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Prehistoric Adaptation, Identity, and Interaction Along the Northern Gulf of California

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ABSTRACT

Archaeological investigations have been conducted along the northern coast of Sonora, Mexico where over 60 prehistoric middens have been identified around Bahía Adair and the town of Puerto Peñasco. The middens include low densities of pottery, chipped and ground stone tools, and some shell tools and ornaments, as well as molluscs, fish bones, crab claws, sea turtle bones, terrestrial animal bones, and charred plant remains. Radiocarbon dates indicate nearly continuous use of the coast from as early as 4,000 BC through late historic times. Pottery types found are associated with the Patayan, Hohokam, Trincheras, and the Ancestral Comcaac cultures. These middens were created by peoples occupying the western Papaguería who interacted extensively with neighboring groups in California, Arizona, and Sonora, Mexico. The Areneños (Sand Papago or *Hia ced O'odham*) occupied the area in historical times and their subsistence, settlement, and interaction patterns can be used as a model for prehistoric groups.

RESUMEN

Se han realizado investigaciones arqueológicas a lo largo de la costa norte de Sonora, México donde se han identificado más de 60 basureros prehistóricos alrededor de Bahía Adair y la ciudad de Puerto Peñasco. Los basureros incluyen bajas densidades de cerámica, herramientas de piedra picada y molida, y algunas herramientas y adornos de concha, así como moluscos, huesos de pescado, garras de cangrejo, huesos de tortugas marinas, huesos de animales terrestres y restos de plantas carbonizadas. Las fechas de radiocarbono indican un uso casi continuo de la costa desde 4,000 AC a través de los últimos tiempos históricos. Los tipos de cerámica encontrados están asociados con las culturas Patayan, Hohokam, Trincheras, del Ancestral Comcaac. Estos basureros fueron creados por personas que ocupaban el oeste de Papaguería que interactuaron ampliamente con grupos vecinos en California, Arizona y Sonora, México. Los Areneños (Sand Papago o *Hia ced O'odham*) ocuparon el área en tiempos históricos y sus patrones de subsistencia, asentamiento e interacción pueden usarse como modelo para grupos prehistóricos.

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Sporadic reconnaissance surveys have been conducted in the northern Gulf of California along the mainland coast of Mexico since the late 1990s. Over 60 discrete shell midden loci have been recorded along the bays and estuaries surrounding Puerto Peñasco (Foster and Mitchell 2000; Mitchell and Foster 2000; Foster et al. 2008). The shell middens of the northern Gulf of California coast have been known by scientists since the 1930s (Lowe 1934, 1935), and various very limited investigations were conducted along the Puerto Peñasco coast as early as the 1940s (Gifford 1946). More recently, development-related compliance work was conducted by the Instituto Nacional de Antropología e Historia (INAH) in the 1990s and 2000s (e.g., García Moreno 2006; Martinez-Ramirez and Pastrana-Oliver 1999; Rodriquez-Sanchez 1996), and there have been a few independent research projects (Brusca and Poulos 2000; Foster et al. 2008; Foster et al. 2012; Mabry et al. 2007; Mabry 2008).

This study recognizes that, in general terms, the coastal adaptions by prehistoric peoples in the northern Gulf of California were similar for Baja California, the Gulf of California islands, and mainland Mexico. Shellfish, fish, and sea turtles were important marine food resources in these areas for millennia. However, this paper focuses primarily on data and interpretations from surveys and excavations conducted between 2015 and 2018 in the Estero de Morúa and Bahía Adair areas, where evidence indicates that these contrasting coastal habitats generated different social practices and ownership strategies over at least the last 6000 years. Therefore, it contributes to the understanding of human-environment relations in the northern Gulf of California and western Papaguería regions and the uniqueness of adaptations to diverse coastal habitats. Furthermore, it employs ethnohistorical records of the Areneños (Sand Papago or *Hia ced O'odham*) that occupied the area in historical times as a model to interpret prehistoric groups and their subsistence, settlement, and interaction patterns. Finally, this study also serves as a starting point for future work in the area that seeks collaboration with the indigenous Tohono O'odham community through consultations with their Tribal Historic Preservation Office and Cultural Committee of the Tribal Council.

Environmental Setting

Descriptions of northern Gulf of California oceanography and ecology can be found in Lavín et al. (1995); Lavín et al. (1997); Lavín, Godínez, and Alvarez (1998), Beier and Ripa (1999), Ortega Guerrero et al. (2004), Lluch-Cota et al. (2007), Marlett (2014), and Brusca et al. (2017). The research region is marked by high aridity and erratic rainfall, averaging around 9 cm (3.5 in) of precipitation annually based on 1982–2005 data from Centro Intercultural de Estudios de Desiertos y Océanos/CEDO. Rain is spread through the fall (50%), winter (26%), and summer (18%) (Davis et al. 1990). Some of the heaviest, though infrequent rainfall events are associated with eastern Pacific tropical storms that are occasionally steered into the Northern Gulf in late summer/early fall, and in those years the annual rainfall can reach 20–25 cm (8–10 in). During dry years, precipitation can be less than 2.5 cm (1 in). Vegetation is generally sparse, consisting of drought- and salt-tolerant shrubs typical of the Lower Colorado subdivision of the Sonoran Desertscrub biotic community (Turner and Brown 1994). Packrat midden studies suggest that this coastal area has supported desertscrub vegetation throughout the Holocene (Van Devender 1990). There is little natural vegetation on the sand dunes where the archaeological sites are located. Charred remains found at these sites are consistent with the modern physical setting and include mostly weedy species, shrubby plants, and occasional small trees (see Mitchell et al. 2017, 2019).

Our study area includes sites primarily at two environmentally distinctive areas: (1) Estero de Morúa, located 10 km east of Puerto Peñasco at the terminus of one of the former channels of the Río Sonoyta, and (2) Bahía Adair, a broad embayment located ~40 km northwest of Puerto Peñasco along the southwestern boundary of the El Pinacate y Gran Desierto de Altar Biosphere Reserve (Figure 1).

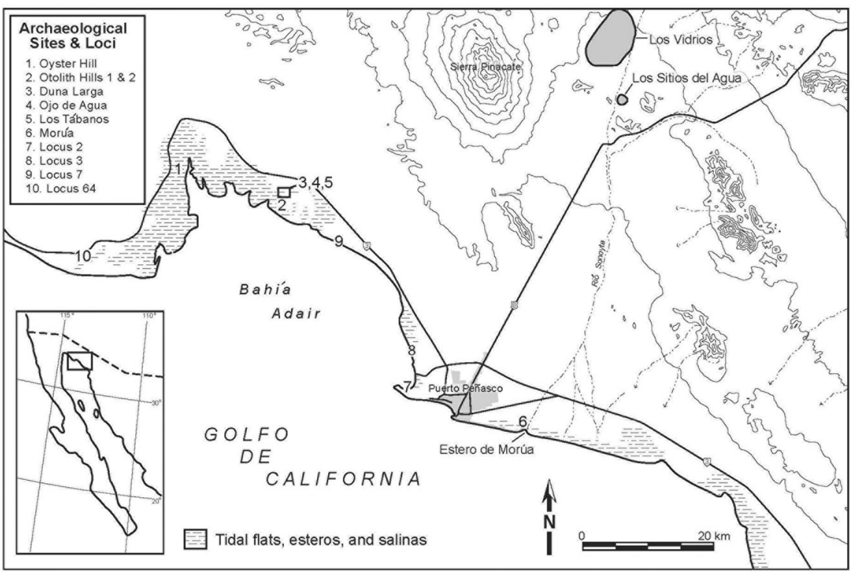

Figure 1. Puerto Peñasco study area showing investigated sites and nearby obsidian sources (Los Vidrios and Los Sitios del Agua). Map adapted from Instituto Nacional de Estadística y Geografía, Puerto Peñasco H1201 (1:250,000). 100 m contour interval.

