

THE MULTI-FUNCTIONAL PITTED STONES OF COASTAL CALIFORNIA AND THEIR USE IN MARINE SHELL PROCESSING

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ABSTRACT

Due to the presence of pitted stones in coastal California shell middens from San Francisco Bay to San Diego as well as on San Clemente and Santa Catalina Islands, it has long been assumed that these artifacts are somehow associated with the processing of marine shellfish. These hand-sized stones often exhibit evidence of grinding and battering as well as small indentations or pits. It is hypothesized that pitted stones found on coastal sites were formed and used to process the turban shell (*Tegula* sp.) as a food resource.

INTRODUCTION

Pitted stones have been referred to in archaeological literature as pitted stones, pitted hammerstones, dimple-stones, acorn crackers, acorn anvils, and pitted anvils. Pitted stones have been found on a variety of coastal California sites beginning over 4000 years ago and are also common on Late Period sites from San Clemente Island (Figures 1-2). The purpose of this paper is to define the pitted stone as an artifact type, to review those coastal sites where they have been recovered, and to identify similarities between those sites. In doing so, it should therefore be possible to correlate the presence of the pitted stone on coastal California sites with a particular use.

There are several types of pitted stone. The definitive characteristic of a pitted stone is a purposefully pecked "pit" usually in the center of the flat side of a hand-sized rock. The pit is always pecked and not ground. Often, artifacts such as hopper mortars and doughnut stones, in their initial stage of manufacture, may appear to be pitted stones but contain ground pits. Pitted stones often contain grinding wear on their sides

like manos and have been referred to as pitted manos. They may also appear to be a form of pestle. Pitted stones can exhibit battering or pecking around their circumference like hammerstones and have been referred to as pitted hammerstones. Pitted anvils are usually larger rocks with no wear other than a pit on one or more sides. The absence of wear other than the pit on a pitted anvil indicates it was not used as a hammerstone or as a grinding stone, only as an anvil. Pitted manos, pitted pestles, pitted hammerstones, and pitted anvils are all referred to herein as pitted stones.

COASTAL SITES WITH PITTED STONES

Pitted stones from San Clemente Island have been described as (McKusick and Warren 1959: 142):

...pebbles with flat surfaces which are pitted or pecked. The material is principally granite and basalt, although other materials occur such as gabbro, amygdaloidal pumice and diorite.... Variations include some with slightly battered edges as if also used as hammerstones.



Figure 1. Coastal occurrence of pitted stones in California.

