of mollusk shells along the Texas coast as ornaments, worn on the body or otherwise associated with burials has been documented in a series of burials reported from the Rio Grande area (Collins 1969, Hester and Rogers 1971, Hester and Ruecking 1969, Hudgeons and Hester 1977), from the Corpus Christi Bay area (Hester and Corbin 1975), and the Galveston Bay area (Aten et al. 1976, Campbell 1957, Hall 1981, Hole and Wilkinson 1973). Similar ornaments also have been found associated with archeological sites along the entire coastline.

The most commonly recovered ornaments are made from whole or slightly modified plicate horn shells, lettered olive, whitened dwarf olive, and common Atlantic marginella (Figure 7, A–D). These apparently were strung through the aperture, with a second opening made through the body whorl (plicate horn shell and common Atlantic marginella) or by removing the spire (lettered olive and whitened dwarf olive).

Of these ornaments, the most commonly recovered are beads made from the lettered olive, which are reported from the Galveston Bay area (Ambler 1973, Campbell 1957, Hudgins 1984), the Aransas Bay area (Johnson 1979), and the Rio Grande delta area (the Anderson Collection, Collins et al. 1969, Hester and Rogers 1971, Hester and Ruecking 1969). Olive shell tinklers have been made by suspending a mammalian canine tooth inside the shell (Hester 1980a). Beads made from the common Atlantic marginella have been reported from Galveston Bay and the surrounding area (Hall 1981), and the Rio Grande Delta area (Anderson Collection; Collins, Hester, and Weir 1969). Beads made from the whitened dwarf olive have been reported from Galveston Bay and the surrounding area (Hall 1981) and there are beads from the plicate horn shell in the Anderson Collection.

Only one bivalve shell is thought to be used as a bead—the ponderous ark found in central and southern coast sites (Collins et al. 1969, Hester 1969b). The bead was apparently strung through a hole in the umbo of the valve (the hole could have been drilled by a predatory gastropod before the valve was collected); its identification as a shell bead was based on its presence in a burial with other shell beads.

Disc-shaped beads also have been made from small parts of shells, round in shape with holes drilled through the centers, they have been reported from the Rio Grande area (Collins et al. 1969, Hester and Ruecking 1969), the Baffin Bay area (Hester 1969a), the Aransas Bay area (Campbell 1952), and the Galveston Bay area (Ambler 1973, Aten et al. 1976, Campbell 1957). These beads reportedly are made from whelk shells, but they are usually modified to such an extent that positive

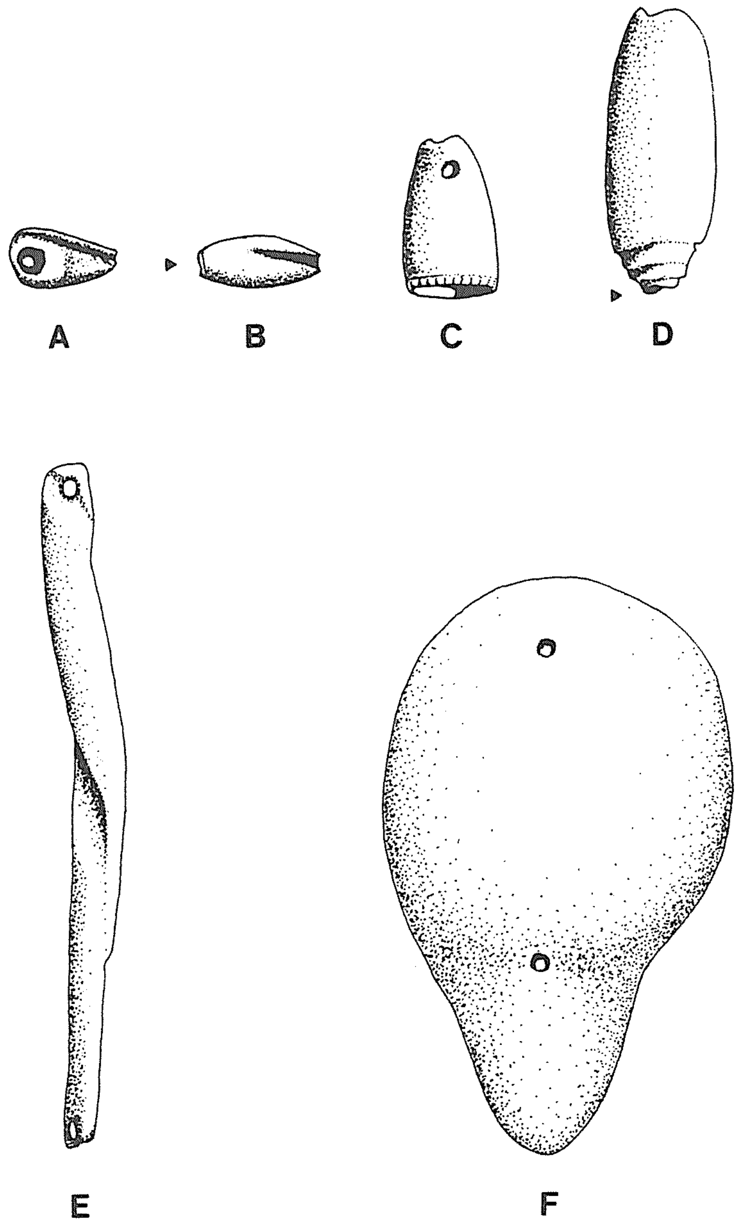

Figure 7. Drawings of shell ornaments from the Texas coast. A, marginella bead with a hole ground through the body whorl (after Hall 1981); B, olivella bead with spire removed (after Hall 1981); C, olive tinkler made by removing the entire spire, incising the margin, and drilling a hole in the body whorl (after Janota 1980); D, olive bead with the apex of the spire removed (after Janota 1980); E, perforated whelk columella (after Hudgeons and Hester 1977); F, whelk body whorl pendant with edges and surfaces ground and smoothed and two perforations in the body (drawn from a slide of a pendant from 41VT1). Not drawn to scale.

identification of the original shell cannot be made.

Ornaments also have been made from the columellae of whelks by one of two techniques. One technique, requiring less modification of the columella, involved smoothing and grinding the piece, blunting the tips and perforating one or both ends to allow for stringing (Hudgeons and Hester 1977) (Figure 7, E). The other more involved technique required cutting or grinding the columella into short sections, smoothing the exterior surfaces more completely, and drilling a hole longitudinally through the center of the bead (Aten et al. 1976, Hall 1981, Janota 1980). These beads are most commonly reported from the Galveston Bay area (Campbell 1957, Hall 1981, Hole and Wilkinson 1973).

Another ornament often recovered in burial contexts is the whelk body whorl pendant (Figure 7, F) reported by Ambler (1973), Aten et al. (1976), Hall (1981), and Hole and Wilkinson (1973) from burials on the upper Texas coast. The author has seen similar pendants from 41VT1 along the middle Texas coast in Victoria County near Lavaca Bay, and they have been reported from burial sites in the Rio Grande delta area (Hester and Rogers 1977, Hester and Ruecking 1969).

The most complete description of these ornaments has been provided by Hall (1981), who recognized 12 different forms made from the body whorl of the whelk. All forms share some features; they are made from the body whorl of the shell, they have shaped and ground edges, and they have one or two perforations that have been ground from both sides. They vary in size, however, from large subtriangular slabs consisting of a large part of a body whorl to much smaller rectangular or round pendants that may or may not be incised.

There is good evidence for regional variation in the extent to which mollusks were used as raw material for tools along the Texas coast. In his report of excavations of shell middens near Trinity Bay, Ambler (1973:102–103)noted the surprisingly few kinds of shell tools and ornaments. He noted a relatively large number of shells with large perforations in the middle of the shell, presumably used as net weights. Except for these, he noted only two whelk columella beads, a whelk body whorl pendant, and a bead made from an olive shell. This meager list of shell artifacts from the upper Texas coast can be expanded to include occasional cutting tools made from the eastern oyster (Aten 1983, McGuff 1978) and habitation platforms consisting of beds of the common rangia (Hollingsworth 1981).

The limited number of utilitarian shell artifacts from the upper Texas coast is in marked contrast to what is seen along the central and southern parts of the coast. No tools made from columellae of gastropods or whelk hammers or chipped shell artifacts been reported, which leaves the impression that these tools were not considered necessary on the upper Texas coast, or equivalent tools were made from stone or wood. It is interesting to note that whereas stone is generally scarce along the Texas coast, the one local source for gastroliths (Aten 1983) is in the area where the fewest shell artifacts are found. It is also of note that wood resources are more extensive along the upper Texas coast. Another factor that may have limited the use of shells for tools along the upper Texas coast was the possible lack of easy access to the wide variety of shell types available farther south.

The highest concentration of shell ornaments was found inland along the upper

Texas coast among the material associated with burials at the Harris County Boys' School cemetery (Aten et al. 1976) and the Allens Creek site (Hall 1981). From these sites were recovered a shell columella atlatl weight (Allens Creek), numerous whelk body whorl pendants, olive shell beads (Allens Creek), marginella shell beads (Allens Creek), two styles of columella beads, disc–shaped shell beads, and a modified bonnet shell (Harris County Boys' School). Hall (1981:214–222) noted little evidence of shell debitage from sites in the area and proposed that these shell artifacts could have reached the upper Texas coast from the southeast Gulf Coast by established trade networks.

Ample evidence for such trade networks was established with the finding of boatstone and gorget material that originated in Arkansas. The author's examination of nonutilitarian material from the Texas coast lends support to Hall's hypothesis for the origins of at least the pendant material and probably all the material. The pendants found at Allens Creek and the Harris County Boys School, although made from body whorl of whelks as are pendants of the Rio Grande delta area, seem to be distinct from southern material in workmanship, common shapes, and placement of perforations.

The evidence for the origin of the other shell ornaments from Allens Creek is slightly more equivocal. With the exception of the columella beads drilled through the center, all of these other shell ornaments have been recovered from elsewhere along the coast. This raises the possibility that at least some of the material could have reached the upper Texas coast through trade networks with peoples from the southern part of the coast. The overall evidence, however, does support the view that the nonutilitarian material, like that found at Allen's Creek, did enter the upper Texas coast through trade networks with the east.

For the central part of the coast, a variety of researchers (Campbell 1947, 1952, 1956, 1958a, 1960, Corbin 1963, Hester 1969a, 1971a,1980a, Martin 1930, Steele and Mokry 1985, Story 1968) have provided ample evidence of the use and manufacture of utilitarian tools from shell by the aborigines. The commonly reported tools are hammers, shell net weights, cutting implements, columella awls, columella gouges and whelk body whorl adzes, and Campbell (1947) reported possible habitation platforms composed of shell at the Archaic Aransas site. Mokry (1980) described the process used locally for manufacturing the whelk body whorl adzes, and Steele and Mokry (1985) reported the high number of broken whelk shells found at sites near Corpus Christi Bay. Steele and Mokry (1985) also reported the high number of sunray venus shells with chipped ventral margins and shells represented by chipped fragments alone. This evidence demonstrates that most of the utilitarian artifacts were being made locally.

The one utilitarian tool for which minimal evidence of local manufacture has been demonstrated is the Florida horse conch columella gouge. With the exception of Corbin's sighting of horse conch shells eroding from sites along Corpus Christi Bay (personal communication), no shells or shell fragments from this species other than the gouge itself have been reported in sites from the central coast. The only shell specimen associated with archeological material seen by the author is a shell in the Anderson Collection; this shell artifact could be of local manufacture, but it has yet to be clearly documented.