The Bahía Adair-Puerto Peñasco coastal region is characterized by large seasonal fluctuations in onshore sea surface temperatures, commonly exceeding 18°C annually. Onshore water temperatures may reach 30–32°C in summer and may drop to 10–12°C in winter, although the usual winter temperatures are around 13–14°C (Brusca 1980). The intertidal region experiences an even greater range of temperatures because of periods of exposure to atmospheric conditions, and temperatures as high as 36°C have been recorded in tidepools at Puerto Peñasco. The Northern Gulf of California also periodically experiences exceptionally cold winters, during which onshore sea surface temperatures drop to 8 or 9°C (or less), and tidepool temperatures as low as 4°C have been recorded at Puerto Peñasco. In summer months, during slack tide periods, temperatures in the shallows of Estero de Morúa can exceed 40°C and salinities can skyrocket from the usual 36–39 ppt to 40–60 ppt. During spring tides Estero de Morúa fills to depths over 5 m at high water, and it drains completely at low water, leaving only a small shallow (~10 cm deep) drainage channel through the middle of the tidal flats.

Shell Middens: Geomorphology and Paleoclimate Evidence

Studies indicate that although the central Sonoran coastline is tectonically stable relative to the Colorado River Delta and Baja California Peninsula, the area around Puerto Peñasco is geomorphically dynamic with respect to three processes: (1) sea level change, (2) sand dune activity, and (3) Río Sonoyta channel shifting.

After stabilization of post-glacial global (eustatic) sea level approximately 6 ka, barrier island complexes developed at the mouth of the Río Sonoyta in the Estero de Morúa area and along parts of Bahía Adair, facilitating the development of protected lagoons and estuaries favorable to fish, shellfish, and waterfowl creating ideal habitats for human occupation. Although sea level at Estero de Morúa appears to have been stable since the middle Holocene, the central and northern portion of Bahía Adair contains stranded tidal flats with thick salt deposits (*salinas*) that are elevated above maximum tide and storm surges. These deposits imply local sea level retreat after 6 ka, likely related to uplift along the Punta Gorda and Cerro Prieto faults to the northwest (Colletta and Ortlieb 1984; González-Escobar et al. 2009; Panich, Shackley, and Porcayo Michelini 2017, 453).

Several of these stranded tidal flats contain small freshwater springs (*pozos*) adjacent to shell midden sites (Zamora et al. 2019). Shell midden sites consist of a dense pavement of shell on dune surfaces, usually adjacent to tidal flats, similar to reported middens from Baja California and the Gulf of California islands (e.g., see Bowen 2009; Camacho Araiza 2012; Celas-Hernández 2015; Laylander 2006; Miljour 2010). Radiocarbon dates of 3794–3528 BC (AA70059) on charcoal from a shell midden layer exposed in an eroded coastal dune at Locus 3, and 4273–3705 BC (AA99042) on a fish otolith from the surface of the Otolith Hill site (SON B:5:7), confirm human exploitation of marine resources in the study area at least as early as eustatic sea level stabilization (Foster et al. 2012).

Due to the long and narrow configuration of the gulf, and its shallowing in the north, tidal ranges of up to 7–8 m occur along the Bahía Adair-Puerto Peñasco coast, generating strong tidal currents and littoral transport of sediment. During low tides, broad tidal flats are exposed allowing sand to be entrained by the prevailing southerly winds (January through September) and blown landward, resulting in extensive dune fields. The largest dune systems extend several tens of kilometers northward from Bahía Adair into the Gran Desierto, crossing portions of the stranded tidal flats. The dunes at Estero de Morúa are concentrated along the water's edge, although an eolian sand sheet extends several kilometers to the north. Dune activity has undoubtedly obscured and eroded parts of the archaeological record, as suggested by extensive lag deposits of midden shell. Nonetheless, excavations confirm that in certain places buried features are well preserved.

The Río Sonoyta originates in the mountains along the Arizona/US-Sonora/MX border and flows west before turning south towards the coast. This ephemeral watercourse was likely a favored route for prehistoric peoples to the coast from the north. Approximately 20 km from the coast, the river forms a braided plain with multiple branching channels. Abandoned channels support only low desert shrubs, whereas the active lower channel bottom, which today joins the coast at Estero de la Pinta ~21 km east of Puerto Peñasco, is lined with mesquite (*Prosopis* spp.) and paloverde (*Parkinsonia* spp.) trees, indicating a subsurface water flow. A paucity of shell midden sites along the active lower channel contrasts with Estero de Morúa where shell midden material extends > 2 km inland along the edges of the westernmost paleochannel. This suggests that this paleochannel of the Río Sonoyta was flowing when these shell midden sites were occupied, but flood runoff later shifted ~10 km to the east due to channel avulsion. A ^{14}C date on midden charcoal of AD 1449–1632 AD (AA111917) from one of the investigated localities at the Morúa site (SON B:11:1) suggests this channel shift may have taken place as recently as the Protohistoric period.

The Río Sonoyta experienced intervals of more dependable surface water during Holocene periods of enhanced precipitation, likely associated with periods of relatively higher temperature resulting in increased summer monsoon rainfall in southwestern North America, and also with periods of increased frequency of the El Niño-Southern Oscillation (ENSO) events that contribute to greater winter precipitation in the region (Hall 2018). Regional proxy records for wetter conditions during the middle to late Holocene include a stratified pollen column from a spring mound (Davis, Jull, and Keigwin 1992), sediment sequences in an inland basin (Ortega Guerrero et al. 1999), and plant remains in packrat middens in mountain ranges (Van Devender 1987, 1990; Van Devender, Thompson, and Betancourt 1987). A few radiocarbon dates associated with these proxy paleoenvironmental records bracket a period of higher runoff between ~5000 and ~2500 BC, an episode of increased spring discharge after ~2000 BC, and episodes of increased summer rainfall near ~2500 BC and ~AD 1100. However, the temporal boundaries of these intervals may change with additional chronometric data.

Shell Middens: Archaeological Evidence

Reconnaissance surveys of the area and test excavations have been conducted at one site along Estero de Morúa named the Morúa site (SON B:11:1) and five sites along Bahía Adair: Otolith Hill (SON B:5:7), Ojo de Agua (SON B:5:8), Los Tábanos (SON B:5:9), Duna Larga (SON B:5:10), and Oyster Hill (SON B:5:11) (see Figure 1). The employed methodology to document these shell middens consisted of close interval surveying, point locating and collecting selected diagnostic artifacts, shovel tests, and the excavation of 1 by 2 m units in 20 cm levels. Buried charcoal and shell lenses were encountered at four of these sites (Figure 2). In three cases, two at the Morúa site and one at Oyster Hill, we found evidence of informal hearths between 80 and 100 cm below the modern surface, from which we

Figure 2. Buried midden lens at Los Tábanos/SON B:5:9 (scale is 10 cm).

were able to obtain radiocarbon dates (see discussion below). Excavations produced subsistence remains such as charred plant remains, fish bones (including otoliths), terrestrial animal bones, mollusc shells, crab claws, and sea turtle bones. During the excavations, shells were sorted and weighed by genera and species.

Artifacts from the documented sites include chipped stone tools, flakes, cores, ground stone tools, pottery, occasional shell tools, and rarely, shell artifacts. Based on our surface counts and collections, surface artifact density is very low, ranging from about one to 12 artifacts per hectare (Table 1). The Morúa site presents the highest number and diversity of features indicating a broader span of social practices occurring at the Estero de Morúa area. The Morúa site is the largest complex of midden sites situated along an extinct channel of the Río Sonoyta where it formerly emptied into Estero de Morúa. Mapping and test excavations were conducted in 2005 (Mabry et al. 2007; see Mabry 2008) and additional testing was done in 2015 and 2018 by this project. Altogether, five excavation units were completed across this large midden site, one trench was profiled, and 11 radiocarbon dates obtained. The dates and diagnostic artifacts from the site indicate nearly continuous use from as early as 2570 BC through the sixteenth or seventeenth century AD. Today, Estero de Morúa continues to be harvested by locals for shellfish, mainly clams, and there are several active oyster farms.

