Observations on the Archaeology, Paleoenvironment, andGeomorphology ofthe Puerto Peñasco Area of Northern Sonora, Mexico

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Abstract
Recent observations and archival research on the archaeology of the Puerto Peñasco area at the northern end of the Gulf of California, Sonora, Mexico, have provided additional insights into the prehistory of the region. The northern Gulf of California has long been recognized as the source of raw marine shell used in the production of shell ornaments by the Hohokam of southern and central Arizona. The most obvious archaeological manifestations in the area are the shell midden sites that occur along the margins of the ocean and estuaries of the region. Based on a small sample of diagnostic flaked stone and ceramic artifacts, a Late Archaic period through Late Ceramic period (Hohokam) use of the area is evident. A small number of independently derived radiocarbon dates appear to support this conclusion. We summarize archaeological, chronometric, environmental, and geomorphic data from the area.

Resumen
Observaciones recientes y la investigación en archivos sobre la arqueología del área de Puerto Peñasco en el extremo norteño del Golfo de California, Sonora, México han proporcionado entendimientos adicionales en la prehistoria de la región. El área ha sido reconocida desde hace tiempo como la fuente de la cáscara marina cruda usada en la producción de ornamentos de cáscara por los Hohokam de Arizona. Las manifestaciones arqueológicas más obvias del área son los concheros que ocurren a lo largo de los márgenes del océano y de los esteros de la región. Además de cáscara, estos sitios contienen restos de crustáceos y otras especies marinas así como las ensambladuras pequeñas de artefactos prehistóricos incluyendo cerámicas, morteros, manos, metates, y lascas. De acuerdo con una muestra pequeña de artefactos diagnosticados, el uso del área es evidente durante un periodo del arcaico tardío al periodo cerámica tardío (Hohokam). Una pequeña cantidad de fechas radiocarbono derivadas aparecen apoyar esta conclusión. Resumimos también datos arqueológicos, cronométricos, medioambientales, y geomorfológico del área.
INTRODUCTION

Puerto Peñasco, Sonora, Mexico, is located at the northern end of the Gulf of California (Sea of Cortez) (Figure 1). Despite little systematic archaeological investigation of the area, it has long been cited as the most logical and primary source of marine shell used in the manufacture of jewelry by the Hohokam of central and southern Arizona (e.g., Haury 1938, 1976). The archaeology of the area is dominated by numerous low shell middens that occur on dunes along the shore of the Gulf and along the edges of estuaries (extinct and extant) as well as inland on the plains of the Desierto de Altar. The small artifact assemblages found on some of these sites are dominated by Hohokam ceramics but also include

![Figure 1](image-url)

**FIGURE 1.** Puerto Peñasco and regional prehistoric cultural traditions.
prehistoric Yuman (Patayan) and Trincheras ceramic types along with occasional pieces of flaked and ground stone.

This discussion is the result of a reconnaissance survey of the Puerto Peñasco area and associated background research. The survey was funded in part by two grants from the Arizona Archaeological and Historical Society and was conducted under a permit from the Centro Sonora, Instituto Nacional de Antropología e Historia. A total of 49 archaeological loci were recorded. To date, recording has been limited to the noting of dominant species of shellfish, the presence of artifacts, and location. Despite the low visibility of the area's archaeological record, it holds the potential to greatly expand our understanding of the prehistoric use of and adaptation to a unique segment of the Sonoran Desert. This discussion updates and expands our earlier report on the archaeology of the Puerto Peñasco area (Mitchell and Foster 2000).

ENVIRONMENT

The Puerto Peñasco area lies within the heart of the Sonoran Desert and is characterized by coastal sand dunes, estuaries, a desert landscape that includes eolian dune fields, isolated hills and mountains, and sparse vegetation. The area receives about 86 mm (3 inches) of precipitation a year, with mean winter and summer temperatures of 12° to 28° C, respectively (Turner and Brown 1994:Figure 107). Little fresh surface water is available.

The vegetation of the area is within the Frenkenia Series of the Lower Colorado River Valley vegetative subdivision (Brusca et al. 2004; Felger 2004; Turner 1994:198). The species diversity within this series is low and includes salt-tolerant shrubs such as alkali heath (*Frankenia grandifolia*), the sole perennial; Palmer’s frankenia (*Frankenia palmeri*); salt bush (*Atriplex* sp.); and white bursage (*Ambrosia dumosa*). Cholla cactus (*Cylindropuntia bigelovii*) commonly occurs in dense clusters on sand dunes adjacent to some of the bays and estuaries.

Two large estuaries and a number of smaller ones occur in the vicinity of Puerto Peñasco. The estuaries Morua and la Pinta are located east of the town, and a number of less-developed and extinct estuaries occur along Bahía Adair. Brusca (2004:3) uses the term “estero” to denote that they are “non-mangrove coastal lagoons lacking regular freshwater input (these habitats are also known as coastal lagoons, tidal lagoons, hypersaline lagoons, and negative estuaries). They are saltier at their head than at their mouth, due to high evaporation and lack of freshwater inflow.”