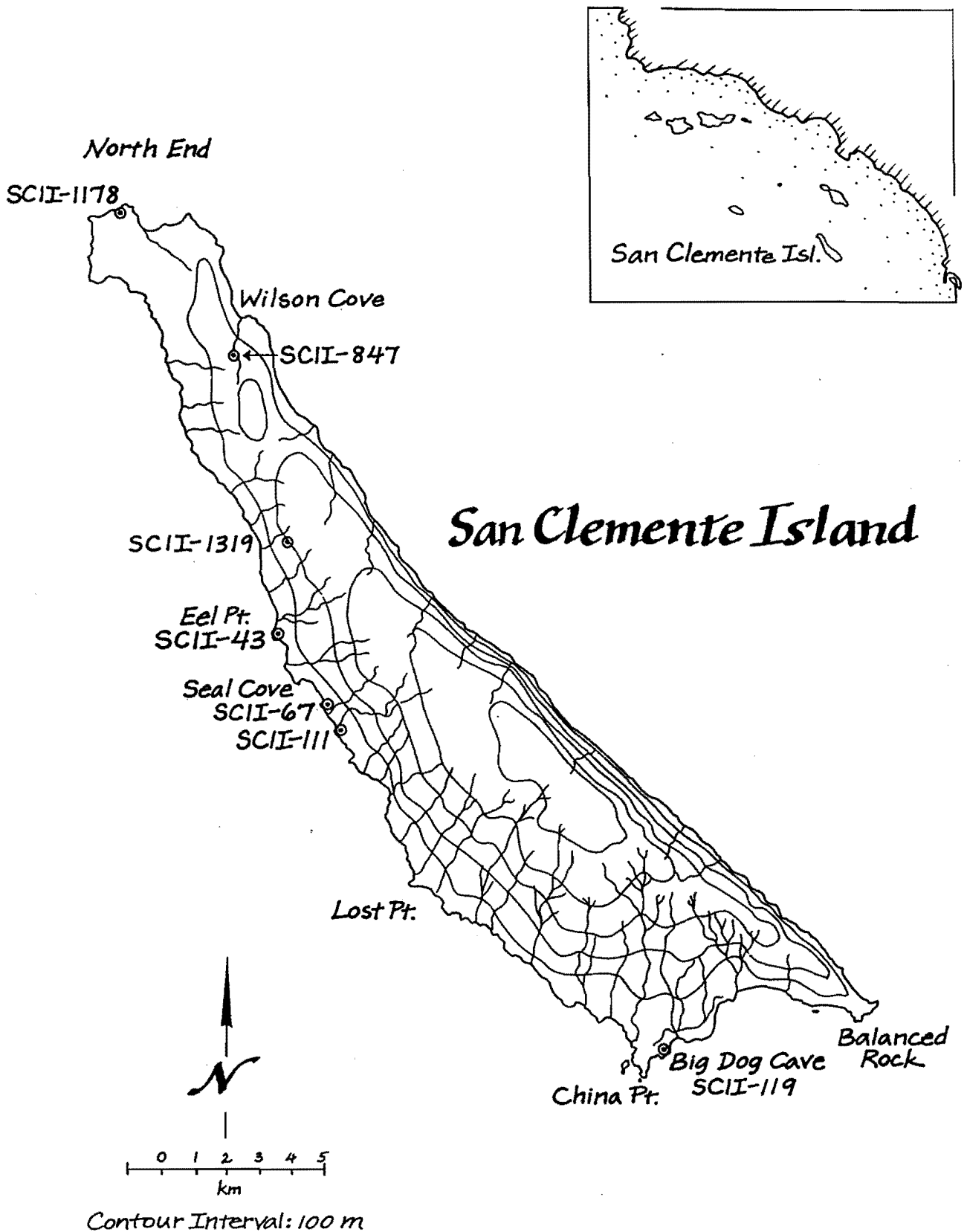


Figure 2. San Clemente Island.

McKusick and Warren (1959) noted two specimens, both of which were ground and contained two pits located on the edge of the rock rather than on the flatter side. As a part of their research, 27 specimens were identified from 14 San Clemente Island sites, including Eel Point Dune (SCLI-43; Table 1).

Personal observation at SCLI-1178 (Xantusia Cave, North End Shelter, or Night Lizard Cave) includes several pitted stones from the dense shell midden (Armstrong 1985). Often, the fist-sized stones were found in pairs, side by side.

From SCLI-847 (Wilson Cove Road Site) three pitted stones and a pitted anvil were recovered. The pitted anvil measured 16.4 x 13.0 x 5.3 cm, was not used as a hammerstone, and contained no evidence of use other than the pit, or dimple, present on one side. The two classic pitted stones from SCLI-847 both contain a single pit, battering and grinding. One specimen clearly exhibits more grinding wear, more well-defined shoulders, and except for the pit would otherwise be considered a mano (Figure 3; Strudwick and Gallegos 1994). The third pitted stone from SCLI-847 contains evidence of use as a core because several flakes have been removed. At SCLI-847, the 20-30 cm level of the thin, buried deposit, has been radiocarbon dated to 4140 ± 80 BP and 4070 ± 80 BP (Beta-69356 and Beta 69357; Strudwick and Gallegos 1994).

Andy Yatsko, Director of Archaeology on San Clemente Island, states that pitted stones are among the more widespread tools found on sites from this island. Collections from the Mesa College surveys (Mesa College 1975-1980) substantiate this.