North of Puerto Peñasco along the shores of Bahía Adair, five other sites (Ojo de Agua, Duna Larga, Oyster Hill, Los Tábanos, and Otolith Hill) have been investigated. Shovel testing along the dune tops that contained midden deposits guided the placement of test units. This strategy resulted in the discovery of buried deposits at three of those sites. Most common was the discovery of buried shell and charcoal lenses about 50–60 cm below the modern surface. Radiocarbon dates and artifacts from these sites indicate occupation in the area as early as 4000 BC, continuing possibly as late as AD 1300 or later (based on associated ceramic dates).

Nearly all the artifacts were recovered from surface contexts. Pottery found on the site surfaces was dominated by plain ware, but also included small numbers of painted sherds. Diagnostic sherds included those associated

Table 1. Artifact Quantity and Density from Midden Sites.

Site	No. of Artifacts	Site Length (m)	Site Width (m)	Site Area (ha)	Artifact Density (No. of Artifacts/ha)
Morúa, entire site*	307	–	–	380.00	0.81
Duna Larga	80	800	100	8.00	10.00
Ojo de Agua	53	425	165	7.01	7.56
Otolith Hill	32	420	90	3.78	8.47
Oyster Hill	28	550	300	16.50	1.70
Los Tábanos	24	325	60	1.95	12.31

Notes: * = see Brack (2008). Using the site length and width measurements likely overestimates the site area; however, for comparative purposes, this statistic is adequate.

with the Patayan culture of southwestern Arizona-southeastern California-northern Baja California (Lower Colorado buffware), the Hohokam culture of southern Arizona (Hohokam Red-on-buff and Wingfield Plain), and the Trincheras culture of northern Mexico (Trincheras Purple-on-red and Plain) (Figure 3), and the Ancestral Comcaac (Tiburon Plain) of the Sonoran north-central coast (see Table 2). Two sherds were also found that are associated with the historic O'odham.

Archaic (Figure 4) and ceramic style projectile points as well as flakes and cores have also been found on the surface of the middens. Chipped stone artifact material types were dominated by obsidian but also included small amounts of chert, basalt, and other stone. Ground stone artifacts included hand stones (informal tools), manos (formal grinding tools), grinding slabs, and stone pipe fragments. There are no natural stone sources inland near the coastal sites studied for this project. Low granite and basalt hills do occur between 10 and 35 km from the sites and there are natural obsidian sources in the nearby volcanic Sierra Pinacate (see Martynec, Davis, and Shackley 2011; Shackley 2005). Nearly all the identifiable obsidian found at the coastal sites is from the two known Pinacate sources, Los Vidrios and Los Sitios del Agua (Shackley 2015, 2016, 2018) located about 75 km to the east-northeast (see Figure 1 and Table 3). Some of the artifacts were produced from the Sauceda Mountains source located in southwestern Arizona. The samples were analyzed at the Geoarchaeological XRF Laboratory, Albuquerque, New

Figure 3. Selected painted sherds from the midden sites. Upper left, Trincheras Purple-on-red; upper right, Lower Colorado buff; lower left and right, Hohokam Red-on-buff.

Table 2. Ceramic Types Found at the Midden Sites.

Site or Locus	Lower Colorado River Buffware	Trincheras Purple on Red	Trincheras Plain	Hohokam Red-on-Buff	Wingfield Plain	Tiburon Plain	O'odham Plain (Folded Rim)	Undifferentiated Plain Ware	Total
Morúa*	X	12	–	1	19	2	–	36	70
Duna Larga	1	10	3	2	6	–	–	22	44
Los Tábanos		4	2?	1	–	–	–	8	15
Oyster Hill	1?	–	–	–	–	1?	–	10	12
Ojo de Agua	2	–	–	1	–	–	2	–	5
Locus 3	2	–	–	–	–	–	–	–	2
Total	6	26	5	5	25	3	2	76	148

Notes: X = present but counts not available; * = These sherds were found during Mabry's 2005 investigations at the Morúa site (Mabry, Carpenter, and Sanchez 2008; Mabry et al. 2007).

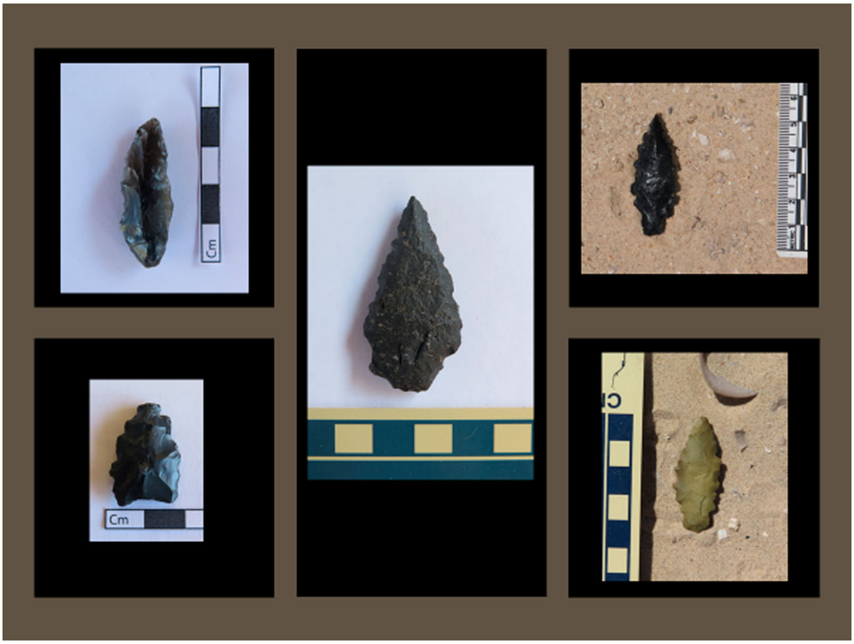

Figure 4. Selected projectile points and bifaces from the midden sites. From upper left clockwise: obsidian biface, Otolith Hill; basalt Empire point (San Pedro phase, 1200–800 BC), Duna Larga; obsidian and rhyolite Empire points, Locus 55 and Oyster Hill; untyped obsidian point, near Duna Larga.

Table 3. Sources of Obsidian Artifacts at the Midden Sites.

Site	Los Vidrios	Los Sitio del Agua	Sauceda	Unknown*	Total
Morúa	28 (61%)**	5 (11%)	2 (4%)	2 (4%)	46
Duna Larga	14 (64%)	6 (27%)	–	11 (50%)	22
Otolith Hill	3 (25%)	2 (17%)	1 (8%)	6 (50%)	12
Oyster Hill	5 (56%)	2 (22%)	2 (22%)	–	9
Los Tábanos	5 (71%)	1 (14%)	1 (14%)	–	7
Ojo de Agua	–	2 (67%)	1 (33%)	–	3
Locus 55	–	1 (33%)	2 (67%)	–	3
Total	55 (54%)	19 (19%)	9 (9%)	19 (19%)	102

Notes: * = this category includes four chemically distinct unknown sources; ** = row percentages.

Mexico using energy-dispersive x-ray fluorescence spectrometry on a Thermo-Scientific Quant'X spectrometer. Instrumental methods are described at http://swxrflab.net/anlysis.htm.

Subsistence and Seasonality

All the surveyed and excavated sites were dominated by shell and over 475 kg of shell from nine test units at five sites were inventoried. In general, the shell assemblages were dominated by oysters (*Ostrea* and *Saccostrea*) and venus clams (family Veneridae: *Chione*, *Chionista*) (Figure 5). There was some variability in shell species diversity at the sites (for example, compare the shell species in Table 4 from Oyster Hill and Otolith Hill) but all these species are common

Figure 5. Examples of the most common shell species found at the midden sites. Top, oyster (*Ostrea angelica* [formerly *Myrakeena angelica*]); bottom, venus clam (*Chione californiensis*).

Table 4. Density of Shells and Dominant Species from the Test Units.