Marine fauna in the area is diverse and abundant, although today many species have been seriously depleted by overfishing. Intertidal habitats include rocky tidal pools and estuaries. Ecologically, the two most important zones of the upper Gulf for the prehistoric peoples of the area were the high-intertidal and the midintertidal zones (Brusca et al. 2004; Foster...
The high-intertidal zone consists of the intertidal and shallow rocky shore, which is exposed twice daily. The upper Gulf is subject to some of the most extreme tidal changes in the world. The high-intertidal zone contains an abundance and variety of marine fauna suitable for human consumption, including oysters, a variety of clams, octopus, sea urchin, and fish. The midintertidal zone consists of sand beaches and tidal flats, which are very broad when exposed during low tides. Food sources within this zone include mussels, conchs, various bivalves and gastropods, sea cucumber, crab, and fish. It also is possible that occasional large marine vertebrates such as sea turtles, dolphins, sea lions, and whales were available after becoming beached. Nonmarine food sources may have included shore birds (e.g., osprey, pelicans, gulls, heron), small desert fauna (e.g., rabbits, rodents), and desert plants.

**REGIONAL PALEOENVIRONMENT**

Floral remains from well-dated packrat middens provide a climate history of the southern Sonoran Desert. These data, based on plant communities and modern plant-climate associations, are perhaps most reliable as a record of rainfall amounts and seasonal patterns; however, some generalizations about temperatures can also be made. In a survey of packrat midden records of the Sonoran Desert, Van Devender (1990; Van Devender et al. 1990) reported two study locations north of the Puerto Peñasco area that represent the Lower Colorado subdivision of the Sonoran Desert. In both locations the vegetation remained desert scrub throughout the Holocene, implying that the climate remained broadly similar to today, although there is ample evidence for a wetter Early and Middle Holocene.

The climatic record of the Hornaday Mountains, approximately 70 km due north of Puerto Peñasco on the north side of the Pinacate Mountains, is based on 10 packrat middens that occur at elevations from 240 m to 260 m and that cover the last 10,000 14C years (Van Devender et al. 1990). The flora indicates an Early Holocene with significantly wetter and cooler winters. Throughout the Holocene the climate became progressively drier, and a modern bimodal (monsoon-style) rainfall pattern developed. After about 4,000 14C years B.P., the modern desert scrub assemblage is established, although there was more available water than today. Around 1,800 14C years B.P. there are indications of very strong late-summer monsoons. After 1,720 years B.P. more xeric conditions arose, and increasing aridity continued until today.

Packrat middens from the Tinajas Altas Mountains, 60 km north of the Hornadys, contain a very similar record for this region (Van Devender 1990). In the Middle Holocene higher species diversity, greater abundance of more mesic vegetation (today limited to washes), and dominance by desert lavender indicate higher rainfall. This study estimates the amount as 20 percent higher than today’s rainfall. The monsoonal rainfall pattern had been established by about 9,000 years
B.P., and summer rains were significant. After about 4,000 $^{14}$C years B.P. the modern drier climate was established, and the flora resembled that seen today. Summer rain exceeded the winter contribution.

Seasonal temperatures increase throughout the Holocene from the significantly cooler late glacial times, culminating in today’s environment—the hottest and driest climate of the last 10,000 years. At both localities there is a large variance in the Late Holocene flora through time. Within the trend to drier climates there were occasional wetter intervals. The climate, therefore, was highly variable; short-term drought alternating with series of wetter years made subsistence and travel in this region difficult.

**GEOMORPHIC OBSERVATIONS**

The Puerto Peñasco geomorphic setting influences the occurrence and preservation of shell middens along the coast. The Gulf of California marks the boundary between the North American and Pacific lithospheric plates, where tectonic forces have created an elongated and narrow gulf with relatively shallow offshore slopes at its northern end. One of the consequences of this configuration is a tremendous tidal range of approximately 8 m creating conditions favorable for the capture of fish and shellfish. As the tide retreats, large tidal flats are exposed and estuaries are almost completely emptied, facilitating the capture of fish in tidal channels and pools. The high tidal range also contributes to strong tidal currents and transport of sediment. This has resulted in the formation of barrier island complexes southeast of Puerto Peñasco that have created protected lagoons and estuaries that provide favorable habitat for fish, shellfish, and waterfowl.

Despite active tectonism in the region surrounding the northern Gulf of California, the area around Puerto Peñasco has remained vertically stable over the last several hundred thousand years (Ortleib 1991). This contrasts with coastal zones along the Baja Peninsula and between Bahía Adair and the Colorado River delta, where the region has experienced late Quaternary tectonic uplift associated with the Punta Gorda and Cerro Prieto faults. Inland from the Puerto Peñasco area is a broad plain mantled with eolian sands known as the Desierto de Altar. Stream channels are poorly developed across this desert plain, as most water infiltrates into the subsurface before reaching the sea. The largest fluvial system is the Río Sonoyta, which originates in the mountainous area near the Arizona-Sonora border and flows south to form a broad distributary alluvial fan east of Puerto Peñasco. In the past, the Río Sonoyta extended to Estero Morua (Davis et al. 1990), but today the system seldom flows and is largely covered by dune sand.

Due to relative tectonic quiescence, past changes in sea level within the Puerto Peñasco area have been driven by climate change, that is, glacial-interglacial oscillations of the Quaternary. Ortleib (1991) recognizes a single marine terrace in the Puerto Peñasco area that he correlates with the previous interglacial high
stand approximately 120,000 years ago, commonly referred to as Oxygen Isotope Stage 5e (Bradley 1999:206–214), based on morphostratigraphic relationships and uranium-series dates on shell from Bahía Adair. This terrace is best exposed near the Colorado River delta where it has been uplifted. At Bahía Adair, it is exposed through wave erosion and forms a prominent cliff (Figure 2). Closer to Puerto Peñasco, the terrace is less prominent and obscured by eolian sand. Current sea level in the Puerto Peñasco area was established approximately 5,000 years ago in association with global eustatic sea level stability.