Limited reports of nonutilitarian artifacts document the presence of olive shell beads (Johnson 1979), shell disc beads (Campbell 1952, Hester 1969a), and ponderous ark shell beads (Hester 1969b). In addition, Hester and Corbin (1975) reported on a juvenile burial fortuitously recovered near Aransas Bay that had a cluster of small white shells, possibly marginella beads, around the neck; similar beads have been found along Baffin Bay (Hester 1969a).

The central coastal material, then, is characterized by a much larger inventory of locally made utilitarian tools that are made from a wider variety of species of mollusks, than is seen in upper Texas coastal sites. The ornaments recovered also differ from those in the upper Texas coast inventory. For instance, ponderous ark shell beads are seen centrally and in the south, and no whelk pendants have been reported. This extensive use of shells for the manufacture of tools and ornaments has been noted as characteristic of the central Texas coast, beginning with Martin during the 1930s and continuing through Campbell's research initiated in 1947 to the work of other current researchers.

Although less research has been conducted along the Texas coast south of Baffin Bay, this area is in many respects the most intriguing, particularly in the extensive use of shell for tools and ornaments. MacNeish (1947), reporting on the sites of the Rio Grande delta region, which he characterized as the Late Prehistoric Brownsville complex, identified projectile points made from columellae of gastropods, chipped shell discs, whelk body whorl pendants, olive shell beads, and shell fishhooks. In the Anderson Collection the author has seen utilitarian tools such as eastern oyster shells with large perforations, whelk body whorl adzes and Florida horse conch gouges similar similar to ones from the central coast, marginella beads, columella tube beads, and beads made from the lettered olive shell.

For this southern part of the coast, researchers beginning with Anderson (1932) have noted that shell tools and ornaments characterized archeological assemblages from the region. Sayles (1935) first defined a Brownsville phase characteristic of sites south of Baffin Bay on the basis of the shell industry; MacNeish (1947) expanded Sayles's concept, defining it as the Brownsville complex of the Late Prehistoric period. More recent researchers such as Collins, Hester, and Weir (1969), Hester and Ruecking (1969), Hester (1969b), and Prewitt (1974a) have provided further evidence of the extensive use of shell for tools and ornaments by aborigines in this region.

The most distinctive features separating the shell industry from that found in the central part of the coast seems to be the columella arrowpoints, fishhooks, and the far more extensive selection of shell ornaments. MacNeish (1947) believed that the aborigines of the Rio Grande delta region were participating during the Late Prehistoric in a large trade network that extended from the Huasteca to the south to Texas groups inland, but did not extend to coastal groups beyond the Baffin Bay region. Hester (1980a:122), more recently discussing the trade networks of the peoples of the Rio Grande region, reconfirmed their ties with the Huasteca along the Gulf of Mexico to the south. He also suggested that their trade network may have included desert groups of northeastern Mexico.

In contrast to MacNeish, the author also suggests that the trade network of the Rio Grande peoples extended up the Texas coastline at least as far as Matagorda Bay. The utilitarian tool industries of the Brownsville, Aransas, and Rockport complexes are remarkably similar since all of them include whelk body whorl adzes, columella awls, and Florida horse conch gouges. Trade with the complex to the south is also suggested by the presence of typical Brownsville complex lithics at sites in Kleberg County (Highley 1980) and on north Padre Island (Gunter 1985).

Probably one of the most intriguing questions about aboriginal use of mollusks along the Texas coast is the extent to which the locally made shell ornaments or locally acquired shells were traded inland. Cabeza de Vaca reportedly traded shells inland (Newcomb 1961:70), and Krieger (1956:52) believes that coastal groups ranged as far as 145 to 190 km (90 to 120 miles) inland. But not all shells found in archeological sites in Texas came from the Texas coast. Hall's (1981) discussion of the shell ornaments reaching the upper Texas coast from the southeastern Gulf Coast has been discussed already, and there is evidence of shell artifacts from the Jornada area in West Texas, whose origins were ultimately the West Coast (Woolridge 1979). Because of this problem, the surest way to examine the question is to consider only those shells and shell artifacts that can be assigned definitely to the Texas coast.

From the southern part of Texas, Hester (1971b) reported fragments of the giant Atlantic cockle found at 41DM30 in Dimmit County and a sunray venus shell with a chipped ventral margin recovered from 41ZV14 in Zavala County. Both of these sites were reported by Hester to be 250 to 320 km (160 to 200 miles) from the coast. In the central part of the coast a giant Atlantic cockle was found at 41GD4, in Goliad County (Hester and Parker 1970), a sunray venus shell was reported at 41GD30, in Goliad County, about 80 km (50 miles) inland from the coast (Fox et al. 1979), and a whelk columella awl similar to ones found along the central coast 96 km (60 miles) south was recovered at 41LK67, in Live Oak County (Brown et al. 1982, Hall et al. 1982). Also recovered from Live Oak and McMullen counties were a battered columella fragment from a Florida horse conch (41LK75), marginella beads (41KL31/32, 41LK87, 41MC55), and a body whorl fragment from a whelk (41MC55) (Hall et al. 1982). Along the upper Texas coast, the historic site reported by Hudgins (1984) and listed in this report as Locality 3, clearly contains material from the Texas coast, 80 km (50 miles) away. Further inland, in Central Texas, Prewitt (1974b) records a conch pendant from the Loeve-Fox site in Williamson County. Although other shell artifacts have been reported from inland sites, it is difficult to identify them as coming from the Texas coast, especially in the case of Caddoan sites, since the Caddos had well–established trade networks with populations of the Mississippi valley.

These sites, then, do document trade by coastal inhabitants with some inland groups and the possible extension of this trade network as far as 250 to 320 km (160 to 200 miles) inland in the southern coastal region.

SUMMARY AND CONCLUSIONS

In summation, a series of patterns in the use of mollusks by Texas coastal inhabitants can be recognized. Although there was extensive reliance on mollusks for subsistence along the upper Texas coast, the emphasis was on harvesting the common rangia and the eastern oyster, primarily in the early summer. Along the upper Texas coast, few utilitarian shell artifacts are recovered; those reported are shell net weights and cutting implements made from eastern oyster shells. Shell ornaments of some variety are reported from the upper Texas coast, but the evidence strongly indicates that at least during the Archaic these ornaments reached the area from the east. This pattern of use was the result of a series of factors. The great amount of water reaching the upper Texas coast created an excellent and extensive habitat for the common rangia, but it limited the availability in the inland bays of the more saline–adapted marine mollusks. A possible factor contributing to the minimal use of mollusks for utilitarian tools was the local availability of stone.

Along the central and southern parts of the coast, reliance on a greater variety of mollusks for subsistence is evident. Here, the bays are more saline and support the varied marine mollusks of the Gulf. On the other hand, the habitat for the common rangia is limited to a narrow band of brackish water near the mouths of the rivers that enter the bays. A far more varied shell industry is also typical of the central and southern parts of the coast. From Matagorda Bay southward, utilitarian tools of great variety are found in the sites, including whelk body whorl adzes, whelk columella adzes and gouges, Florida horse conch adzes, sunray venus and disc dosinia shell cutting implements, and oyster net weights. Columella arrowpoints are limited to the south. From Baffin Bay southward an extensive shell ornamental industry is found, and around the Rio Grande delta region there is strong evidence that the Late Prehistoric Brownsville complex produced large amounts of shell ornaments and tools for trade to the south, north, and possibly northward along the coast. This greater shell industry was possible because of a rich and varied mollusk fauna available in the shallow saline bays and possibly was necessitated by the fact that the nearest lithic resources were 145 km (90 miles) inland.

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Stress and Survival: Models of Adaptive Success in the Texas Late Prehistoric

Joseph F. Powell

ABSTRACT

This paper reports investigations of the adaptive success of Late Prehistoric hunter–gatherer groups in the central and coastal areas of Texas. A spacially stratified skeletal series was drawn from 12 Late Prehistoric sites from the Texas coast, coastal plain, and Edwards Plateau border areas. Individuals were examined for pathologies associated with various types of stress such as infectious disease, metabolic disruption of growth, and nutritional deficiencies. These pathologies were used in the creation of indices that gauge the level of biocultural stress and relative health of the populations. Models of adaptive success in buffering these stressors are presented and statistically tested against these data, and an overview of adaptive success is presented in regional perspective.

INTRODUCTION

Although myriad subsistence and behavioral adaptation models for hunter–gatherer societies are described in the archeological literature (Winterhalder 1981, Cohen 1977a, 1977b, Bettinger 1982, Jochim 1976, Keene 1979), only a few attempt to determine the biological *success* of such adaptive behaviors (Cook and Buikstra 1979, Rose 1983). In this study, an attempt is made to test the success of environmental adaptation in central and coastal Texas during the Late Prehistoric period, from A.D. 600 to 1750 (Prewitt 1985:223) Skeletal pathologies from hunter–gatherer populations are used to test a set of explanatory models of adaptive success. These pathologies are general indicators of the reaction of the population to a variety of environmental and cultural pressures known as stress.

For the purposes of this paper, stress is defined as "the physiological disruption of an organism resulting from an environmental perturbation" (Huss–Ashmore et al. 1982:396). The perturbation may be caused by nutritional, climatic, cultural, epidemiological, parasitic, or demographic factors, or a combination of these. All of these variables decrease the individual's ability to cope with the stressor.

Bone abnormalities can be seen as a general function of the impact of environmental stress (Huss–Ashmore et al. 1982:398, Martin et al. 1985:231, Stini 1985:192). The stress factors that lead to particular pathologies are difficult to sort out because they act synergistically and cumulatively in the production of lesions (Huss–Ashmore et al. 1982:399, Stini 1985: 215, Steinbock 1976:237–238, Ortner and Puschar 1981:270). For this reason, *stress pathologies*, or those skeletal abnormalities caused by environmental perturbation, will be used only as general indices of populations' reactions to stress.

Response to Stress

Skeletal tissue is one of the last tissues to be sacrificed in the maintenance of homeostasis during stress. (McLean and Urist 1968, Hancox 1972); it is most susceptible to stress during growth and development. Only those pathologies that are severe, but not so severe as to kill the host immediately, are manifested in skeletal material. Therefore, most stress pathologies indicate long–term exposure to the stressor.

The Armelegos, Goodman, and Bickerton (1980) ecological model of stress is useful for illustrating how stress pathologies are acquired. In this model the resistance of the host, together with cultural buffers, plays an important role in reducing or augmenting the degree of lesionous expression. When such factors favor the stressor rather than the host, a downward spiral of stress resistance begins, contributing to the death of the individual. These kinds of maladaptive biocultural responses are seen in skeletal series as active stress lesions at death. On the other hand, a positive biocultural adaptation will be evidenced by healed lesions or no lesions at all (Leiban 1977:13).

METHODOLOGY

Sampling Methods

The data for this study come from a set of Late Prehistoric skeletal populations housed at the Texas Archeological Research Laboratory at The University of Texas at Austin. Although sites 41BL3 and 41CV14 do have earlier components, an attempt was made to use individuals from upper excavation levels, most of whom were buried in semiflexed or flexed positions. A stratified sample was selected from 12 sites (containing 348 individuals) in the Brazos and Colorado drainages, using three physiographic strata: the Inner Coastal Plain, the Outer Coastal Plain, and the margin of the Edwards Plateau (Figure 1).