On Santa Catalina Island's west side, the Little Harbor Site (SCAI-17) produced 41 pitted stones, two of which "...would be considered manos except for the pits pecked into the center of each side" (Meighan 1959:396). Average size of the 39 pitted cobble hammerstones is 11.4 x 7.9 x 4.6 cm while average size of the two pitted and ground hammerstones is 13.0 x 9.4 x 4.1 cm

(Meighan 1959:388). The Little Harbor Site has been radiocarbon dated to 3880 ± 80 BP (M-434; Meighan 1959:384).

Pitted stones come from Zuma Creek (Moratto 1984:129) and Little Sycamore sites (VEN-1; Wallace 1954). From VEN-1, on the open coast, 49 pitted stones were recovered and have small pits on one or two surfaces while a pitted stone discoidal is also reported (Wallace 1954:114). At VEN-1, pitted stones were recovered from the lower levels which probably dated from 3,000 to 5,000 years ago.

From LAN-2, Treganza and Bierman (1958: 67) reported a variety of cobble hammer-stones containing "...small bifacial depressions that have been pecked into the more flattened sides...." These appear, from their description, to be pitted stones.

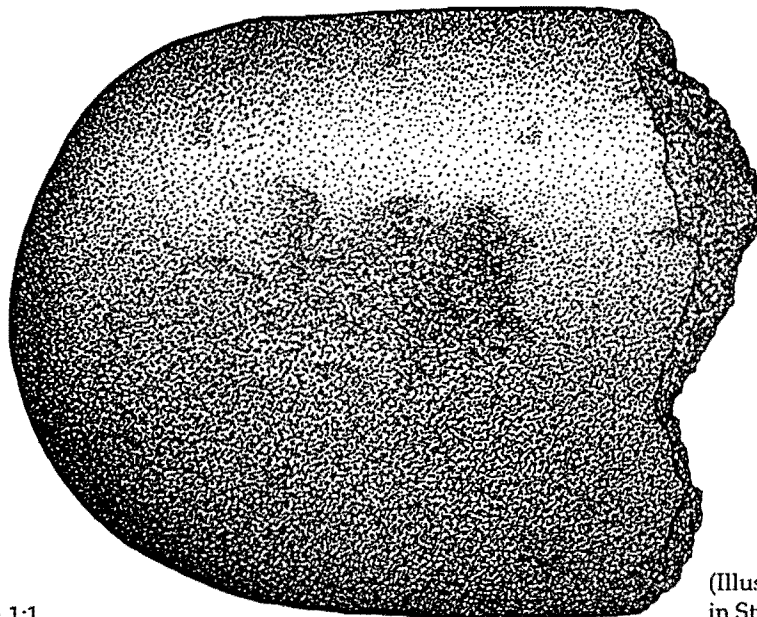
Over 600 pitted stones were recovered from SLO-2 (Greenwood 1972:5, 28) and over 700 were reported from SLO-178 (Hines 1986:24). Hines (1986:60) also records ten pitted stones from a rock feature at SLO-186. All 10 hand-sized specimens were sandstone; eight were burned. Six contained one pit, three contained two pits, and one contained two pits on one surface.

Another 15 pitted stones, all sandstone, were recovered from SLO-187 (Hines 1986:23). The number of pits was determined for 12 stones: eight contained a single pit, three contained two pits, and one stone contained four pits. "Battering was present along the edges of seven of the... (pitted stones), suggesting that these had been used as hammerstones" (Hines 1986:23). These pitted stones averaged 7.4 x 6.2 x 3.8 cm, similar to the 10 x 7 x 3 cm averages reported by McKusick and Warren (1959:142) for San Clemente Island pitted stones.