Site	m^3	Kg of Shell	Kg/m^3	Comment	Shell Types
Morúa, Loc 3	1.6	76.21	47.63	one test unit	Oyster (52%), *Chione** (23%), *Glycymeris* (17%)
Morúa, Loc 4	1.6	39.57	24.73	one test unit	*Chione* (46%), Oyster (24%), *Glycymeris* (21%)
Morúa, Loc 5	1.8	107.22	59.57	one test unit	*Chione* (55%), *Glycymeris* (23%), Oyster (15%)
Otolith Hill	0.4	24.03	60.08	two test units	*Chione* (54%), *Hexaplex* (33%)
Los Tábanos	1.6	73.30	45.81	one test unit	Oyster (48%), *Chione* (44%),
Duna Larga	2.4	55.66	23.19	two test units	*Chione* (73%), Oyster (17%)
Oyster Hill	2.0	102.31	51.16	one test unit	Oyster (79%)

on tidal flats and in estuaries of the region today. It may be that different proportions of shellfish reflect a combination of human choice, the nature of the physical setting, seasonal abundance, altered abundance due to prior harvesting, and distributional patterns of mollusc species throughout the tidal flats.

The Morúa site presented the highest density and diversity in the studied areas. The three excavated units produced varying amounts of shell with some evident species diversity. For the Bahía Adair region, the two test units at SON B:5:10 (Duna Larga) produced 55 kg of shell, dominated by clams and oysters, the one unit at SON B:5:11 (Oyster Hill) produced 102 kg of shell dominated by oysters, and the one unit at Los Tábanos produced 73 kg, both clams and oysters. Two units at Otolith Hill had little depth and produced only 24 kg of shell, dominated by clams and muricid snails (the high weight to volume number in Table 4 reflects the larger size and weight of individual muricid snail shells compared to other shell species). Small fish bones (including otoliths), crab claws, and terrestrial animal bones were also recovered from all test units.

The crab species from the middens is the East Pacific blue crab, *Callinectes bellicosus*. This species is, by far, the most common of the 15 species of swimming crabs in the Gulf today. It is abundant in shallow water, especially in channels within *esteros* (high-salinity coastal lagoons lacking regular freshwater input) and tidal flats, where the sites are located. It is also one of the largest crabs in the Northern Gulf (Brusca 1980; Brusca, Kimry, and Moore 2004, 92) and is harvested commercially today throughout the region.

In addition to the remains of shellfish and crabs, abundant fish bones and over 600 otoliths (fish earbones) were recovered from subsurface contexts. Eighty-two percent of the otoliths were identified as belonging to the bigeye croaker or *chano norteño* (*Micropogonias megalops*), followed by 15 percent shortfin corvina (*Cynoscion parvipinnis*), and 2 percent totoaba (*Totoaba macdonaldi*). Other species have been identified from bone recovered from middens in this region (Follett 1957; Miljour 2008), including striped mullet (*Mugil cephalus*), Gulf grouper or *baya* (*Mycteroperca jordani*), possibly sicklefin smoothhound (or "suckling shark", *Mustelus lunulatus*), finescale triggerfish (*Balistes polylepis*), and Gulf opaleye (*Girella simplicidens*). Identifiable cartilaginous fish include stingray (*Urobatis* sp.) (Follett 1957; Mabry et al. 2007). These species all share the life history trait of being connected to nearshore habitats, estuaries, lagoons and river mouths (Thomson, Findley, and Kerstitch 2000; Thomson and Gilligan 2002; Brusca 2004). These protected and productive habitats are ideal for young juveniles to escape predation and grow and were also good habitats for prehistoric fishermen.

The Gulf of California is home to over 6200 named, marine, vertebrate and invertebrate species, nearly half of which occur in the Northern Gulf, many of which inhabit the several large bays and estuaries of this region (Brusca et al. 2005; Brusca 2007, 2010; Brusca and Hendrickx 2008). Estuaries and *esteros* are well-known spawning, nursery and refuge areas for many fishes (Hastings and Findley 2007). In addition, sea turtle bones, some of which were fire-charred, were recovered from surface contexts at Duna Larga and Oyster Hill and have previously been reported from subsurface contexts at the Morúa site (Mabry 2008; Miljour 2008). These remains may be from the common Pacific green turtle (known locally as black turtle; *Chelonia mydas*) or the less common Olive Ridley turtle, *Lepidochelys olivacea* (Jeffrey Seminoff, pers. comm. 2019).

The subsistence remains recovered from the middens by this project and previous ones (e.g., García Moreno 2006; Mabry et al. 2007; Mabry 2008) indicate that prehistoric groups were engaged in activities designed to obtain a wide variety of marine and terrestrial food resources. These activities included: (1) collecting a variety of shellfish from the intertidal zone of bays and estuaries, (2) catching fish in the waters of *esteros* (e.g., rays, mullet, and others); (3) catching fish in rocky tide pools outside the estuary (e.g., triggerfish, opaleye); (4) catching fish near rocky promontories or shallow rock reefs (e.g., croaker, corvina); (5) catching sea turtles when they strayed into an estero or came onto the beach to nest; (6) hunting small mammals, deer, antelope, birds, and reptiles; and (7) foraging for mesquite pods in the Río Sonoyta channel, and weedy annual plants nearby (Mabry et al. 2007; Mabry 2008). These activities are similar to those carried out by groups exploiting marine resources in Baja California and the Colorado River Delta (Guía Ramírez 2007, 2008; Porcayo Michelini 2010).

Cooking the shellfish was done using available shrubs as fuel. This method has been recorded historically for the Comcaac (also known as the Seris) (see Felger and Moser 1985) who live along the coast south of this region. It included setting clams and oysters on a flat dune surface, covering the shells with brush and twigs, and burning the material. After this brief roasting period, the meat could be extracted from the shells and eaten.

It is most likely that these middens were created primarily during the non-summer season. The summer heat, and perhaps less frequent freshwater sources, would make the coast an inhospitable place during this time of year. Gifford observed long ago (1946, 216) that the middens have "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." Isotope analysis of midden shells also supports this observation about seasonality (see Foster et al. 2012, 765–767; Mitchell et al. 2015, 43–44), indicating that shellfish collection was a late fall, winter, and perhaps early spring activity. However, there is evidence at the Morúa site for use of mesquite pods that ripen in the early summer. Perhaps the shallow water table in the Río Sonoyta channel provided equal or greater access to freshwater than the scattered *pozos* along Bahía Adair.

Other indications of the seasonality of occupation include the represented plant taxa, which become available in the spring (e.g., purslane) and early summer through fall (e.g., mesquite, amaranth). High environmental temperatures may have caused less frequent coastal visits in the summer, but people may have kept close ties to the coast year-round. The presence of sea turtle remains represents one or more seasons other than winter, the season when sea turtles either migrate to warmer waters or go to the sea floor in certain shallow areas of the Gulf and lie dormant from November to March (Felger, Cliffton, and Regal 1976). Furthermore, O'odham songs and oral history, and ethnographic data describe the O'odham salt pilgrimage to the Bahía Adair area (Darling and Lewis 2007) during the month of March, a tradition that has been recently revived (M. Hopkins, personal communication 2018).

These patterns of marine resource exploitation, subsistence strategies, and seasonality parallel those reported for midden sites on the Gulf side of Baja California (see Camacho Araiza 2012; Celas-Hernández 2015). Shellfish and fish were important resources at those coastal sites (also see Bowen [2009] for a discussion of prehistoric use of Gulf of California islands).

Ages of the Middens

Currently, the chronological framework for site occupations is provided by 36 accelerator mass spectrometry (AMS) radiocarbon dates from 11 sites and loci (see Table 5 and Figure 6), along with temporally diagnostic ceramic and stone artifact types. These data indicate nearly continuous use of this coastal area from as early as 4000 BC through the seventeenth century AD. Today, Estero de Morúa is harvested for shellfish and has several oyster farms. The Tohono O'odham have traditionally practiced men's salt pilgrimages to the salt flats (*salinas*) of Bahía Adair and continue to do so today.

The majority of the shell middens demonstrate long occupations presenting evidence for both Archaic- and ceramic-era uses. However, one site contains evidence for only a single early component (Otolith Hill [also see Mitchell et al. 2015]) and another for a single ceramic-era component (Los Tábanos),

Table 5. Radiocarbon Ages on Shell Midden Material from the Bahía Adair and Puerto Peñasco Area.