The stratified sample size necessary for a population of 348 with a 7 percent bound of error was 86 individuals. The sample was allocated to each strata using a weighted Neiman Allocation method. A set of four sites per strata was used to obtain the base population size (Table 1); the use of different sites in each region was an attempt to control for between-group cultural variation in each stratum. The most complete individuals from each regional stratum were then sampled. Age and sex variation was controlled by using an equal number of males and females and a nearly equal number of adults and subadults from each stratum.

Three of the sites included in the sample have questionable Late Prehistoric affiliations. The Crestmont site, 41WH39, has some artifactual material indicative of a Late Archaic population, but an exact temporal affiliation for this population is as yet uncertain. Additionally, Ranney Creek Shelter (41CV14) and Owl Creek Shelter (41BL3) have diagnostic artifacts that span several time periods, including the Late Prehistoric. Because the site notes do not describe the association of specific artifact types with individual burials, only the burials from the upper site strata were included in the sample. As a precaution, the sites in question were removed from the sample and the models were tested again. Examination of the

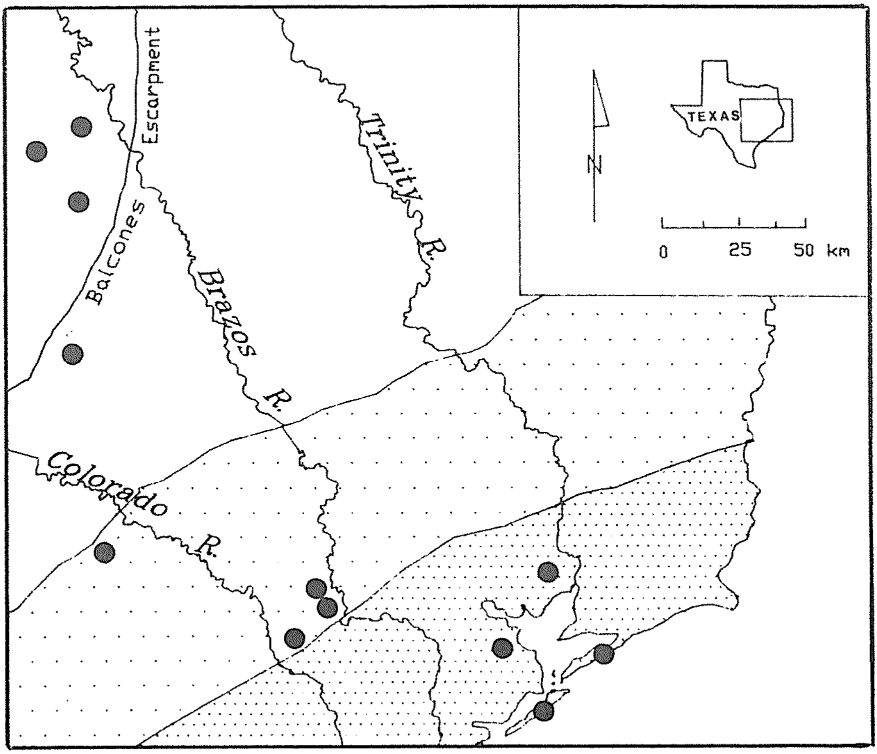

Figure 1. Map of the upper coast of Texas showing site locations and Productivity Zones, based on Rodin, Bazilevitch, and Rozov (1975). The heavy stipple (Inner Coastal) has a Net Primary Productivity (NPP) greater than 50 t/ha; the light stipple (Outer Coastal) has an NPP of 15–30 t/ha; the unstippled area (Plateau) has an NPP of 10–15 t/ha. Circles represent sites mentioned in the text.

results both with and without these sites revealed that the inclusion of possible Late Archaic sites did not significantly alter the test conclusions, so these sites have been incorporated in the analysis results presented below.

Pathologies

Individuals were examined for gross pathologies using a low-powered (10x) microscope. Pathologies were recorded on score sheets by location, degree of involvement, and remodeling of each lesion type. The use of active and remodeled classes of lesions is useful for determining the recovery rate from stress (Martin et al. 1985:267–269). All of this information was then used in a differential diagnosis to determine the probable cause of the lesion. Differential diagnosis is a method by which the etiology of pathological agents is compared. The combination and distribution of pathologies in individuals and populations and age distributions of the possible causes are compared and eliminated until the most likely cause is found.

Table 1. Sites Used in Sample

Site No.	Site Name	N	Subadult to Adult Ratio
	Coastal Stratum		
41HR80	Harris County Boys' School	11	6/5
41CH1	Lawrence Island	3	1/2
41GV1	Caplen Mound	6	2/4
41GV66	Mitchell Ridge	7	5/2
	Total	27	14/13
	Coastal Plain Stratum		
41AU36	Witte, Groups 3 and 4	8	6/2
41AU37	Leonard K	4	0/4
41FY42	Frisch Auf!	4	1/3
41WJ39	Crestmont Cemetery	15	7/8
	Total	31	14/17
	Plateau Stratum		
41BL3	Owl Creek Shelter	6	3/3
41CV14	Ranney Creek	5	2/3
41ML46	Asa Warner	9	5/4
41WM230	Loeve-Fox	8	4/4
	Total	28	14/14

Several pathologies that indicate environmental stress were recorded. For ease of description, the stress pathologies can be classified as either deficiency or infectious pathologies.

Porotic Hyperostosis is a pathology often associated with a nutrient deficiency (Steinbock 1976:236–237, Ortner and Putschar 1981:257), although other stressors such as parasites have been known to cause it. This lesion is generally confined to the cranium and is evidenced by expanded cranial diploe, a thin and eroded outer vault, and exposed trabecular bone (Steinbock 1976:231). This pathology can appear in several forms, from finely pitted (seen in most of the cases below) to porous and sievelike. Lesions were recorded as either active or remodeled at death.

Cribra Orbitalia is a similar erosional lesion, also associated with a deficiency of some kind (Steinbock 1976:244–248). It takes the form of porous, eroded, spongy lesions on the roofs of the orbits (Martin et al. 1985: 266, Steinbock 1976: 239–240, Ortner and Putschar 1981: 258). This lesion was also recorded as active or remodeled.

Enamel Hypoplasia is a dental pathology that can be used to measure responses to stress during growth and development. The pathology develops when the host is exposed to a short–term period of high stress, such as inadequate diet or disease. With the reestablishment of homeostasis comes an overproduction of tooth enamel that produces a visible transverse line in the tooth. Multiple lines sometimes have been associated with recurrent, or seasonal, stress (Martin et al. 1985), but this relationship is not a conclusive one.

For the populations studied, overall health status was gauged by the prevalence of *osteomyelitis* (Leiban 1977:15, Rose 1983:240–241). Acute osteomyelitis is "a destructive invasion of bone caused by pyogenic bacteria" (Steinbock 1976:61). Evidence includes cortical thickening, subperiosteal bone apposition, woven (primitive) bone, cloaccae for suppuration, and in severe cases, complete necrosis of the bone and formation of an *involucrum* (Steinbock 1976:62). Acute osteomyelitis is associated with individuals who have reduced resistance to infection or have had bacteria directly introduced to the bone by trauma.

Chronic osteomyelitis is associated with long–term, recurring infection that may flare only when resistance is reduced (Steinbock 1976:74). Symptoms include minor periostitis, striated bone apposition, partially or totally filled cloaccae, and localized cortical thickening.

From these pathologies, two indices of stress response were created. First, the sum of all deficiency pathologies (porotic hyperostosis, cribra orbitalia, and enamel hypoplasia) was calculated for each individual. This index was called STRESS. A second index, GENERAL STRESS, combined the sums of deficiency pathologies with the sum of osteomyelitis for each individual.

ENVIRONMENTAL SETTING

The environmental analysis presented below is only a general overview rather than an in–depth discussion. Generalizing the biotic zones in the region tends to overlook the diversity of the areas, but it is useful for constructing a basic framework for analyzing human adaptations in a varied environment.

The study area has been divided into physiographic regions with widely varied resources. These have been analyzed by Net Primary Productivity (NPP) (Figure 1) as well as by biotic zones (Figure 2). However, data on the NPP available for human consumption in each region was unavailable.

Net Primary Productivity is "the material actually available for decomposition by the soil flora and fauna or their aquatic equivalent" (Simmons 1979:85). It is measured in tons of dry matter per hectare (t /ha) cycled through all ecosystems.

Each sampling stratum was analyzed for environmental sources of variability.

Inner Coastal Plain

This region is composed of Coastal Plain Prairie (Figure 2) with a large number of estuarine and riverine areas (Blair 1950:102). Forests include mixed oak–hickory in small isolates, with other shrubs and grasses intermingled. Shellfish, freshwater fish, and marine fish are noted in the archeological record at 41GV66, together with opossum, raccoon, cottontail, mouse, rat, skunk, deer, and alligator (Yates 1979:76).

This area has been characterized as having fewer habitats and a lower biomass than other parts of the state (Kotter et al. 1987:14). However, the coastal region has an NPP of more than 50 t/ha, the highest productivity value possible (Rodin et al. 1977, Whittaker and Likens 1975). For archeological populations, this should be a highly productive environment even though the exploitable microhabitats appear to be fewer than in other regions.

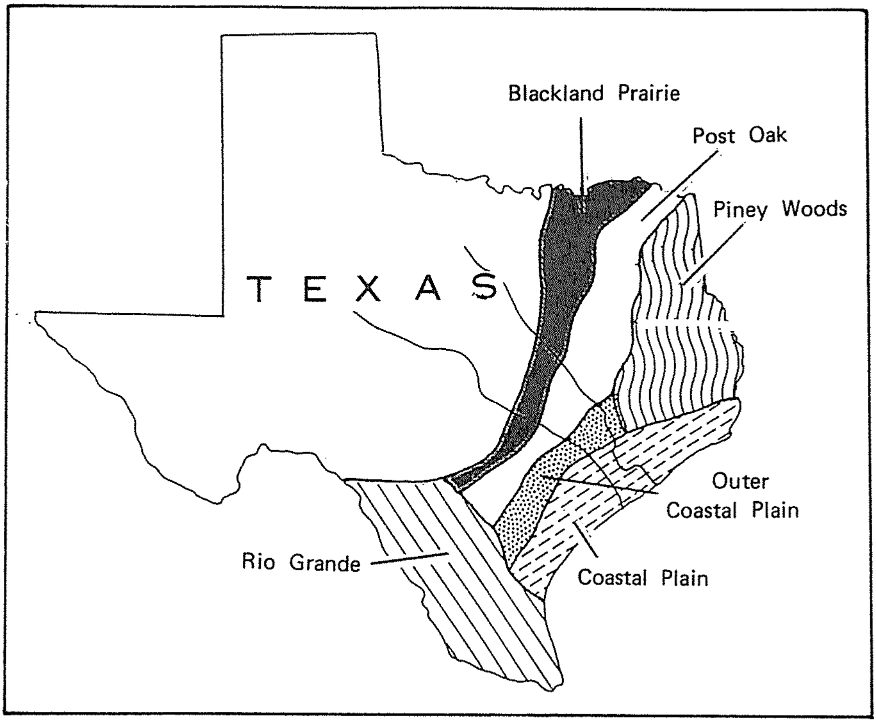

Figure 2. Map showing the environmental zones of Texas (from Kotter et al. 1988).