Most of the shell middens in the Puerto Peñasco area are associated with Late Holocene eolian dune sand. Stratigraphic exposures are few, although wave erosion has produced exposures of marine and eolian deposits at a few localities between Bahía Adair and Estero Morua. These localities reveal a similar stratigraphic sequence: Late Holocene eolian dune sand containing shell middens.
unconformably overlying a mature Late Pleistocene paleosol. The paleosol is quite visible and marked by clay and/or calcium carbonate development (Stage II+) formed into eolian and marine deposits (see Figure 2). Given slow rates of soil formation in this arid region (e.g., Slate et al. 1991), the paleosol marks the stabilization of beach deposits following sea level retreat after the $^{18}$O-Stage 5e high stand.

Since cessation of the most recent sea level advance 5,000 years ago, sand dunes produced along the coast have encroached inland (Davis et al. 1990). In places these dunes, perhaps supplemented by infrequent runoff from fluvial systems such as the Río Sonoyta, have cut off and isolated parts of former estuaries resulting in flat-bottomed pans or playas located several kilometers inland from the coast. Numerous shell middens occur along the edges of these inland pans, attesting to their previous connection to the sea. Both active and coppice dunes are present in the Desierto Altar, with shell midden material commonly occurring at the surface in areas of deflation. However, buried middens with associated charcoal layers are also present in places and appear to maintain good stratigraphic integrity.

**PREVIOUS RESEARCH**

The Puerto Peñasco shell middens were first reported by Lowe (1934, 1935), but it was Gifford’s (1946) reconnaissance survey of the area in 1944 and 1945 that produced the first archaeological discussion of the region. Gifford recorded three midden sites, one at Punta la Cholla (Cholla Bay/Bahía Adair) and two along the Estero Morua. He reports these as “having the appearance of material (mostly shell) left by occasional or seasonal visitors to the region who, due to the dearth of water, could tarry but briefly” (Gifford 1946:216).

Gifford returned to Puerto Peñasco in the winter of 1948–1949. During that time he tested his three sites, collecting sherds, lithic artifacts, shell, and bone. We examined his (Gifford n.d.) notes and correspondences from this work, which are on file at the Robert Lowie Museum of Anthropology at the University of California at Berkeley. He sent material to various experts for analysis, including some shell that was sent to the University of Chicago for radiocarbon dating. However, we found no correspondence discussing the results of any dates or evidence that they were processed. The analysis of the faunal material Gifford collected identified bird bone (species unidentified), sea lion, and possibly whale.

In the 1960s and 1970s, archaeologists from Arizona State University (ASU) made collections from midden sites in the area of the Estero Morua and Cholla Bay. Thomas Bowen ventured into the area in the 1960s and recorded several sites. In the 1970s, John Foster (1975) studied sites at Estero Morua, several of which had been recorded by Bowen. Foster’s study focused an ecological reconstruction of the estuary. He attempted a relative quantification of the different
shellfish species, concluding that there was evidence of change in the species composition in the estuary over time.

More recently, the Instituto Nacional de Antropología e Historia (INAH) conducted surveys and limited testing in the area between Puerto Peñasco and Punta Pelecano near Cholla Bay (Rodriguez Sanchez 1996). Twenty-two sites were recorded, and test excavations were conducted at four. The sites consisted of shell middens with few artifacts on the surface. Test units revealed that the sites were shallow, usually not much deeper than about 50± cm. Artifacts recovered from the sites included hammerstones, ceramics, a mortar, and basalt debitage. Archaeologists from the INAH also recorded middens north of Cerro Colorado (Cerro Prieto?), where they reported Archaic period and later ceramic period remains of the Trincheras culture (Martinez Ramirez and Oliver 1999). A more detailed discussion of artifacts documented is presented below.

CURRENT STUDY

The 49 archaeological loci we have recorded occur between the northeastern end of Bahía Adair and Estero la Pinta (Foster and Mitchell 2000; Mitchell and Foster 2000, 2002) (Figure 3). These range in size from what appear to be single-event cooking and consumption episodes (a lunch break or overnight camp) by a single individual or a very small number of individuals to loci that extend several kilometers along the edge of an estuary (Figures 4 and 5). The latter clearly represent multicomponent sites that were repeatedly used over many hundreds of, if not several thousand, years as places for the capture, preparation, and consumption of shellfish and other marine species. Nevertheless, although there is a substantial accumulation of shell at such sites, it is estimated that deposits of shell even at these sites are generally less than a meter in depth.

ARTIFACTS

Artifacts are not particularly abundant on any of the sites that have them, although John Foster (personal communication 2001) indicated that at the time of his survey in the 1970s artifacts were common on the sites he visited. Undoubtedly, the explosion in tourism has significantly impacted the integrity of the sites in the area as recreational collection of prehistoric artifacts has occurred.

CERAMICS

Ceramics are dominated by Hohokam plain and buff wares. The Hohokam sherds observed at these sites include Sacaton red-on-buff (A.D. 950–1150), Gila
FIGURE 3. Archaeological loci recorded by this project.
FIGURE 4. Locus 2, a midden on an eroded dune overlooking Cholla Bay (arrows point to charcoal lenses at the top and bottom of the midden).