Location	Lab #	^{14}C yr BP (1 sigma)[1]	2 sigma Calibrated Age (Probability)	Median Probability	Calibration Dataset	Material	Context	Reference
Cholla Bay, Locus 2	AA70057	1983 ± 34	53 BC–AD 85 ($p = 1.000$)	AD 16	IntCal13	Charcoal	Erosion-exposed profile; 0.4–0.8 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 2	AA102297	2730 ± 30	294 BC–AD 319 ($p = 1.000$)	AD 24	Marine13	Shell	Erosion-exposed profile; 0.4–0.8 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 2	AA101191	2740 ± 30	319 BC–AD 289 ($p = 1.000$)	AD 12	Marine13	Shell	Erosion-exposed profile; 0.4–0.8 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 2	AA70058	2750 ± 38	993–987 BC ($p = 0.009$); 980–817 BC ($p = 0.991$)	891 B.C	IntCal13	Charcoal	Erosion-exposed profile; 3.4–3.5 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 2	AA102298	3360 ± 30	1010–402 BC ($p = 1.000$)	744 BC	Marine13	Shell	Erosion-exposed profile; 3.4–3.5 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 2	AA101190	3350 ± 30	997–399 BC ($p = 1.000$)	729 BC	Marine13	Shell	Erosion-exposed profile; 3.4–3.5 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 3	AA102321	4880 ± 20	3696–3641 BC ($p = 1.000$)	3661 BC	IntCal13	Charcoal	Erosion-exposed profile; 0.2–0.3 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 3	AA102293	5620 ± 40	3891–3346 BC ($p = 1.000$)	3603 BC	Marine13	Shell	Erosion-exposed profile; 0.2–0.3 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 3	AA102294	5660 ± 40	3916–3372 BC ($p = 1.000$)	3651 BC	Marine13	Shell	Erosion-exposed profile; 0.2–0.3 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 3	AA70059	4887 ± 57	3794–3627 BC ($p = 0.898$); 3589–3528 BC ($p = 0.102$)	3680 BC	IntCal13	Charcoal	Erosion-exposed profile; 1.3–1.4 m below surface	Dettman et al. 2015, Table 1
Cholla Bay, Locus 3	AA101188	5560 ± 40	3839–3258 BC ($p = 1.000$)	3538 BC	Marine13	Shell	Erosion-exposed profile; 1.3–1.4 m below surface	Dettman et al. 2015, Table 1
Bahía Adair, Locus 7	AA72869	2930 ± 40	1258–1246 BC ($p = 0.014$); 1233–1010 BC ($p = 0.986$)	1131 BC	IntCal13	Charcoal	Erosion-exposed profile; 2.5–2.8 m below surface	Dettman et al. 2015, Table 1
Bahía Adair, Locus 7	AA101189	3920 ± 30	1723–1115 BC ($p = 1.000$)	1426 BC	Marine13	Shell	Erosion-exposed profile; 2.5–2.8 m below surface	Dettman et al. 2015, Table 1
SON B:11:1, Morúa	AA72860	2273 ± 40	402–347 BC ($p = 0.455$); 318–207 BC ($p = 0.545$)	306 BC	IntCal13	Charcoal	Erosion-exposed profile; 0.8–1.0 m below surface	Dettman et al. 2015, Table 1

(*Continued*)

Table 5. Radiocarbon Ages on Shell Midden Material from the Bahía Adair and Puerto Peñasco Area.

Location	Lab #	^{14}C yr BP (1 sigma)[1]	2 sigma Calibrated Age (Probability)	Median Probability	Calibration Dataset	Material	Context	Reference
SON B:11:1, Morúa	AA102295	3060 ± 30	728–90 BC ($p = 1.000$)	384 BC	Marine13	Shell	Erosion-exposed profile; 0.8–1.0 m below surface	Dettman et al. 2015, Table 1
SON B:11:1, Morúa	AA108600	post-bomb	–	–	–	Charred seed	Locality 4, Unit 1; Level 4	Mitchell et al. 2017
SON B:11:1, Morúa	AA108601	3925 ± 50	2569–215 BC ($p = 0.094$); 2501–2282 BC ($p = 0.891$); 2248–2233 BC ($p = 0.015$)	2409 BC	IntCal13	Charred seed	Locality 3, Unit 1; Level 4	Mitchell et al. 2017
SON B:11:1, Morúa	AA111917	369 ± 27	AD 1449–1525 ($p = 0.585$); AD 1556–1632 ($p = 0.415$)	AD 1512	IntCal13	Charcoal	Trench 1, Feature 1; South Wall	Mitchell et al. 2019
SON B:11:1, Morúa	AA111918	2924 ± 24	1212–1038 BC ($p = 1.000$)	1122 BC	IntCal13	Charcoal	Locality 5, Unit 1, Level 5; Feature 1	Mitchell et al. 2019
SON B:11:1, Morúa	AA34338	1490 ± 55	AD 1058–1495 ($p = 1.000$)	AD 1309	Marine13	Shell	Locality 1; ash lens	Mabry 2008
SON B:11:1, Morúa	Beta-217125	1860 ± 60	AD 700–1224 ($p = 1.000$)	AD 961	Marine13	Shell	Locality 1, Feature 1 (hearth)	Mabry 2008
SON B:11:1, Morúa	Beta-208379	1900 ± 40	AD 24–222 ($p = 1.000$)	AD 105	IntCal13	Charred seeds	Locality 1, Feature 1 (hearth)	Mabry 2008
SON B:11:1, Morúa	AA-34337	1555 ± 40	AD 1034–1447 ($p = 1.000$)	AD 1252	Marine13	Shell	Surface	Mabry 2008
SON B:11:1, Morúa	Beta-217124	1370 ± 40	AD 600–712 ($p = 0.953$); AD 745–764 ($p = 0.047$)	AD 655	IntCal13	Charcoal	Locality 2, Feature 1 (hearth)	Mabry 2008
SON B:5:7, Otolith Hill	AA64957	5710 ± 40	3966–3438 BC ($p = 0.995$); 3418–3406 BC ($p = 0.005$)	3708 BC	Marine13	Fish otolith	Surface	Foster et al. 2012, Table 3
SON B:5:7, Otolith Hill	AA99041	4750 ± 40	2851–2189 BC ($p = 1.000$)	2511 BC	Marine13	Fish otolith	Surface	Mitchell et al. 2015, Table 5
SON B:5:7, Otolith Hill	AA99042	5980 ± 50	4273–3705 BC ($p = 1.000$)	4000 BC	Marine13	Fish otolith	Surface	Mitchell et al. 2015, Table 5
SON B:5:8, Ojo de Agua	AA11267	76 ± 36	AD 1684–1733 ($p = 0.269$); AD 1807–1928 ($p = 0.731$)	AD 1844	IntCal13	Charcoal	Erosion-exposed profile	Mitchell et al. 2019
Otolith Hill 2, Locus 52	AA99043	6040 ± 60	4332–3767 BC ($p = 1.000$)	4068 BC	Marine13	Fish otolith	Surface	Mitchell et al. 2015, Table 5
SON B:5:9, Los Tábanos	AA108602	1164 ± 25	AD 774–901 ($p = 0.826$); AD 920–961 ($p = 0.174$)	AD 860	IntCal13	Charred twig	Unit 1; Level 4	Mitchell et al. 2017