Outer Coastal Plain

This region contains parts of the Coastal Plain and Post Oak zones (Figure 2) with gently rolling terrain (Chambers 1948). Vegetation includes post oak savannah (Gould 1975:3) which is composed of post oak, blackjack oak, and hickory, together with little bluestem, Indian grass, and other grasses. Common mammals include opossum, badger, fox, skunk, raccoon, ringtail, gopher, rat, mouse, squirrel, and deer (Blair 1950:101, Davis 1978). Prehistoric resources also included a wide variety of riverine products such as shellfish, fish, reptiles, deer, and small mammals (Lord 1981:421-432).

The Outer Coastal Plain region has an NPP of 15 to 30 t/ha (Figure 1). Although this is lower than the coastal NPP, the region still has an abundance of resources and is comparable in productivity to the subtropical forests of Southeast Asia and Central Africa (Rodin et al. 1977). The potential for adequate resources is very high; Aten (1983:66) believes that if they consumed 100 percent of the NPP available for humans, dense native populations could be supported.

Plateau

This area is a mix of grasslands of the High and Low Plains (Figure 2), including the Blackland Prairie (Chamber 1948, Blair 1950:101). Juniper/oak woodlands are scattered among the grasslands. A wide variety of fauna are available, including opossum, skunk, raccoon, squirrel, shellfish, fox, and deer. Most of the resources are concentrated along river drainages (Kotter et al. 1987:16).

The NPP for the Plateau region is 10 to 15 t/ha (Figure 1), which is low compared to the coast; however, the NPP of the plateau is similar to other environments known to be very productive, such as the woodlands of eastern Europe (Rodin et al. 1977). Prehistoric hunter–gatherers would have had quite adequate resources for exploitation even if only a part of the NPP was available for human consumption.

ADAPTIVE MODELS

From the data presented above, it is apparent that there is an abundance of resources in all physiographic regions in the study area, although the productivity of the coast differs from that in other areas. Ethnographic research among hunter–gatherer groups shows that the positive adaptations of these groups to their environments results in minimal stress to individuals (Lee 1968:45), even in marginal environments, as long as the necessary .05 to 5 percent consumption of the NPP is provided (Casteel 1972:21–22).

So far we have assumed that Late Prehistoric hunter-gatherers stayed within the physiographic borders of the study area. It is much more probable that most of the populations in this study had wide territorial ranges that crosscut the physiographic areas. Evidence has been found for the existence of trade or direct contact between the plateau and coastal groups in the Late Archaic period (Prewitt 1982:218, Hall 1981:291-296). Ethnohistoric accounts from the Mariames of South Texas describe 80–mile trips to and from seasonal resources (Campbell 1983:349), with an estimated territory of 1000 square miles (Campbell 1983:353,356). Such information certainly suggests that the Late Prehistoric populations in this study exploited resources outside of their cemetery areas. But even assuming that there was no movement outside of their physiographic area, the resources there should have been more than adequate to provide a relatively nonstressful environment.

Model Definitions

Assuming that the areas of lowest NPP contain enough available resources to prevent environmental stress, it is possible to define a set of explanatory models of subsistence success.

Model 1

Adaptive strategies suited to the environment and cultural interactions will have succeeded in providing adequate buffers against stress. Successful adaptations will result in good health and high resistance to stress.

Expectations. Low rates of STRESS and other stress pathologies, with a high degree of healing. Low rates of bone infection indicate high resistance; most bony infections are chronic.

STRESS Rate. 0 to 5 percent involvement.

Model 2

Strategies adapted to seasonal exploitation of abundant resources will be moderately successful in providing buffers against stress. However, occasional deficiencies could occur, depending on the fluctuation of seasonal resources. Seasonal stress would then result, causing yearly variations in resistance.
Expectations. A moderate rate of STRESS; enamel hypoplasia will be higher than in Models 1 and 3. Other lesions will evidence remodeling. Infection rates will be moderate; most or all infections will be chronic.
STRESS Rate. At or near 20 percent involvement

Model 3

Adaptive strategies poorly suited to the environmental and cultural factors will be unsuccessful in providing buffers against stress. Such adaptation will result in profound stress and little or no resistance to infection.
Expectations. High rates of all stress pathologies, especially STRESS and GENERAL STRESS. Most stress lesions will be active, as will bony infections, due to low resistance.
STRESS Rate. At or above 50 percent involvement

The estimated rates of STRESS involvement are derived from modern data on nutritional deficiency and infection from nonindustrial countries (Schaefer 1966:1091, Lowenberg et al. 1968:295), and from prehistoric incidence rates of similar lesions (Steinbock 1976:242, Carlson et al. 1974:408). Using these values, it will be possible to test the proportions of stress lesions in the three geographic samples.

ANALYSIS OF DATA

The data were analyzed using a variety of nonparametric tests for discrete variables. Nonparametrics were favored because the underlying population distribution is unknown. Tests included contingency table analysis, Kendall's Tau–b correlation coefficient, and binomial probability tests (Large Sample Approximations). The results of these analyses are presented below.

Overall, the percentages of both STRESS and GENERAL STRESS (STRESS+infection) are very high (Table 2); the percentages increase with distance from the coast (Figure 3). Along the coast, infection appears to contribute nearly equally with other lesions. Levels of STRESS and GENERAL STRESS increase dramatically away from the coast.

Correlation coefficients show a positive correlation between STRESS and distance from the coast (Table 3). These values are significant at $p<.02$. In addition, chi-square values for GENERAL STRESS indicate that the level of environmental stress depends on the geographic location of the population ($p<.05$). There does not appear to be any relationship between stress and sex or stress and age in any of the populations studied.

Rates of osteomyelitis have a similar pattern of distribution. Chronic infection

Table 2. Percentage of Involvement of Stress Lesions

Variable	Percentage			
	Overall	Coast	Plain	Plateau
GENERAL STRESS	67.4	56.5	61.3	85.7
STRESS	38.4	14.8	35.5	57.1
PH, active	5.8	3.7	3.2	10.7
PH, remodeled	17.4	14.8	16.1	21.4
Enamel hypoplasia	31.0	23.5	30.0	88.9
Infection, active	3.5	0.0	0.0	10.7
Infection, chronic	13.9	11.1	16.1	14.3

Table 3. Kendall's Correlation Coefficients

Pathology	Variable					
	Region	p	Age	p	Sex	p
GENERAL STRESS	.2776	.002	*	*	*	*
STRESS	.2758	.003	*	*	*	*
Enamel hypoplasia	.1986	.022	*	*	*	*
Cribra orbitalia	.3200	.002	*	*	*	*
Infection, active	.2223	.032	*	*	*	*

p-The significance level, P, is the probability that the correlation of variables would occur by chance alone.
* no significant correlations

peaks in the Outer Coastal Plain sample (Table 2), whereas acute infection is found only in the Plateau groups (Figure 4). There is a positive correlation between infection and distance from the coast, with the highest rates farther inland (Table 3).

TRENDS

Several trends are present in the data.

1) There is a significant difference among regions in STRESS–associated pathologies, which is unexpected, since all of the environments were assumed to have sufficient resources to support hunter–gatherer populations.

2) There tends to be less STRESS along the coast, with a linear increase in the inland areas. Infection accounts for fewer of the lesions in the Outer Coastal Plain and Plateau groups (Figure 3)

3) STRESS pathologies affect all age and sex groups equally in all of the populations studied.

4) Resistance to disease, as reflected in the ratio of chronic to acute infection,

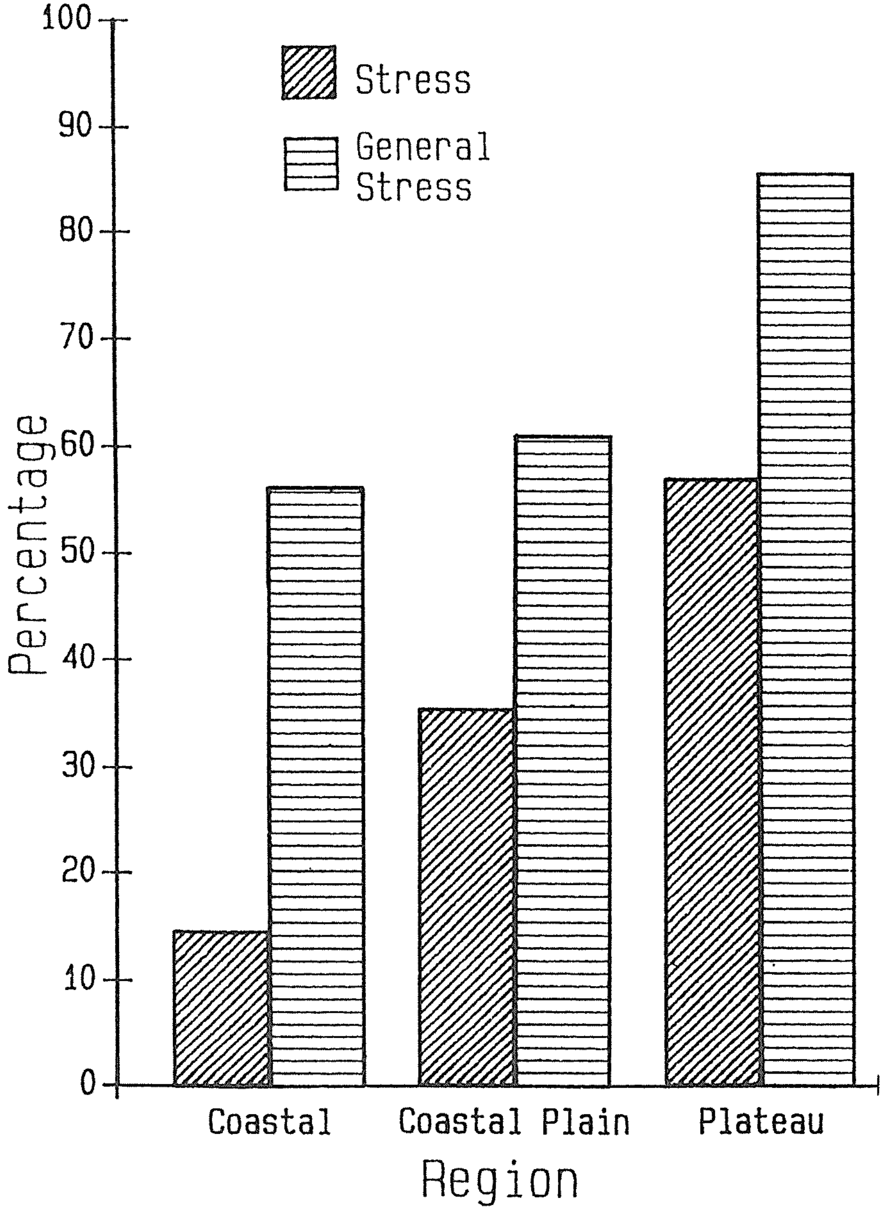

Figure 3. Graph showing percent of region affected by STRESS.