FIGURE 5. Black murex (*Hexaplex nigritus*) at Locus 48.
Plain, Gila Bend variety, Vahki Plain (A.D. 400–600), and probably Sells Plain (A.D. 1200–1400) (Gifford 1946). These suggest some form of Hohokam presence in the area from circa A.D. 400 to 1400+ (see Dean 1991). The ASU collection contained Gila Plain (probably Gila Bend variety), Santa Cruz red-on-buff (A.D. 750–950), and Santa Cruz or Sacaton red-on-buff. Rodríguez Sanchez (1996) reported a plainware (probably Gila Plain) sherd and two Sacaton red-on-buff sherds.

Some prehistoric Yuman and Trincheras sherds are reported for the area. However, other than Yuman types, we have not identified any Trincheras or other types. The Yuman sherds (Gifford 1946)—Black Mesa Buff, Tumco Red (probably Tumco red-on-buff), and Tumco Buff—indicate Yuman use of the area between A.D. 700 and 1500 (Waters 1982a, 1982b). Gifford (1946:221) noted that the Yuman sherds occurred in the Punta la Cholla area but were not represented at his sites in the Estero Morua area where Hohokam ceramics occurred. However, the occurrence of Hohokam sherds seems more widespread than Gifford suggests. Nevertheless, Yuman sherds do appear to be more common in the Bahía Adair area than farther east. The presence of Trincheras purple-on-red (Gifford 1946) suggests a link, albeit limited, to the Trincheras area of western Sonora between A.D. 1000 and 1300 (Bowen 1976; Johnson 1966; McGuire and Villalpando 1989; Villalpando 2000).

**FLAKED STONE**

Flaked-stone artifacts are sparse at the sites recorded. Artifacts identified or reported include a San Pedro point (cf. Huckell 1995:Figure 4.1j, k, Figure 4.13a), a small late Hohokam or perhaps early protohistoric O’odham point, small obsidian and chert bifaces, a small side-notched point, and debitage. Gifford (1946) lists a crescent-shaped flake tool among the artifacts he observed in the Punta la Cholla sites and some debitage at the Río Sonoyta sites. Small amounts of obsidian, probably from the Sierra Pinacate, have been found. Most appear to be from small pebbles. The ASU collection contained basalt flakes.

The bifaces (Figures 6a and 6b) and San Pedro point (1200–800 B.C.) are of particular interest in that they represent a probable Late Archaic period (1500 B.C.—A.D. 150) use of the area. The San Pedro point (Figure 6c), made from highly siliceous rhyolite with phenocrysts, was found on Locus 25 adjacent to the Estero Morua. The small side-notched point (Figure 6d) is reported by R. Cudney in Martínez Ramírez and Pastrana Oliver (1999). They discussed this as a small Archaic point, but it is very similar to late Hohokam or perhaps protohistoric O’odam points (cf. Loendorf and Rice 2004:48–51, Figure 7a, b). Based on the published photograph, the specimen appears to have had the tip broken off and is estimated to be 1.5–1.74 cm in length.
FOSTER, MITCHELL, HUCKLEBERRY, AND DETTMAN

Ground stone implements appear to be somewhat more common than flaked-stone artifacts. Slab and basin metates (Figures 7a and 7b), mortars (Figure 7c), and manos (Figures 7d and 7e) have been recorded. At the Punta la Cholla sites, Gifford (1946) reported the presence of a possible hammerstone, stone mullers, and a pestle, and at the Río Sonoyta sites he reported a metate, muller fragments, and an elongated cobble pestle.

**GROUND STONE**

Surprisingly few shell artifacts have been observed. Two Glycymeris bracelet blanks (Figures 8a and 8b), and numerous Dosinia ponderosa shell choppers (Figure 8c) (e.g., Tyree 1998; Rosenthal 1977) have been recorded. These shell choppers have also been found on prehistoric sites in the Papaguería and on a historic Seri site on Isla San Lorenzo in the Gulf of California (Bowen 2005; Vokes 2000). It is likely these were multifunctional tools used for chopping, scraping, cutting, and sawing.

Gifford (1946) reports what he believed to be a pendant of a bivalve from _Arca pacifica_ and another made from a _Cardium procerum_ (= _Trachycardium procerum_). _Arca_ shells rarely appear to have been used for ornaments, and they often have worm trails on them that mimic incising. The lack of shell ornamental items, in any stage of production, is interesting. There is little doubt that the raw shell collected was transported inland for trade and jewelry production at base camps or village sites in the Papaguería. Surveys in the Sierra Pinacate and on the Arizona side of the border have resulted in the identification of trails, trade corri-
OBSERVATIONS OF THE PUERTO PEÑASCO AREA OF NORTHERN SONORA

...dors, shell petroglyphs along trails, and shell processing sites (Hayden 1972; Martynec 1989; Slaughter and Lascaux 2000). Sites in the western Papaguería, such as Verbena Village, Lago Seco (Huckell 1979), and Lost City (Fontana 1965), and in the eastern Papaguería sites such as Shelltown (Copus 1993; Howard 1993) are known as important components in the Hohokam shell trade and jewelry production.

**RADIOCARBON DATES**

Despite the limited amount of archaeological work in the area, 11 radiocarbon dates have been reported. All but one (an otolith) are derived from shell; 9 are...
FIGURE 8. Shell artifacts from the Puerto Peñasco area: (a and b) Glycymeris bracelet blanks and (c) Dosinia shell chopper.
OBSERVATIONS OF THE PUERTO PEÑASCO AREA OF NORTHERN SONORA

reported from the Bahía Adair area, and 2 are from the Estero Morua area (Table 1). Radiocarbon dating shell (and marine fish bone) is problematic because ancient marine carbon incorporated into the animals makes the derived dates older than the actual date of the organism’s death. For the Gulf of California, uncorrected marine shell dates are 500 to 600 years older (Delta R age) than the actual archaeological context of the shell (Goodfriend and Flessa 1997; Stuiver, Pearson, and Brazunas 1986).