From SLO-383, 42 pitted stones were identified (Hines 1986:46). Thirty two were sandstone and 10 were volcanic. Over half of these pitted stones had been burned and although 30 contained only one pit, 11 had two pits on two

Table 1. Coastal California Archaeological Sites with Pitted Stones

Site Trinomial	Site Name	Reference	<i>Tegula sp.</i> Association
SCaI-17	Little Harbor, Santa Catalina Isl.	Meighan (1959)	Unknown
SCLII-16, 17	San Clemente Island	McKusick & Warren (1959:176)	Unknown
SCLII-43	Eel Point Dune, San Clemente Isl.	McKusick & Warren (1959:124)	Unknown
" "	" "	Salls (1990:67); Raab & Yatsko (1992:34)	Yes
SCLII-67	Seal Cove Midden	McKusick & Warren (1959:124)	Unknown
SCLII-105, 111, 116	San Clemente Island	McKusick & Warren (1959:126)	"
SCLII-119	Big Dog Cave	McKusick & Warren (1959:132)	Unknown
SCLII-21, 197, 205, 442, 463, - 533, 710, 871, 916, -946, 985, 1122, 1242, -1320, 1326, 1652, 1668	San Clemente Island " " "	Mesa College (1975-1980) " " "	" " " "
SCLII-847	Wilson Cove Road	Strudwick and Gallegos (1994)	Yes
SCLII-1178	North End Shelter/Xantusia Cave	Personal Observation/ Armstrong (1985)	Yes
SDi-7	Scripps Estates	Shumway et al. (1961:80)	Yes
LAn-2		Treganza & Bierman (1958:7)	Unknown
	Zuma Creek	Moratto (1984:129)	Unknown
Ven-1	Little Sycamore	Wallace (1954)	Unknown
SLO-2	Diablo Canyon	Greenwood (1972)	Yes
SLO-178		Hines (1986:23)	Yes
SLO-186, 187, 383	San Simeon State Beach	Hines (1986:23-24, 60)	Yes
Mnt-281, 282	Willow Creek	Pohorecky (1976)	Unknown
SMA-22	Princeton Mound	Loud (1912, 1915); Beardsley (1954)	Unknown
" "	"	Kroeber (1925:925)	Yes
	Estero & Bear Valley Sites	Beardsley (1954:34)	Unknown
SFr-7	Bayshore Site/Crocker Mound	Beardsley (1954:92)	Unknown



Scale 1:1

(Illustration by Mike Caldwell
in Strudwick and Gallegos 1994)

Figure 3. Pitted stone artifact (Cat. No. 238), SClI-847.