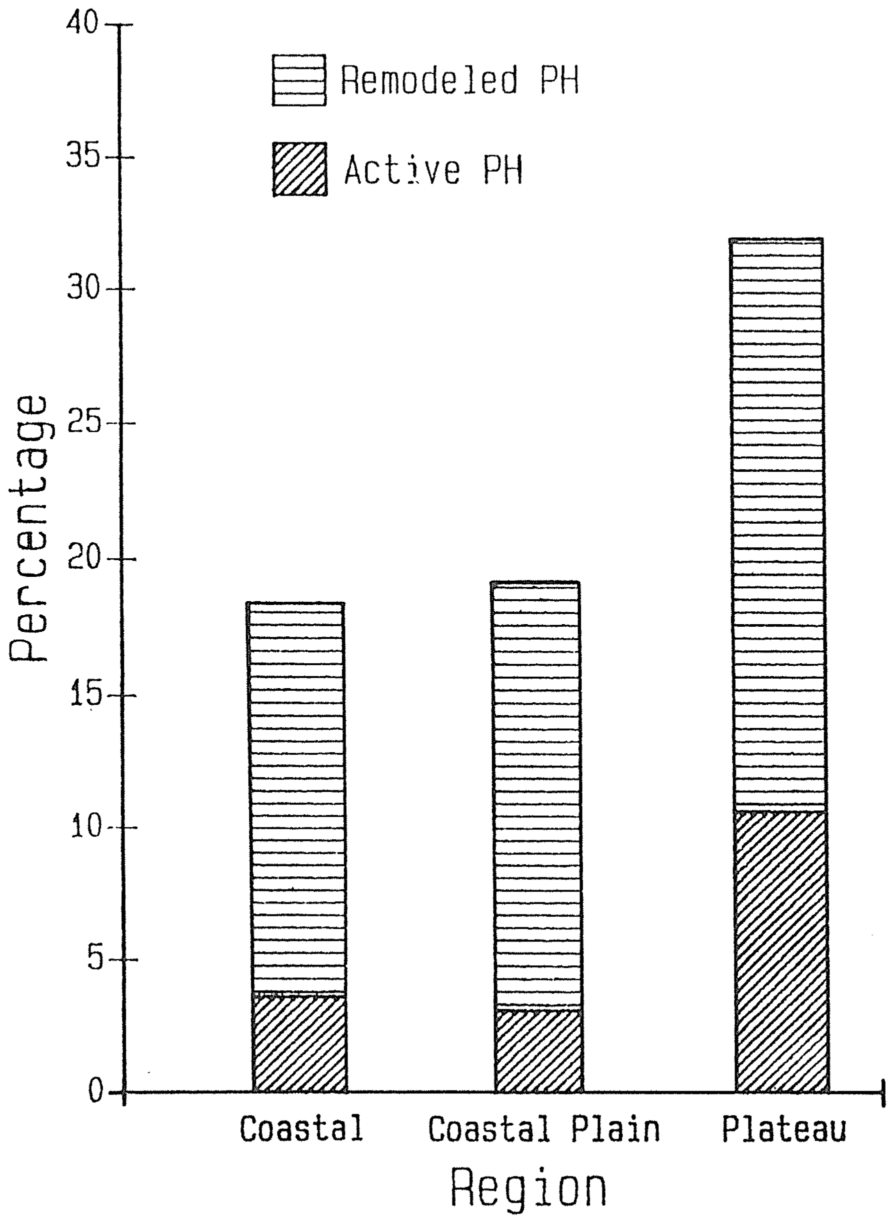

Figure 4. Graph showing porotic hyperostosis types by region.

decreases dramatically in the Plateau sample. The proportion of active–to–remodeled porotic hyperostosis also increases (Figure 4)

If stress had been adequately buffered in all populations, trends such as these would not have occurred. Since all of the regions have resource bases adequate to support hunter–gatherers, and all were exposed to similar STRESS, the occurrence of STRESS in some groups indicates that in the affected ones an ineffective cultural buffering mechanism was at work.

TESTING THE MODELS

To test the models of adaptive success, nonparametric binomial probability tests were employed. (The Large Sample Approximation is a binomial approximation of a normal distribution. The statistic,

$$B^* = \frac{Bi - Ni\,(p^\wedge)}{\sqrt{(Ni(p^\wedge)\,(1 - p^\wedge))}}$$

has an approximate standard normal distribution, where Bi is the number of stress–affected individuals in stratum i, p^ is the hypothesized value of STRESS rate from the model, and Ni is the size of stratum i.) The binomial test compares the proportion of STRESS found in each region to the various hypothesized stress rates presented in the models. One–tailed tests at alpha=.01 were used.

In the coastal groups, stress was found in 4 of 27 individuals (14.8 percent). This was then tested against Model 1 (STRESS= 5 percent) and Model 2 (STRESS= 20 percent). Similar tests were conducted for the Outer Coastal Plain and Plateau sample, using Models 2 and 3 (STRESS= 50 percent) (Table 4).

Table 4. Results of Binomial Probability Tests

Region	Null Hypothesis	B*	Null Hypothesis	Range
Coastal	Ha:P^<.05	2.34	Reject	
	Ha:P^<.20	.518	Accept	.50> B* >.20
Coastal Plain	Ha:P^<.20	2.16	Reject	
	Ha:P^<.50	.759	Accept	.20> B* >.05
Plateau	Ha:P^<.20	3.19	Reject	
	Ha:P^<.50	2.35	Reject	B* >.50

The adaptive success of the coastal sample shows that this population was moderately successful in adapting to environmental stress. Model 1 does not appear to fit the coastal data exactly; however, Model 2 appears to be too severe (Table 4).

The coastal groups show an adaptive behavior to stress that might be attributable to seasonality. Stress pathologies are present but most are healed (Table 2; Figure 4). Enamel hypoplasia is, however, low, indicating that periodic or seasonal stress may have occurred less often among coastal groups than in other regions. Chronic infection is found in subadults and young adults, which is another expectation of Model 2. Overall, the coastal data appear to resemble more closely the expectations of the seasonal stress model.

The Outer Coastal Plain groups have a STRESS value that places them somewhere between Models 2 and 3 (Table 4). This sample has a moderate rate of stress, with very high rates of chronic infection (Table 2). As noted previously, chronic infections can be activated by periods of reduced resistance; these periods can be, but are not necessarily, seasonal in nature. There is a higher percentage of nonhealed lesions in the Outer Coastal Plain groups than on the coast. These data indicate that the Outer Coastal Plain populations may have had much more severe periods of stress or that they may have had a greater number of stressors in their environment, combined with periods of "punctated" deficiency.

The test of the Plateau STRESS rate shows that the data fit Model 3. An apparently unsuccessful adaptation to stress resulted in the high number of stress lesions, high infection rate, reduced resistance, and unhealed lesions. These results were expected under the Model 3 assumptions.

Interestingly, when sites of doubtful Late Prehistoric affiliation were removed from the sample, the statistical tests did not significantly differ from the results presented above. This suggests that the pattern of adaptation to stress is fairly consistent, not only for the Late Prehistoric period, but for earlier time periods as well.

INTERPRETATIONS

The exact types and origins of the stressors experienced by these populations is unknown. Causes can only be inferred from the available biological and archeological data. Completely different stressors, i.e., nutritional stress, demographic stress, etc., could be experienced by the three regions, and, too, relative population densities may enhance or diminish the effects of stress factors. Understanding the cause of the stress is not as important as understanding whether the biocultural adaptation is effective in protecting the population from it. The main purpose of this report has been to assess, from biological evidence, the adaptive success of populations.

POSSIBLE CAUSES OF STRESS

Hypothesizing the causes of stress in the Late Prehistoric groups in Texas can be somewhat helpful in understanding some of the suggested changes in the Late Prehistoric period.

In the coastal groups we have noted that the adaptations to stress were moderately successful, although not totally so. One possible explanation for the low levels of stress in these populations is competition for resources with neighboring groups or encroachment into the population's home range by migrating groups, Aten (1983:42) has suggested that the displacement of indigenous groups on the Texas coast occurred during the Historic period. This displacement certainly created stress for native groups at that time (Aten 1983: 60–64); prehistoric displacements may have been a factor in the adaptations of earlier populations in this area. The resulting migratory stress might have been responsible for the low levels of stress pathologies seen in the inner coastal populations.

The Inner Coastal pathologies also may be the result of a cultural activity associated with seasonality—aggregation of smaller hunter–gatherer groups. Jackson, Boone, and Hennenberg (1986), noting that some coastal hunter–gatherers have treponemal lesions, have hypothesized that this contagious disease was transmitted during seasonal aggregation of hunter–gatherers. If seasonal transhumance (See Ricklis, Hamilton, and Prewitt and Paine, herein) was an adaptation of the coastal groups sampled in this study, the resultant pathologies might include elevated infection rates (from contagious diseases affecting all tissues) as compared to populations with no intergroup contact. Although very tentative, this coastal stress data might fit the aggregational model proposed by Jackson, Boone, and Henneberg (1986).

For the populations farther north there is evidence of less successful adaptation to stress, as presented above. Encroachment by Plains groups is evident during the Historic period (Campbell 1986:9), an event that could account for the higher stress rates in the Outer Coastal Plain and Plateau groups. Evidence of intergroup conflict has been noted in the Late Archaic (Hall 1981:303) and Late Prehistoric (Prewitt 1981:176) in these regions. Cultural systems not adapted to intergroup competition can be seen as unsuccessful ones; in them, inadequate stress buffering would be manifested in the skeletal populations.

Inefficient subsistence strategies could be another stress factor. Since human populations usually need only between .05 and 5 percent of the NPP of an area for survival (Casteel 1972:21–22), any stress from inadequate diet would be a factor of a cultural adaptation (rather than lack of resources) that prohibited optimal exploitation of the environment (Winterhalder 1981:86–88). This stressor could, in turn, be the result of competition for resources.

Whatever the cause, this study has shown that the groups studied have to some degree been unsuccessful in preventing stress from impacting the biological systems of these populations.

CONCLUSIONS

In this study, a case was made for the interrelationship of biology and culture. An analysis of stress pathologies provided data to be tested against a set of models describing a group's success in preventing environmental stress from affecting its members. From the tests, it appears that the Inner and Outer Coastal Plain groups have moderate success in buffering stress, although they may experience it during seasonal or random intervals. The Plateau groups apparently were unsuccessful in nullifying the effects of stress in their populations.

The models of adaptive success presented here are only a rudimentary effort to connect the biological and cultural systems at work in hunter–gather cultures. Several of the limitations that have become apparent probably can be overcome by further research. Detailed investigations concerning the interactive roles of prehistoric diet, demography, and material culture will be necessary for models such as this to be fully useful for research.

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Recommendations for the Conservation of Shell Materials

Paul S. Storch

ABSTRACT

Recovery of mollusk shell from excavations can be difficult for the archeologist because of poor preservation. A search of the archeological literature on field conservation reveals a lack of concern and knowledge of techniques applicable to the treatment of shell in the field. After summarizing the structure of shell, factors affecting preservation, and the categories of information inherent in shell deposits, this paper reports the results of a laboratory experiment performed on archeologically recovered *Rangia cuneata* (Gray) specimens in order to determine which consolidants are best at preventing further deterioration and loss of information on both wet and dry shell. Recommendations on which consolidants to use and how to apply them in the field are based on the experimental data.

INTRODUCTION

Mollusk shell, when found in large concentrations such as are found in littoral shell middens may be in excellent condition (Aten 1981:179, Meighan 1970:415, Sparks 1970:395–396). On the other hand, individual specimens that have been deposited in organically rich acidic soils in terrestrial sites may be weak and friable. Inquiries by several Texas archeologists as to the best methods for recovering shell specimens from excavations made the author aware of a lack of recognition of this problem in archeological field manuals. The field techniques that can be found consist of dousing the finds with a proprietary formulation such as Elmer's Glue–All, which rarely, if ever, gives satisfactory results.