Three of the dates obtained by Julian Hayden (1981) are older than 30,000 years (beyond calibration). These led Hayden to speculate that some of the middens in the area were of great antiquity (Bowen 1998). A fourth date obtained by Hayden is around 10,000 years old. It is likely that these four dates were from Pleistocene age fossil shell deposits and were not cultural.

As part of a larger project focusing on environmental change in the Colorado River delta area, David Dettman (personal communication 2006) has recently run a radiocarbon assay on an otolith (the small calcium carbonate bones found in the inner ears of fish) from a site, Locus 46, at the northeastern edge of Bahía Adair. The 14C age was 5,711 ±42 years B.P. This date is certainly provocative in that it is Middle Archaic period in age. Calibrated using a Delta R age of 546 ±35 (an average of Delta R ages for the northern end of the Gulf of California), Dettman reports an age of 3630–3520 B.C. ±200/300. No ceramic sherds or other ceramic period artifacts were observed at the site. It is possible that it does represent a preceramic period site; however, such speculation requires verification.

Four other dates are more recent and fall within the expected range of the pottery-producing groups that are known to have used the area. When adjusted for ancient marine carbon, these range from around 1,500 to 1,000 years B.P. or A.D. 500–1000, a time during which the Hohokam intensively acquired marine shell and made marine shell jewelry.

Davis and others (1990:140) report two radiocarbon dates from Chione shell. One from First Salina yielded a date of 1,570 ±70 years B.P., and the other, from El Boroscano, is 3,450 ±50 years B.P. These two dates come from an area northwest of Puerto Peñasco, from sites near the railroad track between the station (railroad camp and well) at Gustavo Sotelo and the Cerro Prieto area, perhaps in the vicinity of our Locus 9 (or Locus 17 or Locus 23). These dates fall into the ceramic period and Late Archaic period, respectively.

SUBSISTENCE: SHELLFISHING AND FISHING

Shellfish have long been a source of nutrition for humans worldwide (e.g., Claassen 1998; Erlandson 2001; Waselkov 1987). The west coast of Mexico and the coasts along the Gulf of California are covered with numerous archaeological and historical examples of shellfish exploitation by their indigenous populations (e.g., Bowen 1976; Hubbs and Roden 1964; Mitchell and Foster 2000; Ritter 1985;
<table>
<thead>
<tr>
<th>Location</th>
<th>¹⁴C Date B.P.</th>
<th>Calibrated Dates¹</th>
<th>Material Dated</th>
<th>Context</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahía Adair</td>
<td>&gt;37,000</td>
<td>Shell (Chione sp.)</td>
<td>In dune, 10 cm below surface in clean, loose sand</td>
<td>Hayden 1981 (GX-7022)</td>
<td></td>
</tr>
<tr>
<td>Bahía Adair</td>
<td>&gt;37,000</td>
<td>Shell</td>
<td>20 cm below surface, in a paleosol of brown, caliche-bearing decayed sand</td>
<td>Hayden 1981 (GX-7023)</td>
<td></td>
</tr>
<tr>
<td>Bahía Adair</td>
<td>33,950 ±1,250</td>
<td>Shell</td>
<td>Surface</td>
<td>Bowen 1998:139 (GX-8190)</td>
<td></td>
</tr>
<tr>
<td>Bahía Adair</td>
<td>10,880 ±240</td>
<td>Shell (Pectin sp.)</td>
<td>Loose sand between dunes</td>
<td>Hayden 1981 (GX-7024)</td>
<td></td>
</tr>
<tr>
<td>Bahía Adair</td>
<td>1,525 ±125</td>
<td>A.D. 1163–1633</td>
<td>Not reported, probably shell</td>
<td>Bowen 1998:139 (GX-8191)</td>
<td></td>
</tr>
<tr>
<td>Bahía Adair</td>
<td>1,840 ±120</td>
<td>A.D. 836–1324</td>
<td>Not reported, probably shell</td>
<td>Bowen 1998:139 (GX-8192)</td>
<td></td>
</tr>
<tr>
<td>Estero Morua</td>
<td>2,010 ±55</td>
<td>A.D. 777–1064</td>
<td>Not reported, probably surface</td>
<td>Brusca 2004:16 (Gulf of Arizona)</td>
<td></td>
</tr>
<tr>
<td>Estero Morua</td>
<td>2,075 ±40</td>
<td>A.D. 734–995</td>
<td>Shell (Cardita affinis)</td>
<td>Brusca 2004:16 (Gulf of Arizona)</td>
<td></td>
</tr>
<tr>
<td>First Salina</td>
<td>1,570 ±70</td>
<td>A.D. 1228–1461</td>
<td>Shell</td>
<td>Davis et al. 1990:140 (Chione sp.)</td>
<td></td>
</tr>
<tr>
<td>El Borascado</td>
<td>3,450 ±50</td>
<td>855–518 B.C. (Chione sp.)</td>
<td>Not reported, probably surface</td>
<td>Davis et al. 1990:140 (U. of Arizona)</td>
<td></td>
</tr>
<tr>
<td>Bahía Adair</td>
<td>5,711 ±42</td>
<td>3630–3520 B.C.</td>
<td>Otolith</td>
<td>D. Dettman (personal communication 2006)</td>
<td></td>
</tr>
</tbody>
</table>