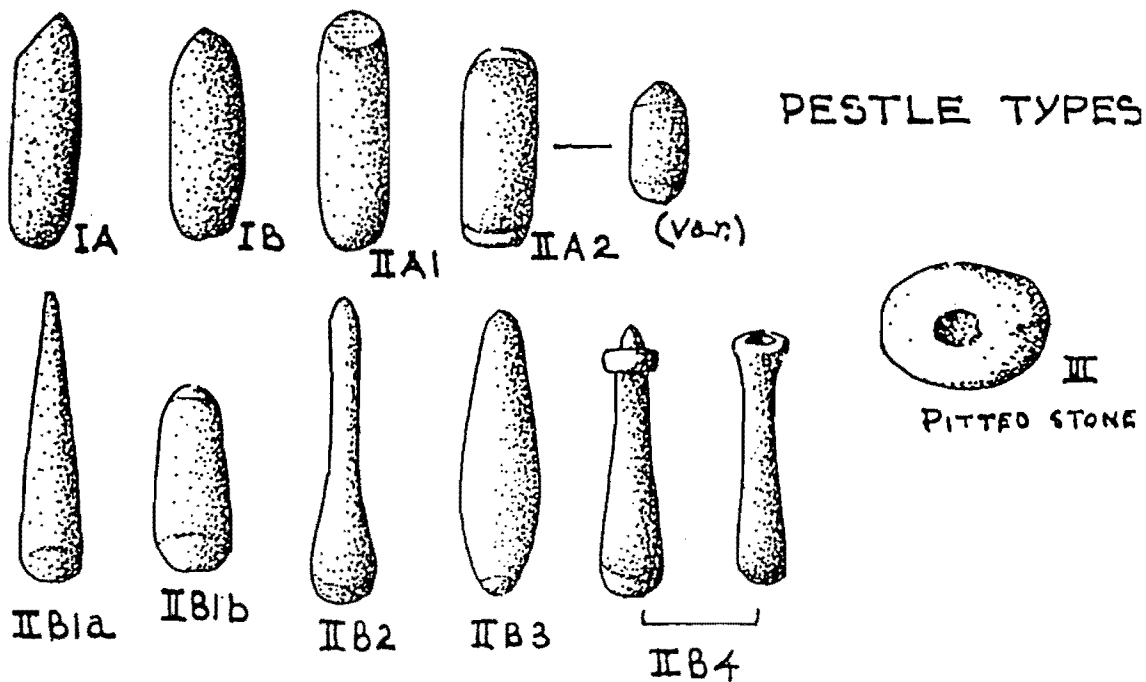


Figure 4. The pitted stone as a pestle type (from Beardsley 1954:35).

surfaces and one contained two pits on one surface and a third pit on another surface. Additionally, the pitted stones tended to be found in groups, "vertically clustered" (Hines 1986:46). All specimens were hand-sized and dimensions averaged 9.9 x 7.0 x 4.4 cm (Hines 1986:47). "Twenty three are fire-affected. Only three are complete. Edge battering is evident on nine pieces, which were probably used as hammer-stones" (Hines 1986:46).

In Monterey (MNT-281, MNT-282), pitted stones were used over 2,000 years ago (Pohorecky 1976). Twelve pitted stones were found at MNT-281, primarily in the upper portions of the deposit. A single specimen was recovered within the deposit at MNT-282 (Pohorecky 1976; Moratto 1984:240).

Pitted stones have been recovered from Half Moon Bay where Loud (1912, 1915) recorded numerous small pitted stones from SMa-22, the Princeton Shellmound. These specimens were subsequently described (Beardsley 1954:94) as both large and small. Six pitted stones are also known from the "Bear Valley Site," a similar open coast site in Marin County (Beardsley 1954:34). Another pitted stone, noted from the Estero site, was made of granite, measured 13.5 x 10.0 cm and contained a single pit with battering around its edges.

The Bayshore Site, or "Crocker Mound" (SFR-7; Beardsley 1954:92), the largest of a group of mounds at the waters edge near Hunter's Point, also contained a pitted stone. This is the northernmost coastal occurrence of the artifact noted.

In San Diego County, at the Scripps Estates Site (Shumway et al. 1961), three pitted stones were identified. All were bifacially pitted, all were sandstone, and all were broken. Shumway, Hubbs and Moriarty stated that these artifacts were used for grinding and pounding, as the broken ends show battering. The three artifacts were nearly identical in size, measuring 10.4 x 8.7 x 6.5 cm; 12.3 x 8.3 x 5.6 cm and 8.1 x 10.1 x 5.3 cm

(Shumway et al. 1961:80). A fourth stone from the Scripps Estates Site appeared to be a pitted stone, but with a large, ground pit. Shumway et al. (1961:81-82) believed it is an incomplete doughnut stone, broken during manufacture. This specimen contained two ground pits on opposing sides. As noted earlier, pecking is the manner in which pits are produced on pitted stones. Radio-carbon dates from the Scripps Estates Site range from 5460 ± 100 BP to 7370 ± 100 BP (LJ-110, LJ-109; Shumway et al. 1961:97). The Scripps Estates Site is the southernmost occurrence of pitted stones on the California coast, although it is a distinct possibility that they may occur in Baja California, but have not yet been reported.

Franklin Fenenga and William Wallace (personal communications, 1994) have both assured me that pitted stones are found across the North American continent. Fenenga stated they are found in the hardwood forests of the southern and eastern United States, where they were used for hulling the hard outer covering of such nuts as hickory. William Wallace stated that pitted stones are found in the interior of California as he has excavated them on sites in the Sierra Nevada. Both Fenenga and Wallace referred to the pitted stone as an "acorn cracker." Ron Bissell (personal communication, 1994) observed a mano with a purposefully made pit or indentation in it from La Habra, inland of Orange County, on a site with limited marine shell. He believes that this mano may have been used to crack open acorns. Moratto (1984:129), however, believes that pitted stones were not found inland. My limited experience has only associated pitted stones with coastal sites.