The goal of this paper is not to promulgate a panacea for all problems concerning shell specimens and artifacts, but rather to provide usable data and to make practical recommendations that can be used until something better is developed. The proper conservation of any material requires an understanding of the physical and chemical nature of that material and procedures acceptable for testing the field consolidants. The advice given here is not intended to replace the assistance of a trained archeological conservator and should not be taken as such.

THE PROPERTIES OF SHELL

Shells are the calcareous outer protective covering of invertebrate animals belonging to the phylum Mollusca. This phylum is divided into six classes; the two most important in archeology are Gastropods (snails) and Bivalvia (Pelecypoda, or clams, oysters, and mussels).

The shell itself consists of a matrix of calcium carbonate covered with a noncalcareous membrane called the periostracum, which is analogous to the periosteum on the outer surfaces of bones (Morris 1973:xviii). As the periostracum dries and flakes from the shell, it breaks the delicate growing distal edge of the valve (Aten 1981:186–187). The shells of bivalves are excreted by tissue layers called the mantle, which cover the visceral mass (Weisz 1963:274). The shells of most bivalves are laid down in visible layers that are useful in seasonality studies, since the thickness and spacing of the layers correlate with the seasonal growth of the animal.

PRESERVATION

The primary parameters in the preservation of shell remains in the ground are the pH level of the soil matrix, the amount of shell in the deposit, and aeration. Secondary factors affecting preservation are human and animal disturbances and erosion, which allow increased weathering and leaching to occur. For example, burning or calcination of shell leads to poor preservation. The habitat of the mollusc may also be important to preservation after death. The shells of some terrestrial gastropods that live on calcium–depleted soils may be thin and easily broken, and pelecypods that live in brackish or marine environments rich in calcium ions will be preserved very well. Although there are technical distinctions among different types of shell midden deposits, the term is used here to refer to deposits consisting almost entirely of shell remains (Meighan 1970:415). Water percolating downward through such a concentration of shell may become charged with carbonic acid, causing a leaching and redeposition effect on the shells, serving to encrust or even cement some of them together with a caliche coating (Sparks 1970:395). The pH levels of shell middens that are deposited in initially acidic soils such as sandy loams can be raised to alkaline ranges that encourage the preservation of bone and other organic materials such as wood, cordage, and seeds, especially if the site is waterlogged or wet as well.

THE ARCHEOLOGICAL IMPORTANCE OF SHELL REMAINS

Shell has been used as a material for ornaments in the New World at least since the Archaic stage, perhaps reaching an artistic apex during the Mississippian period in midwestern and southeastern North America, so the need for preserving shell artifacts is obvious. Shell refuse, on the other hand, can provide invaluable information about the economy of the site occupants, population, climate and habitat, radiocarbon age, and, from the season of death of the mollusks, the seasonality of the site's occupation (Aten 1981:179, Shakelton 1970:407).

In order to determine seasonality from bivalve remains, a sample of at least 50 to 100 fairly complete specimens is needed. Aten (1981) describes in detail the morphological approach to the determination of seasonality in the Gulf Coast brackish water species *Rangia cuneata* (Gray). This approach requires that the outer edges of the bivalve be as well preserved as possible to allow measurement of the most recent growth rings. The exterior surface of the valve should also be stable, since powdering and flaking will obscure the earlier growth rings, making accurate measurement difficult.

FIELD TREATMENTS

The few archeological manuals that deal with field conservation pay little or no attention to the problems attendant on the excavation of shell. Dowman (1970), in her book that is still the only work devoted entirely to archeological field conservation, does not mention shell at all. Joukowsky (1980:258) discusses the treatment of shell together with bone and ivory. For dry shell requiring in situ stabilization, she advocates the use of a polyvinyl acetate (PVAc) resin in acetone.

Lamb and Newsom (in Fairbanks 1983:30), in a misguided and dangerous attempt to standardize archeological field conservation, state that "shell artifacts generally do not present a problem with preservation." They go on to say that in archeological deposits, shell can become very fragile and advocate the use of ethulose and PEG (polyethylene glycol, Carbowax). Conceding that these materials may not provide adequate consolidation, they describe the use of cellulose (sic) in either ethanol or acetone. They advocated Duco cement, an unstable and unsuitable material, which should not be used on any artifactual material whatsoever, for use on shell in a "2% solution in alcohol." Duco is composed of nitrocellulose and is soluble only in ether–alcohol mixtures and acetone.

Cease (1985, personal communication) also states that shell usually is found in good condition, but that if it is extremely friable, it can be consolidated by brushing on a 2 percent solution of acrylic resin (Acryloid B–72) in acetone or toluene. If the specimen is damp, Cease states that a PVAc emulsion can be used. However, PVAc emulsions are irreversible once they dry completely, unstable, acidic (pH less than 7), can attract moisture, and should not be used on artifacts.

Hester, Heizer, and Graham (1975:214), using outdated references, describe the use of celluloid (nitrocellulose) on dry shells and gelatin/formaldehyde for damp shells. The latter treatment is unstable and harmful to the specimens, since formaldehyde will form formates with the calcium in the shell over time (Tennant and Baird 1985:77).

TREATMENT EXPERIMENTS

As can be seen from the sources described above, there is no consensus as to the best treatment for shell, either wet or dry. An experiment was undertaken using several consolidant formulations in order to determine which type gives satisfactory results and to develop techniques that can be applied to treatment in the field.

A sample of 50 valves of *Rangia cuneata* (Gray) recovered from archeological sites in the Gulf coastal brackish water environment along the San Jacinto River in Harris County were obtained from Prewitt and Associates, Inc., of Austin. After excavation, the shells had been air–dried slowly on screens. The condition of the surfaces could be described best as moderately deteriorated, a rating of 2 to 3 (Table 1). Some of the outer edge rings were already broken, and the exterior surfaces powdered under light pressure, but none were brittle or exfoliating.

ded to "corrode" the shells artificially using hydrochloric acid, in order to reproduce a natural weak and unstable condition, but the acid treatment only served to dissolve the shells without causing friability and exfolia-

Table 1. Qualitative Ratings of Shell Deterioration Conditions

Rating	Surface	Pitting	Striations	Layers & Edges	Stability
Excellent (1)	Not powdery	None	All visible	---	Both wet & dry
Good (2)	Exterior slightly powdery	Some	Most are visible	Most outer edges extant	Both wet & dry
Fair (3)	Exterior surfaces powdery	Yes	Mostly obliterated on exterior	---	Unstable when dry; flakes or crumbles to touch
Poor (4)	Flaking, crumbling, soft	Heavy on exterior surface	---	---	Minimal, soft, unstable dry or wet

tion. The results of the control sample group and the group that was soaked in a 1.75 percent g/l sodium chloride salt solution are reported here (Table 2). The salinity of

Table 2. Weights of the Shell Specimens Before Treatment

	Control Group (A)	Test Group (B)[1]		
Specimen No.	Dry, No Preparation	Before Soaking	After Drying 6 hrs in Lab Oven at 40°C	After Soaking; Treated Wet
1	15.64	21.27	21.22	-
2	10.30	11.54	11.50	-
3	14.16	13.36	13.25	-
4	13.44	19.90	19.84	-
5	6.53	14.61	14.58	-
6	13.51	6.60	6.63	-
7	15.95	7.90	-	8.61
8	22.21	7.64	-	8.30
9	16.20	10.62	-	11.18
10	14.25	4.45	-	5.00

[1] Specimens 1-6 were soaked for 4 weeks in the 1.75% saline solution.

seawater is about 3.5 percent, so a concentration of 1.75 percent would approximate the salinity of brackish water. The pH of the salt solution was measured at 5.0. Weight (Tables 2, 4) was the parameter used to measure the efficacy of the treatment and to indicate the reversibility of the consolidant. It was assumed in this experiment that the influence of density, porosity, and age of the shell would be negligible. There are, of course, other considerations in the choice of a consolidant than weight gain and reversibility; they are chemical compatibility with the artifact material, stability over time, surface appearance, and toxicity to the operator. All of the consolidants that were chosen for this experiment have satisfactory characteristics and have been used in other applications by conservators (Table 2).

The specimens were divided into two groups. Group B specimens 1–6 were treated with solvented resins; the last four were treated with water–based and emulsion consolidants. The resins, which included PVAc–AYAA, PVAc–AYAF, and polyvinyl butyral (PVB) B–98, were applied in 5 and 10 percent g/l solutions in acetone and ethanol. The wet consolidants were Rhoplex acrylic emulsion AC–33, polyethylene glycol (PEG) 400, a mixture of PEG 400 and methylcellulose (25 percent l/l) and CM Bond (a PVAc emulsion) used at 25 percent strength.

The solvented resins are clear, dry by evaporation of the solvent, and are stable. PVB may yellow over time if exposed to UV radiation. The AC–33 is an acrylic emulsion that is stable, neutral in pH, and more easily reversed than the PVAc emulsions. PEG 400 is a low–molecular–weight glycol ether commonly used in the preservation of wet and waterlogged wood and leather. It acts as a bulking agent by forming hydrogen bonds between hydrogen and hydroxyl groups and by replacing water in the material. The mixture of PEG and methylcellulose was proposed by Brown in 1974 as a 4:1 PEG/ethulose solution in water. This mixture never dries completely and is hygroscopic. CM Bond is a PVAc emulsion formulation with a high molecular weight of about 30,000. It has the drawbacks discussed above that are inherent to most emulsion products.

Consolidant solutions were brushed onto the specimens and allowed to air dry. The specimens were then weighed and placed in a Hotpack environmental chamber for 14 days at 80 percent R.H. and 90°F (33°C), which simulates storage conditions in an environmentally uncontrolled building.

RESULTS

After treatments of the shell surfaces (Table 3), the specimens were soaked for 12 hours in a solvent specific for the consolidant solution that was applied. They were removed from the solutions, light–dried with a paper towel, and weighed. A weight lower than the initial weight indicated removal of the consolidant (Table 4).

Table 3. Visible Effects of Treatment on Shell Surfaces

Specimen No.	Observation[1]	Consolidant Used
1	Slight sheen; stopped surface abrasion	PVA–AYAA 5%
2	Sheen slightly heavier than 5%; stopped surface abrasion	PVA–AYAA 10%
3	Slight sheen; stopped surface loss	PVA–AYAF 5%
4	Slight sheen; stopped surface abrasion	PVA–AYAF 10%
5	No sheen noted on Group A specimens; stopped surface loss	PVB 5%
6	No sheen; stopped surface loss	PVG 10%
7	Marked sheen; shallow penetration; no abrasion noted	Rhoplex AC–33
8	Stayed wet in areas; no abrasion resistance	PEG 400
9	Group A stayed wet; Group B dried; no abrasion resistance	PEG/MC
10	Slight sheen; abrasion resistance	CM Bond

[1] Observations are for both groups unless otherwise noted.

It can be seen (Table 4) that the most successful reversibility occurred with the PVAc resins. PVB was not easily removed by soaking in ethanol and tended to absorb solvent instead, slightly increasing the weight. The water soluble consolidants also were removed after soaking. This was most likely due to the fact that poor

Table 4. Results of Reversibility Tests: Comparison of Treated Weights With Weights After Consolidation

Specimen No.	Soaking Agent	Control (A)		Treatment (B)	
		Treated Weight	WeightAfter Removal	Treated Weight	Weight After Removal
1	Acetone	15.72	15.69	21.40	21.34
2	Acetone	10.41	10.35	11.74	11.65
3	Acetone	14.24	14.21	13.38	13.34
4	Acetone	13.58	13.51	20.05	19.95
5	Ethanol	6.60	6.64	14.69	14.73
6	Ethanol	13.58	13.76	6.77	6.84
7	Acetone	16.28	16.03	8.10	8.00
8	Ethanol	22.93	22.58	8.07	8.00
9	Ethanol & water, 50%, 1/1	16.53	16.31	10.96	10.97
10	Acetone	14.44	14.33	4.58	4.54

penetration had occurred, especially with the PEG and PEG/methylcellulose mixture.