¹ Delta R corrected; 2-sigma date range. The CALIB 5.0 program was used to calibrate these dates using the Marine 04 calibration curve (http://radiocarbon.pa.qub.ac.uk/calib/index.html) based on a reservoir correction factor (Delta R) for the northern Gulf of California of 546 ±35 years (Regional Mean: Gulf of California North, from the global database at http://www.calib.qub.ac.uk/marine).
Villalpando 2000). Chione and oyster are the most commonly represented species in the Puerto Peñasco middens. Murex (Hexaplex nigritas) and Glycymeris were also popular, and to a lesser degree Strombus, Arca, Laevicardium, Trachycardium, Dosinia, and Argopecten. Table 2 lists the species that have been identified as food or probable food remains. It is of note that several of the genera consumed (e.g., Glycymeris, Laevicardium, Argopecten) were also used as a source of raw shell by the Hohokam and other prehistoric groups of the region for the making of jewelry (whole and cut shell).

The nutritional potential of shellfish is high. Although the caloric value of shellfish is generally lower than many terrestrial animals, they yield high-quality protein that is often the equal of fish and that equals or surpasses that of many plant species. Shellfish provide niacin, ample amounts of amino acids, various minerals and vitamins, and omega-3 fatty acids. The amounts of the nutrients vary seasonally and by gender and are influenced by the environmental setting (Claassen 1998:183).

Perhaps the best example of the use of shellfish, from a northwestern Mexico perspective, is the Seri Indians of the central coast of Sonora. Shellfish played an important role in their diet prehistorically and historically (Bowen 1976; Felger and Moser 1985:36-38), and the list of shellfish (Felger and Moser 1985:37) captured and consumed by the Seri closely parallels the species found in the Puerto Peñasco middens. Thus, the Seri serve as a general model for shellfish procurement and preparation for the Puerto Peñasco remains (for other ethnographic examples, see also Bird and Bird 2000; Meehan 1982). The Seri also exploit a variety of other marine invertebrates and fish.

The majority of the shellfish species represented in the Puerto Peñasco middens lived close to shore in the high-intertidal and midintertidal zones (up to 10 m) or in estuaries (Skoglund 1970). Clams would have been collected during low tides by inspecting the beaches and mud (tidal) flats for trails or siphon holes. They could have then been dug up by sifting the sand or mud with one’s feet or fingers or by using a digging stick. Many of the gastropods represented would have been exposed at low tide and could have easily been collected. It is also possible that some of the species may have been obtained by diving or by using a drag net. Oysters, attached to rocky substrate or fossil shell beds in the estuaries and bays of the area, would have been easily seen during low tide and could have been pulled or knocked off their roosts with little effort. Felger and Moser (1985) describe Seri use of most of these methods and further indicate that women are generally the ones participating in shellfish collecting, although men and children help as well (see Bird and Bird 2000).

The Seri cooked shellfish by steaming them, placing them around hot coals, boiling them, placing them on a grill (a rather recent innovation), or eating them raw (Felger and Moser 1985). Larger species, such as black murex, are cooked by burning sticks over them. Meehan (1982) reports that Australia's Gidjingali cook...
<table>
<thead>
<tr>
<th>Species</th>
<th>Habitat</th>
<th>Food or Probable Food</th>
<th>Examples of Use in the Southwest and Northern Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agaronia testacea</td>
<td>Intertidal; 0–10 m</td>
<td>X</td>
<td>Whole shell pendants, finger rings</td>
</tr>
<tr>
<td>Arca pacifica</td>
<td>Intertidal; bottom dwelling; coastal lagoons and estuaries; 0–10 m</td>
<td>X</td>
<td>Whole shell pendants, finger rings</td>
</tr>
<tr>
<td>Argopecten circularis</td>
<td>Intertidal; 0–135 m</td>
<td>X</td>
<td>Whole shell pendants, finger rings</td>
</tr>
<tr>
<td>Carditamera affinis</td>
<td>Intertidal; bottom dwelling; coastal lagoon and estuaries; 0–10 m</td>
<td>X</td>
<td>Whole shell pendants, finger rings</td>
</tr>
<tr>
<td>Cerithidea albonodosa</td>
<td>Intertidal and midtidal; 0–30 m</td>
<td></td>
<td>Whole shell beads</td>
</tr>
<tr>
<td>Cerithium sp.</td>
<td>Intertidal; coastal lagoons and estuaries; 0–10 m</td>
<td>X</td>
<td>Disk beads, tubular beads</td>
</tr>
<tr>
<td>Chama sp.</td>
<td>Intertidal; coastal lagoon and estuaries; 0–82 m</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chione californiens</td>
<td>Intertidal; coastal lagoon and estuaries; 0–80 m</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chione undatella</td>
<td>Intertidal; coastal lagoon and estuaries; 0–90 m</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chione fluctigraga</td>
<td>Intertidal; coastal lagoon and estuaries; 0–25 m</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Conus regularis</td>
<td>Intertidal; 5–90 m</td>
<td>X</td>
<td>Tinklers, pendants</td>
</tr>
<tr>
<td>Crucibulum spinosum</td>
<td>Intertidal; coastal lagoon and estuaries; 0–61 m</td>
<td>X</td>
<td>Armlets, pendants</td>
</tr>
<tr>
<td>Dosinia ponderosa</td>
<td>Intertidal; coastal lagoon and estuaries; 3–110 m</td>
<td>X</td>
<td>Bracelets, whole shell pendants, finger rings</td>
</tr>
<tr>
<td>Glycymeris gigantea</td>
<td>Intertidal; coastal lagoon and estuaries; 0–92 m</td>
<td>X</td>
<td>Bracelets, whole shell pendants, finger rings, frog effigies</td>
</tr>
<tr>
<td>Glycymeris maculata</td>
<td>Intertidal; coastal lagoon and estuaries; 0–84 m</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hexaplex (Muricanthus) nigritos</td>
<td>Intertidal; coastal lagoon and estuaries; 0–60 m</td>
<td>X</td>
<td>Pendants, horn (trumpet), whole shell burial offerings</td>
</tr>
<tr>
<td>Hexaplex princeps</td>
<td>Intertidal; coastal lagoon and estuaries; 0–60 m</td>
<td>X</td>
<td>Pendants, horn (trumpet), whole shell burial offerings</td>
</tr>
</tbody>
</table>