SON B:5:11, Oyster Hill	AA111919	3423 ± 22	1866–1849 BC ($p = 0.032$); 1773–1660 BC ($p = 0.968$)	1720 BC	IntCal13	Charcoal	Unit 1, Level 5; Feature 1	Mitchell et al. 2019
SON B:5:11, Oyster Hill	AA112666	168 ± 22	AD 1665–1950 ($p = 1.000$)	AD 1765	IntCal13	Charcoal	Shovel Test 1, 5–15 cm below surface	Mitchell et al. 2019
SON B:5:10, Duna Larga	AA112166	3996 ± 38	1831–1221 BC ($p = 1.000$)	1520 BC	Marine13	Shell	Unit 2; level 3	Mitchell et al. 2019
SON B:5:10, Duna Larga	AA112167	2860 ± 21	1111–973 BC ($p = 0.948$); 957–940 BC ($p = 0.052$)	1026 BC	IntCal13	Charcoal	Shovel Test 8, 50–60 cm below surface	Mitchell et al. 2019
SON B:5:10, Duna Larga	AA112665	2967 ± 23	1262–1115 BC ($p = 1.000$)	1181 BC	IntCal13	Charcoal	Shovel Test 6, 50–60 cm below surface	Mitchell et al. 2019
Locus 64, Salina Grande	AA112730	560 ± 24	AD 1314–1357 ($p = 0.500$); AD 1388–1423 ($p = 0.500$)	AD 1360	IntCal13	Charcoal	Road-cut exposure	Mitchell et al. 2019

Notes: 0 BP = AD 1950. All ages were calibrated with Calib 7.10 using IntCal13 northern hemisphere atmospheric and MARINE13 datasets for non-marine and marine materials, respectively (Reimer et al. 2013). The marine reservoir correction is 425 ± 115 yr (Dettman et al. 2015). Locus 2 at Cholla Bay is also known as JJ's Cantina locus.

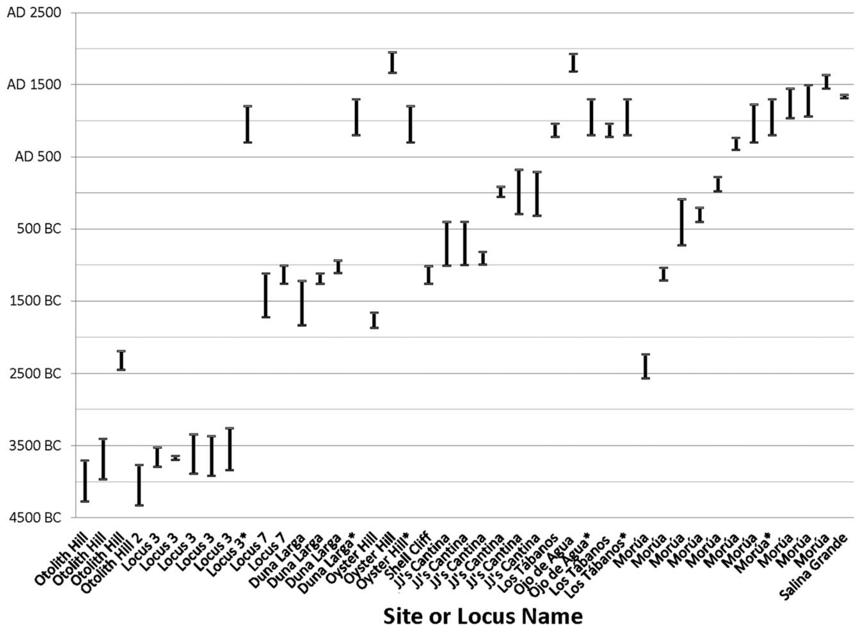

Figure 6. Calibrated ^{14}C dates and selected ceramic dates (*) from the Bahía Adair and Puerto Peñasco middens.

There are some gaps in the radiocarbon chronological data, such as between about 3500 and 2500 BC, in the mid-1000s BC, and the mid-100s BC. Although we cannot determine whether these gaps are related to paleoenvironmental perturbations or changes, or cultural changes, or a limited sample, it is likely that the longer and earlier gaps in our chronology are related to the currently small sample size of radiocarbon dates.

Discussion

In this article we provide archaeological evidence to support the interpretation that our two research areas indicate different functions and ownership concepts. The different shell middens were used for long periods of time for particular and diverse subsistence practices, as well as for other social practices of economic, political, and ritual importance. Excavations at the Morúa site (SON B:11:1) revealed artifact diversity and abundance, hearths, and cranial fragments of an infant (Mabry et al. 2007; Mabry 2008). These patterns point to family groups camping at the site, indicating a different pattern of occupation at the Morúa estuary than at the sites in the Bahía Adair region. The Morúa site can be interpreted as a residential campsite for marine foods procurement with repeated seasonal occupations. Based on visible evidence of a subsurface flow in the present-day lower channel of the Río

Sonoyta (large trees and shrubs growing in the channel bottom) and charred plant remains of mesquite trees from archaeological contexts, there was likely at least a subsurface flow in the westernmost paleochannel of the Río Sonoyta during intervals of prehistoric occupation along its banks. Due to its proximity to the Río Sonoyta and its shallow subsurface water flow during all, or at least most of the year, this site may have had a greater resource base and longer seasonal occupations than other locations.

In contrast, the Bahía Adair region is characterized by stranded tidal flats with thick salt deposits (*salinas*) that are elevated above maximum tide and storm surges. Several of these stranded tidal flats contain small freshwater springs (*pozos*) adjacent to shell midden sites (Broyles 1996; Ezcurra et al. 1988; May 2007; Zamora et al. 2019) and these springs, as well as knowledge of their specific locations, would have been integral to use of this area (see Rankin, Eiler, and Joaquin 2008). While the procurement of salt in the area most likely varied through time, there are diverse lines of evidence indicating that salt was an important trade item between mobile foragers and agricultural populations in the Sonoran Desert (Doelle 1980; McGuire and Howard 1987; McGuire and Villalpondo 2016). In addition, there are numerous ethnohistorical accounts of O'odham ritual pilgrimages to the coast to obtain salt and visit the ocean (e.g., Underhill 1938, 1946). Furthermore, ethnographic information from desert foragers has shown that, while the distribution of water sources constrains movement (Kelly 2007,117), residential campsites were usually not located directly adjacent to fresh water sources for several reasons: to keep them clean, to avoid social conflict, and as a defensive mechanism (Martínez-Tagüeña and Torres 2018).

In general terms the study area was occupied since at least the Middle Archaic period, with older sites likely occupied along earlier coastlines that were subsequently inundated by the postglacial rise in sea level that stabilized approximately 6 ka. Diagnostic projectile points and pottery found at these middens indicate occupation by pre-ceramic groups as well as later groups who used pottery associated with the Patayan culture of northern Baja California, southeastern California, and the lower Colorado River Valley of southwestern Arizona; the prehistoric Hohokam culture of southern Arizona; the Trincheras culture of northwestern Mexico; and the Ancestral Comcaac culture of the north-central Sonoran coast (Figure 7). All of these ceramic-era groups had distinctive cultural identities between about AD 700 and 1400–1500. One focus of our study was whether all these groups visited the Puerto Peñasco-Bahía Adair coast.

Researchers have proposed the presence of a prehistoric indigenous population in southwestern Arizona and northwestern Mexico—the Papaguería—who interacted with the more populous farming and pottery-making cultures to the north, east, west, and south (Altschul, Doolittle, and Homburg 2008; Ezell 1955; Hayden 1967). Bayman commented that " … the social identity