Treatment Recommendations and Techniques

Based on the results of the experiment, the following materials and techniques are recommended for shell materials requiring treatment in the field. For dry conditions, one of the grades of PVAc in either acetone or ethanol should be used. If the ambient temperature is over 80°F, use ethanol, since it will evaporate more slowly, eliminating the risk of shallow penetration of the consolidant. The lowest–molecular–weight grade of PVAc, AYAA, should be used if the shell is very porous and fragile in order to afford the best penetration. The AYAF grade may be used if the condition is moderate, but fragile. It is best to apply a light spray of pure solvent onto the object being treated before the consolidant is applied. This helps to drive off residual moisture and to introduce the solvent into the material, aiding the penetration of the consolidant. In a midden site, the individual pelecypod valves may be tightly packed together. It is best to excavate a pedestal, consolidate the shells with the surrounding matrix, and remove the sample in a block, either with or without jacketing. This is the standard method for removing fragile bone and other objects and has been described in detail elsewhere (Rixon 1976, Storch 1983).

When wet or damp shell is encountered, an aqueous–based consolidant is required because it would be impossible to allow the material to dry enough to use a solvented system. Use of a solvented resin on material that is too damp will result in the formation of a white skin on the surface and lack of penetration. The recommended wet consolidant is Rhoplex AC–33 acrylic emulsion. It can be used as supplied, which is 45 percent solids, or diluted with distilled or deionized water. It is the most stable of the emulsion formulations and is of neutral pH. The sheen can be toned down by swabbing with acetone once the material is stable and dry.

Koob (1984) describes the use of this consolidant on archeological bone in the field. The same excavation method can be used with the emulsion as the one described for the solvented PVAc system.

Once the specimens have been returned to the laboratory, they should be carefully removed from the jackets and placed in an environmentally stable area (without major fluctuations in temperature and relative humidity). Cleaning of consolidated specimens can be done by dissolving the adhered matrix with the appropriate solvent, and, once it is cleaned, reconsolidating the actual surface of the object. Objects requiring more than simple mending and cleaning treatment should be treated by a qualified archeological conservator.

CONCLUSIONS

It is difficult to describe every possible object, condition, or problem that might be encountered in the field, but it is hoped that this article can help to solve some of the problems posed by fragile shell materials. Several consolidants have been tested in controlled experiments and, based on the results, the stable, conservation quality consolidants polyvinyl acetates and acrylics have been recommended for most stabilization procedures. Although it was not tested in this experiment, the author agrees with Cease's recommendation of using a dilute solution of Acryloid B–72 as a consolidant on dry shell. A recommended dilution is 1:2 B–72/acetone; acetone is less toxic to the operator than toluene. The resin is known to be stable, has been well tested on several artifactual materials, and is compatible with shell. Its main advantage over the PVAc resins is that B–72 has a higher Tg than the PVAc's, meaning that it will not cold–flow once it has set up.

Proprietary compounds such as Duco Cement and Elmer's GlueAll must be avoided. These materials were not formulated to meet the standards of conservation practice, are not stable, and actually may be harmful to the specimen. It also must be remembered that the consolidation with a carbon–containing solvent or resin should be avoided on any samples that might be subjected to radiocarbon dating.

ACKNOWLEDGMENTS

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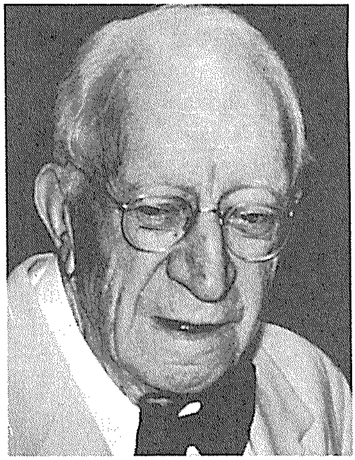

Photograph courtesy of Corpus Christi Geological Society

W. ARMSTRONG PRICE, 1889–1987

In this issue of the *Bulletin,* which features archeology of the Texas coastal zone, it seems appropriate to call attention to the recent death, at the age of 98, of W. Armstrong Price, geologist and oceanographer, whose studies of shoreline dynamics have made it easier for archeologists to correlate human occupations with environmental changes that occurred during the late Pleistocene and Recent epochs. These changes, all in some way connected with fluctuations in global sea level, controlled the distribution of archeological sites along the shallow bays, deltas, and offshore barrier islands that characterize the Texas coast.

Price (Ph.D., Johns Hopkins University, 1913) was a versatile man who had several careers in his very long and productive life. For many years he was a consulting petroleum geologist in Corpus Christi, and he is credited with the discovery of five oil and gas fields in southern Texas. During that time he steadily published the results of basic geological research (his name is now linked with some 150 publications). At the age of 61 he entered academic life at Texas A&M University and was one of the three professors who organized its very successful Department of Oceanography. After retiring from his position at Texas A&M, Price returned to Corpus Christi, resumed his consulting work, continued his research, and lectured at the University of Corpus Christi. His mind was clear to the very end of his life, and shortly before death he was preparing another manuscript for publication.

Although Price carefully recorded any archeological evidence he encountered while doing geological field work, he was content to leave artifact description and interpretation to archeologists. What interested him most were the environmental changes that affected successive human occupations along the Texas coast. Of special interest to archeologists are his studies of sedimentation in coastal bays and lagoons, of factors involved in the formation and maintenance of offshore barrier islands, of the distributary channel sequences found on the Brazos and Rio Grande deltas, and of conditions leading to the formation of clay and sand dunes.

My most treasured memory of Armstrong Price is connected with a three–day trip I once made with him to examine shoreline features in northern Tamaulipas. We traveled southward from Corpus Christi in a chartered twin–engine amphibian plane, so landings could be made on either ground or water. This trip turned out to be exciting because of two near disasters while trying to take off from landing areas that were too small. In one instance the plane did not become airborne but came to rest atop a dense thicket of thorny brush. Price complimented the pilot on his skill in making such an unusual landing, crawled down from the plane, surveyed the situation, and suggested that we get men with machetes from a nearby village to come and clear a runway for the perched plane.

Later, while flying northward from Matamoros to Corpus Christi, one of the plane's engines died, and we slowly but steadily lost altitude. Price entertained us by pointing out and explaining various topographic features along the Laguna Madre and Padre Island. You would have thought he was lecturing in a quiet classroom. When the Corpus Christi airport came into view, the plane's altitude had fallen to about 500 feet. After landing I asked Price what he thought of the trip. He replied: "Wonderful! We found that clay dunes occur as far south as the Rio Soto la Marina."

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Book Reviews

El Paso's Prehistoric Past. By Mark T. Bentley. Published by Mark T. Bentley, Austin. First edition 1981, second edition 1985. xi+100 pages, 21 figures, 5 figures. Softbound, $5.95.

Bentley's small volume fills an important need in Texas archeology. It is a regional synthesis written primarily for the layman, but it also appeals to the vocational and professional audience. It is clear, without knowing the author or anything of his background, that Mark Bentley has had some professional training, but he still understands the needs of nonprofessionals.

El Paso's Prehistoric Past is divided into three chapters, each dealing with an archeological area of concern—physical environmental, socio–technological, and socio–ideological. The first chapter is a straightforward discussion of the geography of the El Paso and Hueco Bolson area. Parts of this chapter reflect some indecision about which audience is being addressed, and, like other parts of the book, have some literary fence-straddling. From the professional archeologist's point of view, Bentley impresses one as knowing what he talks about, but whether neophytes will be equally impressed or just lose interest is not certain.

The second chapter, on the socio–technological concern, is a clean and precise cultural-historical discussion covering time periods, projectile points, house types, etc. Its title, "Socio–Technological Parameter," is more than an example of "old wines in new skins," as Walter Taylor has put it. The title and the presentation reflect a way of thinking about prehistory that is different from the time–worn culture history. However, this concept comes from a school of thought that grew out of the *New Archeology* of the Southwest, particularly at the University of Arizona. In the 1970s, it was innovative, but in 1988 it seems overly simplified and passé. However, this criticism may be too harsh here, for Bentley's volume was first published in 1981 and has not been updated.

The third chapter focuses on the socio–ideological concerns of prehistory. Rock art and pottery designs are discussed in an interesting and informative manner. This may be Bentley's best chapter. The first–time reader suddenly finds here that the people of the past still have interesting things to say to the people of the present, and this chapter probably has brought more than one new member to the El Paso Archaeological Society.

Bentley ends the volume with a useful appendix covering ceramic types of the El Paso area. This may not be useful for the novice, but it is a handy reference for those who are familiar, but not intimately so, with the area.

It is unfortunate that his book is already becoming outdated. Scarborough's discoveries of prehistoric irrigation canals in the El Paso area and recent work by

Tom O'Laughlin, of the Centennial Museum at The University of Texas at El Paso, for example, have forced a great deal of restructuring of our understanding of the prehistory of Southwest Texas, but these developments are not reflected in Bentley's volume. This reviewer is concerned too that Bentley lacks a clear understanding of what is palatable to his audience—that is, if this reviewer understands correctly what that audience is. Finally, Bentley presents no discussions of interaction of the prehistoric El Pasoans with other people, such as those at Casas Grandes in Mexico. This is in accordance with the wholesale abandonment of diffusion as a valid concept by the Arizona *new archeologists* of the 1970s.

Despite these problems, *El Paso's Prehistoric Past* is recommended to everyone interested in Texas archeology. This will be as welcome an addition to their bookshelves as it has been to this reviewer's. It is hoped, too, that Bentley's lead will be followed by others. Can *East Texas's Prehistoric Past* or *The First Residents of the Panhandle* be seen coming over the horizon?

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The Rock Art of Seminole Canyon State Historical Park: Deterioration and Prospects for Conservation. By Constance S. Silver. Texas Parks and Wildlife Department Report 4000-430, February 1985. 43 pp., 6 figures, appendix.

Rock art, including both petroglyphs and pictographs, executed by vanished and vanishing aboriginal peoples, is one of the world's most precious cultural resources. Conservators, and archeological conservators in particular, recently have become interested in developing methods and techniques for conserving and preserving this art. The difficulties involved in this endeavor stem from the fact that rock art is often found in remote areas, is exposed to both the elements and human caprice, and is executed on and in rock substrates that are subject to progressive natural deterioration.

The published work that has been done on pictographs—paintings with pigments on rock surfaces—has consisted of compilations of data describing in detail the problems connected with the the preservation of the paintings and the rocks themselves and the straightforward documentation of these problems. These data presumably will be used to design intelligent preservation programs that will slow, if not arrest, further deterioration of the paintings (Dragovich 1981:143–149). It is therefore disappointing to find that this publication—concerned with the endangered rock art sites in Val Verde County, Texas—is merely an exercise, reviewing the problems of rock art in a general way, as has been done already in other publications. In addition, the author postulates that the prehistoric pictographs were executed in the fresco technique, a misleading assertion (to be discussed below) that clearly betrays a lack of understanding of the local geology and rock deterioration processes. Publication of assertions such as this are particularly disturbing to conservators in this area, where specialists are few and not well known.