Pitted stones are therefore generally hand-size (McKusick and Warren 1959; Strudwick and Gallegos 1994), no smaller than a golf ball (Hines 1986:23; Mesa College Collections), made of many materials including sandstone (Shumway et al. 1961; Hines 1986), granite, basalt (McKusick and Warren 1959), and coarse-grained volcanics (Strudwick and Gallegos 1994; Mesa College 1975-1980).

The pit diameter of 42 pits from 21 pitted stones (Mesa College Collection) varied from 1.2 to 4.1 cm with an average diameter of 2.2 cm. Generally, the deeper the pit, the wider. Pit depth varies but is usually less than 0.5 cm. Pits are pecked and not ground, indicating a variable pounding motion as opposed to grinding.

Although pitted stones need not contain more than one small dimple or pit, they often contain as many as four pits on various portions of the rock, sometimes with two pits side-by-side. Many times the stones are battered as if used as hammerstones; often the artifacts exhibit grinding wear. The term pitted hammerstone is therefore correct for many of the specimens. The occasional larger specimen containing no observable wear other than a single pit is often referred to as a pitted anvil. If pitted stones were used in pairs, then it is possible that they were used interchangeably, one as an anvil and the other as a hammerstone.

The use of pitted stones for grinding purposes may indicate that the stone was a modified mano or pestle. Perhaps, however, grinding occurred following the tool's use as a pitted stone. Often, pitted stones contain both battering and grinding, suggesting a multi-functional use. Recently, the use of grinding tools has been associated with faunal processing (Yohe et al. 1991) and a symposium on ground stone tools given during the 1992 Society for California Archaeology meetings (including Fenenga 1992; Adams 1992; Pritchard-Parker 1992; Pritchard-Parker and Reid 1992; Schneider 1992; Schroth 1992) discussed the various aspects of ground stone use. Additionally, ground stone has been associated with processing fish (McLendon and Lowy 1978) and this practice is likely to have been widespread in aboriginal California (Kroeber 1925:409).

SITE SIMILARITIES

Previously mentioned coastal sites with pitted stones have certain similarities. These are (1) the sites contain relatively large amounts of shell and are sometimes referred to as shell middens; and

(2) the sites are all located near areas of rocky coastline. More specifically, marine shell obtained from middens where pitted stones are found originated predominantly from the rocky intertidal region. This is understandable on islands such as San Clemente and Santa Catalina where sandy coastlines are rare, but along the mainland this may indicate the relationship of pitted stones with a rocky intertidal mollusk.

On San Clemente Island, many of the sites located on the upper marine terraces (such as SCLI-1316 and SCLI-1319) are composed primarily of the small turban or top shell, *Tegula* sp. (Raab and Yatsko 1990:16). Although many pitted stones were collected by Mesa College (1975-1980), shell species from these sites are not well documented, allowing only a limited correlation. Andy Yatsko (personal communication, 1994), however, believes the pitted stone to be among the most widespread of artifacts on San Clemente Island; a few pitted stones have been found on nearly every San Clemente Island site.

The evidence from San Luis Obispo sites SLO-186, SLO-187, and SLO-383 indicates that the overwhelming majority of shellfish recovered originated from a rocky intertidal environment. The majority of shellfish found at these three sites consists of *Tegula* sp. and *Mytilus* sp. (mussel). At SLO-187 and SLO-383, *Tegula* sp. is the single most commonly recovered shellfish, and on SLO-186 it is the second most commonly recovered shellfish (Hines 1986:69).

At SLO-2, *Mytilus californianus* is the most commonly recovered shellfish. Other important species include the black turban (*Tegula funebris*), barnacles, and red and black abalone (Greenwood 1972).