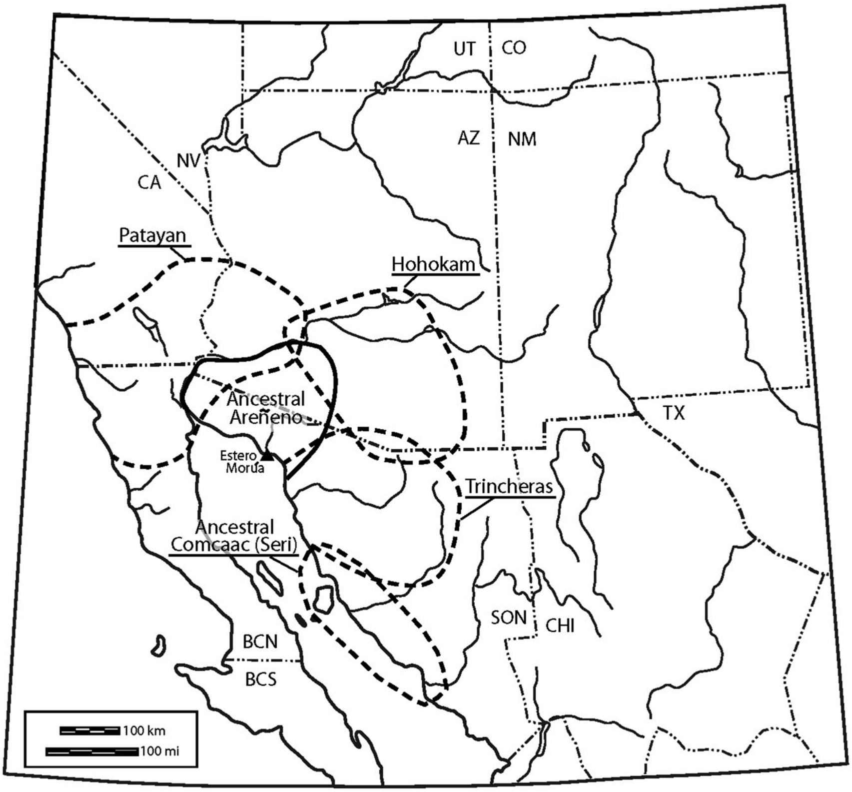

Figure 7. Prehistoric cultural groups who inhabited the northern Gulf of California region.

of populations who traveled through, or resided in, the Papaguería is a confounding problem for the region, at least from the standpoint of conventional culture-historical archaeology" (2007, 111). Beck (2008) has attempted to answer this question of how we can we use ceramics to assign cultural affiliation in the western Papaguería.

> There are at least three possible connections between ceramic tradition and ethnic or social identity in this region: 1. Most of the ceramics at a site were used and left by the group that manufactured them . . . 2. Most of the ceramics at a site were used and left by the group that manufactured them, but some were acquired from other groups . . . 3. Most of the ceramics at a site were acquired from other groups . . . [Beck 2008, 499].

We favor Beck's third model, that during the pre-contact ceramic era an indigenous Papaguerían population interacted with, and obtained pottery from, the contemporary and adjacent Patayan, Hohokam, and Trincheras groups and the pre-contact Comcaac. There is little evidence that these mobile foragers produced their own pottery and the diversity of ceramic types at many of the coastal midden sites suggests exchange. These Papaguerían peoples consisted of small populations of mobile bands who may have exchanged labor, obsidian, shell (for ornaments), antelope and deer meat and hides, salt, and marine resources for agricultural produce, ceramics, and possibly textiles.

Our interpretation includes cultural and linguistic continuity over the last 6000 years—the full time span of the archaeological record we have documented—because that fits with models considering a combination of paleoclimatic, archaeological, and historical linguistic lines of evidence and which reconstruct a repopulation of the lowlands of the Sonoran Desert by forager populations speaking related languages of the Proto-Southern Uto-Aztecan subfamily at the beginning of a relatively wet period 6000 years ago (Mabry, Carpenter, and Sanchez 2008; Merrill et al. 2009). In our model, older (pre-6 ka) archaeological sites in the northern Gulf of California, that would now be beneath the surface of the Gulf of California, were associated with populations speaking earlier languages related to both the Yuman language family and Comcaac language of the historical era.

A number of historical linguists interpret shared features of several historical-era language families of northern California, the Chumashan family of the central California coast, the Yuman family of Baja California and the lower Colorado River Valley, and the Comcaac language of the coast of central Sonora as representing survivals of an earlier continuum of related languages of the "Hokan stock" across northern Mexico, southwestern U.S., and California from the early to mid-Holocene, between approximately 10,000–9000 BC and 4000–3500 BC (Hopkins 1965; Krantz 1977; Morzaria-Luna et al. 1984; Taylor 1961). All of these models reconstruct this continuum being split by later expansions into southern California, the Great Basin, and the Sonoran Desert by populations speaking languages of the Proto-Uto-Aztecan stock.

A number of archaeologists and linguists (Carpenter, Sanchez, and Villalpando 2005; Mabry, Carpenter, and Sanchez 2008; Merrill et al. 2009) model a late Holocene expansion of Southern Proto-Uto-Aztecan groups into the lowlands of the Sonoran Desert beginning approximately 4000 BC. This expansion split the Yuman family from the Comcaac language, as a repopulation of this region after only sparse, episodic occupation during a middle Holocene that was hotter and drier (i.e., higher summer rainfall than earlier or today, but lower effective moisture due to evaporation).

The post-contact people (after the AD 1500s) who lived in the Papaguería have been referred to as the Areneños, or Sand Papago (*Hia ced O'odham*). This group spoke one or more dialects of O'odham (a Southern Uto-Aztecan language previously known as Pima-Papago) and may have included two bands, the Areneños proper and the Areneño Pinacateños, the latter living within the Pinacate volcanic field (see Hayden 1998).

> These Sand Papagos, as they have been called in the twentieth century, were truly nomadic No Villagers. 'Home' was most of the Lower Colorado Valley. People lived in an undetermined number of bands probably composed of extended families, and band size probably never exceeded 80 or 90 people. Even this would have been exceptionally large. Seafood, reptiles, insects, and small mammals were the principal ingredient of their diet; their tools were few (they made no pottery of their own); and they relied heavily on native flora to remain alive [Fontana 1983, 131].

We would apply Fontana's observations on historically known groups as well to the prehistoric groups who inhabited this area from 6000 years ago into the historic era. We think that over that timespan there was continuity of a relatively small indigenous population in the western Papaguería who were very mobile and very adapted to the hyperarid conditions of this part of the Sonoran Desert. They traded resources (notably salt and marine shells) to riverine groups (mainly of the Colorado, Gila, and Salt Rivers, and possibly the Río Magdalena in Sonora) for agricultural products and pottery (also see Doelle 1980; McGuire and Howard 1987; McGuire and Villalpondo 2016). Their range included the coast, which they regularly visited to secure shellfish, finfish, and sea turtles as part of a predictable, sustainable resource zone during their seasonal rounds. These visits probably occurred on a regular basis during the cool months. For the Comcaac immediately south along the same coast, exploitation of marine resources during the winter months was influenced more strongly by high marine productivity than proximity to fresh water, thus their residential campsites were usually not located near water sources (Martínez-Tagüeña and Torres 2018).

The Patayan, Hohokam, Trincheras, and Comcaac sherds found at the sites (see Table 2) are likely a result of trade with these groups by the ancestral Areneño people, but provenience identifications, possibly through temper sourcing, are needed. The analysis of obsidian artifacts found at the coastal middens supports the interpretation that local groups created them, rather than visitors from other cultural areas. Of the obsidian artifacts analyzed, 74 were identified as being from the Los Vidrios (n = 55) or Los Sitios del Agua (n = 19) sources, both of which are on the eastern edge of the Sierra Pinacate (Figure 1). Only nine artifacts were from the Sauceda deposits, in the eastern Papaguería. Nineteen artifacts are from unknown sources that are quite likely from, as yet, unidentified local Pinacate volcanic sources (Table 3). Adjacent culture groups likely used obsidian from nearby sources (the law of monotenic decrement [Renfrew 1977] where the frequency of a source decreases with distance from it) but unfortunately, there is little published obsidian analysis data for Patayan (although see Porcayo Michelini 2017 for a discussion of prehistoric use of the obsidian in southern California and northern Baja California), Trincheras, and Comcaac sites (for Hohokam obsidian use, see Mitchell and Shackley 1995; Loendorf 2010).

But this does not necessarily mean that other groups did not visit the coast. There are numerous ethnographic accounts of O'odham pilgrimages to the coast to obtain salt and visit the ocean (e.g., Underhill 1938, 1946). These journeys, taken by small groups, were probably filled with both real and perceived dangers. This practice has been revived recently by some tribal members. Hohokam and Trincheras task groups may have gone to the coast to obtain the shell, in addition to trading with the ancestral Areneños. The Comcaac may have also been part of this interaction network, or they may have traveled directly up the coast since they used reed boats (Felger and Moser 1985). Farther south on the Sonoran coast, ethnographic evidence demonstrates that various campsites were occupied by mixed Comcaac and O'odham family groups, where campsite place names along mobility routes and seasonality has been described (Martínez-Tagüeña 2015).