These few individuals spend much of their time trying to educate archeologists and the general public in the scientific study of archeological materials. Unfortunately, since this report will be accessible to the general public, its contents undoubtedly will be incorporated into the archeological folklore that causes professional archeological conservators so much trouble and that results in well-meaning but incorrect and harmful treatments.

Silver's report is based on only nine days' work in the field, although she calls repeatedly for long-term data collection, and no definite data are presented in support of the recommendations. Instead, she proposes that an international conference be held in the Seminole Canyon area in order to assess further the problems associated with the rock art. It is this reviewer's opinion that such a conference would accomplish nothing except the generation of one more publication stating the need for more work on the problem.

In the "Methodology" section, the manner in which the condition of the shelters was assessed is not defined, nor is there any description of how the "possible agents of deterioration" were studied. Such a lack of specific information about methodology in a scientific report is inappropriate.

Under the "Component Materials" section, a "white stratum" that overlies the limestone "support" and apparently the basis for a mistaken inference that the pictographs were executed in the fresco technique (i.e. painted on a prepared base layer) was identified as gypsum by an analyst who did not visit the site but who stated that "it does not seem likely that a gypsum stratum could develop naturally." According to Solveig Turpin, who has written an extensive archeological report on the Seminole Canyon sites (Turpin 1982), deposits of gypsum efflorescence—a naturally hydrated calcium sulfate ($CaSO_4$–$2H_2O$)—develop naturally on limestone outcrops in the area. As in the rest of this report, the words *possibly, likely,* and *probably* abound in descriptions of the "white preparation stratum." As evidence for this "intentional preparation layer" at Seminole Canyon, Silver cites a layer of similar appearance in the Courthouse Wash Pictograph in Utah, identified as a "white clay," that may have been used for making preparatory sketches on the wall. However, later on in the report she states that a dull red clay layer does precipitate out onto the pigments (p. 19), producing a surface accretion that is "typical of normal surface weathering of limestone caves due to condensation." Because these observations are without documentation and data to back them up, they lack credibility. There are no documented occurrences of true fresco technique in the Southwest before the coming of the Spaniards in the sixteenth century. Furthermore, neither Turpin nor Zolensky (Turpin 1982), in presenting clear cross section photographs and complete x–ray diffraction data, mentions any frescolike preparation layers.

Under "The Deterioration of Stone in Deserts and Semi-arid Regions," three pages are devoted to restating standard references on stone deterioration and environmental factors. This is a useful review, but the purpose would have been served more effectively if these references had been cited in conjunction with actual data from the rockshelters as they were in Turpin's archeological report (1982:197, 200–201). Silver has overlooked an important rock art reference that looks at the same problems she was attempting to address: *Conservation of Rock Art*, edited by Colin Pearson and published in 1977, the result of a conference in Australia on the agents of deterioration that affect sites. It is surprising that the author has not used more Australian references, since researchers there have done considerable research on arid and semiarid sites during the past two decades.

The subsection titled "Exfoliation of Stone" is the most critical to the credibility of this study. A functional explanation given for the exfoliation and obfuscation of the pictographs relates the two phenomena to each other, but no data are presented to show how these factors operate at the Seminole Canyon sites. One type of exfoliation, called *granular* by Turpin (1982:200), was not mentioned by Silver because she did not examine any of the shelters where it occurred. She is correct but not helpful in noting that "stone exfoliation and obfuscation of the pictographs are complex phenomena whose mechanisms change from shelter to shelter and within discrete areas of each individual shelter."

The data presented under "Exfoliation of Stone" consist of three x–ray powder diffraction spectrograms that are not adequately explained. In addition, there is confusion between the singular and plural of the word stratum. It is unclear from the text and the illustrations whether the author is referring to a single stratum or to multiple strata in the explanations of the cross sections on pages 17 and 19. "Strata 2" is not explained at all in the text, nor is there any explanation for giving different samples to two different analysts. The work of a third analyst, a geologist, is not explained, except for a statement that exfoliation is caused by the leaching of clays and salts to the surface of the rock.

The major theoretical problem with the report comes in the "Recommendations for Conservation" section, where the rockshelters in the canyon are compared to a hypothetical Byzantine crypt. The reviewer wonders why Silver reached for an exotic model to back up her findings instead of using more-comparable data from similar environmental situations. Comparison of a fresco done in lime plaster to paintings on rock, supposedly done on a gypsum ground, is bound to cause confusion, since the comparison is not based on any data presented in the text. Mora, Mora, and Phillipot (1984) state that the making of gypsum plaster requires the knowledge of calcination; there is no evidence that this technology existed on the Lower Pecos at the time the pictographs were executed.

The chemical EDTA is mentioned (p. 28) as a strong chelating agent for the removal of obfuscation crust, but it is not clear whether the author is referring to the acid of EDTA or to one of its sodium salts; the salts are the proper chemicals to use in chelation treatments. The pH level of the EDTA solutions can be adjusted with EDTA acid or other chemicals such as ammonium acetate.

In the discussion of the reattachment of loose plates of limestone (p. 31), there is a major contradiction. Silver states that "in the case of Seminole Canyon there are many considerations in regard to reattachment of loose areas . . . . there are no precedents in the literature on rock art conservation." However, on page 26 she quotes the conservator Barbara Kennedy as saying that the reattachment of large plates of limestone at the Deer Corral Pictograph in British Columbia was successful after six years. Furthermore, Silver goes on to say that "similar rock stabilization has been carried out for decades in the White Mountain[s}, New Hampshire," and "studies are now underway to stabilize Mt. Fuji (sic), Japan," but she does not describe the methods of stabilization used at these sites. Again Silver calls for pilot tests of adhesives before further work is done, something that should have been carried out before this report was written.

The appendix is indeed the most useful and coherent part of the report, since it deals objectively with the condition of the pictographs at the time they were examined (1980). The recommendations for treatment give readers a general idea of what treatment is required at each shelter.

In summary, this report would have served its intended purpose better if it had been published in a conservation journal in abbreviated form after the study was complete. A report of field work such as this should be more comprehensive and should include a fully developed plan of research.

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Commentary

San Patrice and the Early Archaic: Comments on H. Blaine Ensor's "San Patrice and Dalton Affinities on the Central and Western Gulf Coastal Plain."

Blaine Ensor's recent article on the relationships between the San Patrice and Dalton complexes is a long overdue and welcome addition to the published literature (Ensor 1987). He has deftly combined material from across the upland south in a manner that could be done only by one with experience with both San Patrice and Dalton materials.

In the article, Ensor notes that San Patrice and Dalton complexes have been argued to be Late (or terminal) Paleo–Indian or Early Archaic by various previous investigators. He states that "the general consensus . . . has been that data for distinguishing San Patrice from earlier, later, or contemporaneous manifestations are not available" (Ensor 1987:70). Interestingly, he has overlooked archeological efforts of the University of Southwestern Louisiana's program at Fort Polk, Louisiana from 1977 to 1979 (Servello 1983, Guderjan and Morehead 1981), which included intensive surveys, testing, and excavations on the Fort Polk Military Reservation and have given us some insights into this problem. Because of the size of the sites encountered and the number of artifacts recovered, techniques of numerical taxonomy were applied to lithic debitage to gain insight into the relationships among site components that were otherwise difficult to identify. The reasoning was straightforward—if an artifact assemblage of known date, e.g., San Patrice, can be characterized numerically, then it should be possible to characterize and compare assemblages of unknown date numerically and, by so doing, to date the unknown assemblages. In carrying out this process, several artifact assemblages of known dates and cultural affiliations were compared.

The procedure required examining lithic debitage for a series of attributes such as platform facetting, platform profile, presence of cortex, dorsal–ventral profile, dorsal ridge pattern, dorsal scar pattern, lateral profile, and axial cross section. In the context of this commentary, it is not possible to describe fully these attributes and the system of analysis. However, more detailed information is available elsewhere (Guderjan and Morehead 1981, Servello 1983:329–378). The results of these analyses were then subjected to a factor analysis that effectively filtered out undesirable variability in the information, after which a cluster analysis was performed on the resulting factors. This procedure resulted in a dendrogram that described the relative similarities and differences in the original data. The basis for this procedure was developed originally by Parks (1970) for use on geologic samples.

At the Big Brushy site (16VN24), four components were identified—San Patrice, one that was termed "Middle Archaic" (in deference to the possibility that

San Patrice might be considered Early Archaic), Late Archaic, and a later Ceramic component. Cluster analysis was performed on a variety of attribute sets for each of the components; Guderjan and Moorehead published an article (Guderjan and Moorehead 1981) summarizing the results, and also a more detailed report (Guderjan and Moorehead 1983). Since the results are detailed in these publications, it is important here only to highlight particular information. When about 80 percent of the variability was accounted for, and using sets of four, six, and all of the attributes examined, the similarity between the San Patrice and "Middle Archaic" samples was remarkable. In all cases the two samples were virtually indistinguishable.

In the Peason Ridge area of Fort Polk, several Paleo–Indian and more recent sites were clustered around Eagle Hill (Servello 1983). These sites—Eagle Hill I through IV—were marked by the tabular chert that was used as raw material throughout the Paleo–Indian sequence. This chert, which appears to be similar to Edwards Plateau chert, was obtained from a now–lost or depleted source near Eagle Hill. Following the Paleo–Indian pattern discussed by Goodyear (1979), the Eagle Hill source was used intensively. Eagle Hill materials are found in sites for many miles around the source but generally only in Paleo–Indian contexts. Interestingly, only one of the seven San Patrice points found on Peason Ridge by the University of Southern Louisiana survey teams was made of Eagle Hill chert (Brassieur 1983). Furthermore, a survey of collections from Eagle Hill and Peason Ridge confirms this pattern (John Guy, Anacoca, Louisiana, personal communication; Guderjan, field notes).

Servello compared the San Patrice artifact assemblages from Big Brushy and elsewhere with the Paleo–Indian assemblages of the Eagle Hill sites (1983:156) and found that the San Patrice assemblages clustered closely to, but quite separately from, the Eagle Hill Paleo–Indian materials. This may be due in part to the use of differing raw materials. However, a major part of the distinction is clearly due to differing lithic technologies. The attribute sets selected for the computer runs that were analyzed were intentionally chosen to avoid variability due to differences in raw material. The technological similarity between the San Patrice complex and later Archaic materials at Big Brushy, then, coincides with the distinction between San Patrice and Eagle Hill Paleo–Indian materials.

In addition, the shift in resource utilization at the end of the Paleo–Indian period is widespread (cf. Ensor 1987, Goodyear 1979) and is not seen only at Fort Polk. With this information in hand, it is difficult to perceive the San Patrice complex as anything but an Early Archaic pattern.

As a final point, the relationship between San Patrice and Dalton complexes has been noted in the past by investigators other than Ensor (cf. Morehead and Guderjan 1983:27). Some investigators have seen the typological distinctions between even San Patrice and Hardaway points as being only a function of the historical development of local typologies (Robert Thorne, personal communication). Limited information was gathered by the Fort Polk project on San Patrice settlement patterns in an effort to determine whether they follow the Dalton model proposed by Dan Morse and his associates in various publications (Morehead and Guderjan 1983).

Interestingly, a Dalton point was found in association with San Patrice points at the Big Brushy site (Guderjan and Morehead 1981, 1983).

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