**TABLE 2.** Some Mollusks Identified in the Puerto Peñasco Middens

[Q21: What does "X" represent in this table? Could we use em-dashes instead?]
<table>
<thead>
<tr>
<th>Species</th>
<th>Habitat</th>
<th>Depth</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laevicardium elatum</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>0–161 m</td>
<td>Cut shell ornaments, bracelets, armlets, scoops, whole shell burial adornments</td>
</tr>
<tr>
<td>Lyropecten subnodosus</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>30–70 m</td>
<td>?</td>
</tr>
<tr>
<td>Melongena patula</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>0–2 m</td>
<td>Pendant, horn (trumpet)</td>
</tr>
<tr>
<td>Modiolus capax or Mytilus guyanensis</td>
<td>Intertidal on rocks and boulders; mud up to 46 m</td>
<td>X</td>
<td>Whole shell beads</td>
</tr>
<tr>
<td>Olivella sp.</td>
<td>Intertidal; 0–10 m</td>
<td>X</td>
<td>Whole shell beads</td>
</tr>
<tr>
<td>Ostrea angelica</td>
<td>Bays and estuaries</td>
<td>X</td>
<td>Whole shell pendants, finger rings</td>
</tr>
<tr>
<td>Ostrea palmula</td>
<td>Bays and estuaries</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pecten vogesi</td>
<td>Intertidal; 0–155 m</td>
<td>X</td>
<td>Whole shell pendants, finger rings</td>
</tr>
<tr>
<td>Phyllopecten (Hexaplex)</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>0–100 m</td>
<td></td>
</tr>
<tr>
<td>Polinices uber</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>0–100 m</td>
<td></td>
</tr>
<tr>
<td>Pteria stema</td>
<td>Off shore; weedy muds; 1–30 m</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Solenosteira macrospira</td>
<td>Intertidal and offshore; 0–73 m</td>
<td>X</td>
<td>Disk beads</td>
</tr>
<tr>
<td>Spondylus princeps</td>
<td>0–25 m</td>
<td>X</td>
<td>Horns (?) (trumpets)</td>
</tr>
<tr>
<td>Strombus gracilis</td>
<td>Intertidal; 0–10 m</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Tegula sp.</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>0–1 m</td>
<td></td>
</tr>
<tr>
<td>Trachycardium panamense</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>0–65 m</td>
<td></td>
</tr>
<tr>
<td>Turbo fluctuosus</td>
<td>10–30 m</td>
<td>X</td>
<td>Whole shell pendants, tinkers</td>
</tr>
<tr>
<td>Turritella gonostoma</td>
<td>Intertidal; coastal lagoon and estuaries</td>
<td>0–2 m</td>
<td></td>
</tr>
</tbody>
</table>


clams in a similar fashion. This method requires a limited amount of fuel and thus a limited amount of time. The small charcoal lenses containing some shell (Figure 9) observed in road cuts, the eroded faces of dunes, and within midden deposits appear to be manifestations of this cooking technique.

The larger gastropods consumed apparently required additional cooking time; their shells usually exhibit greater evidence of burning. Additionally, these required more effort to extract the meat. Black murexes often have holes broken in the main body whorl and on the opposite side of the aperture (Figure 10a). The holes, which were likely produced using a hammerstone or perhaps another shell, were used to facilitate the removal of the meat. *Strombus gracilior* and *Melongena patula* shells often have substantial portions of their outer lips broken away, presumably also to make the extraction of the meat easier (Figures 10b and 10c). Waselkov (1987) notes that cooking, either roasting or boiling, of gastropods causes the muscle of the animal to relax and makes extraction of the meat from the shell much easier.

As previously discussed, numerous examples of the large clam *Dosinia* were broken in a way that forms a sharp cutting or chopping edge. The meat of such larger clams is extremely tough when cooked and can only be eaten after being tenderized, sliced, or chopped into smaller pieces. It is possible that *Dosinia* choppers may have been used for tenderizing the meat of the animal.
It is likely that most of the shellfish represented in the Puerto Peñasco area middens was cooked and consumed on the spot. However, it is possible that cooked shellfish meat or meat that had dried or been salted could have been carried as food on logistical treks or taken back to base camps or to villages located within the Papaguería. Henshilwood and others (1994), experimenting with mussels, have shown that shellfish can be effectively dried by cooking and will last for several days. The meat from cooked shellfish was free of bacteria and was considerably lighter than the uncooked meat. They also found that small fires were suitable for cooking the shellfish.