Other historically known groups in the northern Gulf of California, the Colorado River Delta, and northern Baja California include the Yuma (Quechan), Cocopah, Kumeyaay, Paipai, and Kiliwa. The history of interaction among these groups is complicated. There were certainly commonalities regarding subsistence pursuits such as floodwater farming along the Colorado River, fishing and shellfish collection along the coast, and the exploitation of desert plants and animals. However, the nature of interaction among these groups was strongly influenced by sociopolitical factors that included amity-enmity relationships. Did the groups along coastal Baja California, coastal mainland Mexico, and the lower Colorado River Delta frequently interact? In his study of the Faro site in northern Baja California, Porcayo Michelini noted the following regarding the lower Colorada River Delta:

> As more studies become available from the upper Gulf of California region, it can be tentatively proposed that isolation and marginalization will be found to have been constant factors for groups living in this area of the Baja California Peninsula. The degree of isolation seemingly characterizing the Yuman groups may have been heavily influenced by the geographic circumscription caused by the annual floods of the Lower Delta zone of the Colorado River. The continual intertribal warfare also undoubtedly affected the regional isolation. Accounts of wars, skirmishes, and intertribal vengeance are frequent during the entire historic period in this zone, and occur as late as the middle of the nineteenth century. Indeed, the Cocopah mentioned to Garcés (1996:31) that the constant wars continued to keep them " … lagging behind and in need of living wherever there was scarce water and no firewood … ". Under such marginal conditions, the exchange of ideas, cultural traits, and material goods with outside groups would have been very difficult during contact times, if not before [Porcayo Michelini 2010, 13].

Further, there were no artifacts from the midden sites produced from obsidian sources to the west in southern Alta California, or northern Baja California. Although this situation could be a result of sampling error (Porcayo Michelini 2017; Shackley 2019a), no obsidian artifacts have yet been found to cross the Colorado River. While the California obsidian sources (Obsidian Butte and Tinajas) are more distant from our study area than the Pinacate sources, and the reverse is also true, the apparent complete absence of cross-over obsidian is significant. Shifting relationships likely occurred for centuries between various groups due to warfare and alliances. Ethnographic accounts indicate that the Cocopah were allied with most of the western Yuman groups. Alliance conflicts between the Cocopa and other Delta Yumans and the O'odham, combined with the physical barrier of the Colorado River Delta, may have been important factors responsible for the lack of obsidian artifacts (signaled by obsidian provenance) on either side of the river crossing. Given that this pattern is also present in earlier Archaic sites west of the Colorado River, it appears to be a long-term social and cultural effect (McDonald 1992; Shackley 2005, 2019b) although the scarcity of obsidian in western Archaic sites makes any inferences tentative.

While at different times it is possible that ancestral Areneños had territorial rights to, or control of, the rich coastal resources—particularly salt and maybe marine resources (fish, oysters, clams) and certain shell species used for ornament manufacture (giant Pacific cockle/*berberecho gigante*, *Laevicardium elatum* and bittersweet clams *Glycymeris maculata* and *G. gigantea*)—it is more likely that the coast was a common-pool resource, wherein the available natural resources were used by multiple individuals or groups. We believe the evidence points to this coast being primarily used by local populations, although the coast also fell within the range of neighboring agriculturally based populations. Bayman's (2007) model for the relatively arid and sparsely settled interior of the western Papaguería seems equally applicable to the Puerto Peñasco-Bahía Adair coast:

> The social and economic rules for managing this joint-use territory were institutionalized by local populations *and* visiting practitioners of Patayan, Hohokam, and Trincheras technological traditions … . The region contained resources that both local and non-local groups used, and it embodied a buffer zone between the most archaeologically robust traditions (i.e., Patayan, Hohokam, and Trincheras) [Bayman 2007, 112].

However, while the population of the western Papaguería was indeed less "archaeologically robust" (i.e., has less material culture visible in the archaeological record), we interpret the coastal middens as an archaeological signature largely associated with the seasonal residential cycle of the foragers of the western Papaguería rather than with sporadic visitors from neighboring agricultural populations. But we also note that non-Papaguerían groups probably visited the coast at times, perhaps associated with specialized activities like the historic O'odham ritual salt-gathering journeys.

The ceramic-era archaeological records of more densely settled areas of the interior Sonoran Desert indicate that shell ornaments were important items for the Hohokam and other cultures. In fact, *Glycymeris* shell bracelets were part of the Hohokam identity (Haury 1976). Although small quantities of shell were obtained from the California coast (e.g. abalone [*Haliotis sp.*]) and may have been obtained from the Baja California coast, there is little question that the bulk of the raw shell from which ornaments were fashioned originated from the Sonoran coast. However, very little evidence of actual shell manufacturing occurs at the coastal middens, except for a few localities at Morúa (Mabry et al. 2007; Mabry 2008). The cultural deposits are almost entirely composed of food residues. Sites that do contain abundant shell manufacturing evidence occur away from the coast, in the western and eastern Papaguería. Presumably this pattern occurred due to the sparse freshwater sources at the coast and probably the lack of natural stone sources for shell manufacturing tools at the coastal sites studied by this project.

Changes in shell acquisition patterns are evident in the archaeological record after AD 1200 (McGuire and Howard 1987) and certain site types (*cerro de trincheras*) became more prominent in the eastern Papaguería and northwestern Sonora at this time, suggesting that "the institutional arrangements that once governed the use of common-pool resources in the Papaguería apparently unraveled" (Bayman 2007, 124). According to our current chronometric data, there does appear to have been a hiatus in exploitation of coastal resources in this area between the AD 1000s and 1300s. In Figure 6, six sites have estimated ceramic dates ranging between AD 800 and 1300 (or later). If we consider only the charcoal radiocarbon dates, there is an apparent gap between about AD 1000 and the 1300s. However, if we include the shell radiocarbon dates, the chronology does not suggest a hiatus in human activity. Like the other gaps in our chronology, it remains to be seen whether this represents an actual interruption in occupation or an effect of sample size.

The varied lines of evidence from our explorations along the coast lead us to conclude that, beginning 6000 years ago, the Puerto Peñasco-Bahía Adair middens were mainly created by the desert dwelling ancestors of the Areneños (Sand Papago or *Hia ced O'odham*) who lived in the western Papaguería during historical times, and whose exploitation of marine resources along this northeastern stretch of coast is recorded by both first-hand accounts and oral traditions (Lumholtz 1912; Childs 1954; Hayden 1988a, 1988b). As in the historical era, these prehistoric people developed extensive relationships with neighboring groups in southeastern California, southwestern Arizona, and northern Mexico but appear to have retained their own social identity. Over the last several millennia, the complex interactions between riverine and non-riverine groups likely changed, perhaps dictated by interactions with the shifting social forces within the densely populated riverine farming and pottery-making villages on both sides of the Colorado River, the Gila and Salt Rivers in southern Arizona, and Río Magdalena in Mexico. Further work north and south of the international border, and along the coast, may help us to unravel the multifaceted, shifting interaction patterns that likely existed in this area for thousands of years.

This research describes continuity of cultural-linguistic groups and general patterns of subsistence, settlement, and interaction in the Puerto Peñasco-Bahía Adair area over the last 6000 years, while it demonstrates the uniqueness of particular coastal environments and the human-environment relationships through this timespan. Thus, the study contributes to the understanding of the varied prehistoric coastal adaptations on the coasts of the Gulf of California. In addition to continuing our research to understand prehistoric coastal adaptations in the Gulf of California, future directions also include integrating ethnohistorical data and archaeological research with Tohono O'odham oral tradition. Collaborative research undertaken by archaeologists with indigenous communities (Colwell-Chanthaphonh and Ferguson 2008; Ferguson 1996; Martínez-Tagüeña and Torres 2018) has demonstrated that they have a distinctive manner of interpreting objects and places in addition their important contribution of traditional and historical knowledge about the studied regions and the material evidence.

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