**FISHING**

In addition to shellfish remains, the Puerto Peñasco area middens often include fish bone and crab remains. Varieties of fish are and were historically abundant in the Gulf; however, our understanding of the role of fish in the prehistoric subsistence activities of the area is unclear. Fish could have been speared, netted, or

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**FIGURE 10.** Food shells showing damage from the extraction of meat: (a) *Hexaplex nigritus*, (b) *Strombus gracilior*, and (c) *Melongena patula*. 
trapped after they were stranded in tidal pools. Species identified from Gifford’s (1946) Cholla Bay and Estero Morua sites include sicklefin smoothhound (*Mustelus lunulatus*), Pacific sharpnose shark (requiem shark, *Scoliodon longurio*), Gulf grouper (basses, *Mycteroperca jordani*), striped mullet or lisa (*Mugil cephalus*), Pacific porgy (*mojarrón chino* or *morarra garabata* (*Calamus taurinus*), orangemouth corvine (*Cynoscion xanthulus*), totuava or totoaba (*Cynoscion macdonaldi*), Gulf opaleye (*Girella simplicidens*), and the fine-scale triggerfish (*Verruculus polylepis*) (Follett 1957). Follett (1957) reports that these species were being eaten at San Felipe, Baja California, and that most were 40–80 cm long. While we have observed noticeably smaller specimens in the tidal pools of the area, it is likely that the larger estuaries that become isolated during low tides would contain larger individuals.

Additionally, the recent discovery of a midden site at the north edge of Bahía Adair resulted in the identification of hundreds of otoliths mixed with the shell. The site sits at the edge of a vast tidal flat that could have been fished at low tide using fish traps or nets. The otolith processed for the radiocarbon date reported in this discussion was from a species of *Micropogonias*, a croaker.

**OTHER SPECIES**

Crab claws and occasionally carapace and leg fragments have also been identified in the middens. These appear to be from blue crab (*Callinectes bellicosus*). Crabs could have been chased down on the beach, caught in tidal pools, or pulled from pockets in the reefs exposed at low tide. These remains generally appear to have been burned, so it is assumed that they were cooked in an open fire. It is also possible that the occasional beached whale, dolphin, or nesting sea turtle might have been encountered and butchered (e.g., Gifford n.d.).

**SUMMARY**

Despite the limits of our research, we have been able to better define the extent and nature of prehistoric use of the Puerto Peñasco area. It appears that the prehistoric local environment, based on regional paleoclimatic studies, was much the same as it is today. Inlets and estuaries of various sizes appear to have been more common than today, but the number and configuration of these undoubtedly changed through time. It appears that the area was being used at least by the Late Archaic period lasting perhaps into the Protohistoric period, with the peak of use between A.D. 500 and 1000/1200. This assumption is based on the presence of temporally diagnostic artifacts (projectile point types and decorated ceramic types) and a smattering of radiocarbon dates (most of which are from less than sound cultural contexts). The most intensive use of the area appears to
have been associated with the acquisition, directly or indirectly, of raw marine shell by the Hohokam. It is our assumption that Hohokam of the Papaguera, in the Gila Bend vicinity, were primarily responsible for the Hohokam-related archaeological materials in the Puerto Peñasco area. During Colonial and Sedentary times, they were probably responsible for procuring shell and trading it (both raw and finished products) with the Hohokam core area in central and southern Arizona. Numerous trails, trade corridors, shell petroglyphs, trail markers, and shell-processing sites have been documented in the western Papaguera (e.g., Fontana 1965; Hayden 1972; Huckell 1979; Martynec 1989; Slaughter and Lascaux 2000) as well as in the eastern Papaguera (e.g., Copus 1993; Howard 1993). The lack of processed raw shell (bracelet and pendent performs) and shell-working tools and debris on the Puerto Peñasco middens attest to the fact that raw shell was being taken out of the area for working elsewhere.

Much of the shell refuse present in the middens is likely associated with shell-procurement forays into the area. While raw shell was being collected, shellfish, fish, and crabs were caught, prepared, and consumed. It is also likely that some of the remains are associated with a broader subsistence pattern that included treks, seasonal or otherwise, to coastal areas for the procurement of marine resources. This may explain the presence of Archaic period remains, a time during which mobile foraging societies exploited a variety of environments for specific resources.

The Hohokam were not alone in their use of the area during the Formative period. Prehistoric Yuman and Trincheras sherds have been found in the area as well. The distribution of Yuman and Hohokam sherds suggest the possibility that a cultural boundary existed. Yuman sherds are more common in the area of Bahía Adair and appear to be rare to the east along the coast and around Estero Morua and Estero la Pinta. The Trincheras culture was also noted for its marine shell working. The Yumans were not noted shell workers, and their presence in the area may have been primarily associated with subsistence.

Clearly, the archaeology of the Puerto Peñasco area requires further systematic investigation. It holds the potential to expand our understanding of prehistoric human use of the Sonoran Desert and its varied environments. Unfortunately, the archaeological recorded of the region is disappearing quickly with the onslaught of commercial and recreational development of the area.

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We would like to thank Chris North, Ronald Towner, Jane Bradley, Charles Coyle, and an anonymous reviewer for their comments and insights. We also thank María Elisa Villalpando, the Centro INAH Sonora, and the Arizona Archaeological and Historical Society for their support of this project.
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