At the Scripps Estates Site, prehistoric inhabitants collected primarily from the rocky intertidal zone and although sandy coasts are common in the region, mollusks originating from a sandy substrate (such as the pismo clam, *Tivela stultorum*, and the bean clam, *Donax* sp.) were rarely recovered (Shumway et al. 1961:117). Al-

though not the most commonly recovered shellfish, *Tegula* sp. did occur (Shumway et al. 1961: 100). Notably, the authors commented on the seemingly limited amount of shell in the midden.

Kroeber (1925:924-925) reported that the most common shell species within San Francisco Bay shellmounds were *Mytilus edulis* (bay mussel), *Macoma nasuta* (bent-nosed clam), and *Ostrea lurida* (California oyster). "On the open ocean at Half Moon Bay, the native sea foods possessed a quite different range. *Tegula funebris* was secured in greatest quantity, the *californianus* mussel came next...and the bay species are hardly represented." (Kroeber 1925:925)

Notably, the Princeton Mound (SMA-22; Loud 1912, 1915; Beardsley 1954) contained pitted stones.

At SCLI-847, the principle shellfish identified from column samples was the black abalone (*Haliotis cracherodii*) followed by the turban (*Tegula* sp.; Strudwick and Gallegos 1994). Nearly all the *Tegula* sp. shell recovered was fragmented, while *Haliotis cracherodii* shell was almost always recovered unbroken. SCLI-847 is located high on San Clemente Island's central ridge, nearly a mile from the coast.

At SCLI-1178 (North End Shelter) on San Clemente Island, the UCLA field school of 1985 identified marine shell recovered within column samples. Abalone was the predominant shellfish within some levels, while *Tegula* sp. shellfish predominated in other levels. Because the *Tegula* sp. shell was fragmented it was often initially confused with abalone since they are both ventrally iridescent and the much larger abalone comprised the majority of the complete specimens. Interestingly, although stone tools were rare within the dense shell of SCLI-1178, pitted stones were occasionally found side by side.

Tegula sp. is recorded as a prominent portion of the midden at Eel Point Dune (SCLI-43), from the lowest levels upward (Raab and Yatsko 1992: 19; Salls 1992:116). Pitted stones were also

identified from SCLI-43 (McKusick and Warren 1959). The three most common shellfish from nearby Eel Point Canyon (SCLI-48) are *Mytilus* sp., *Haliotis* sp., and *Tegula* sp. (Wissler 1959: 147-149) with *Mytilus* sp. and *Tegula* sp. supplying the bulk of the shell.

Tegula sp. middens occur in large numbers along the west shore of San Clemente Island (Yatsko 1987; Raab and Yatsko 1992:34) and are typically small, less than 15 m in diameter. Salls (1992:160) believes that the most common shell species on late sites at San Clemente Island are *Haliotis cracherodii* and *Tegula funebris*. These are also the most commonly occurring shellfish on SCLI-847, a site dated to approximately 4,000 BP (Strudwick and Gallegos 1994). *Tegula* sp. is also the most prominent shellfish by weight within middens at SCLI-1318, SCLI-1319, and SCLI-1325 (Raab 1988:12; Raab and Yatsko 1990:16). "*Tegula* shell within the middens is virtually always found to have been deliberately crushed" (Raab 1988:14). Therefore, it is clear that on many prehistoric San Clemente Island sites, over a period of several thousand years, *Tegula* sp. forms a large portion of the shellfish within middens and therefore a considerable portion of the shellfish diet within the aboriginal population.

Although no *Tegula* sp. is recorded from the midden at Santa Catalina's Little Harbor Site (SCAI-17; Meighan 1959), aboriginal shellfish exploitation occurred primarily intertidally and focused on *Mytilus* sp. and *Haliotis* sp. shellfish. It is possible that because shell was identified only from column samples, the *Tegula* sp. shell went unidentified.

Tegula sp. shellfish is not reported from the Little Sycamore Site (VEN-1) for perhaps the same reason it is absent at SCAI-17: marine shellfish from the archaeological deposit were not specifically identified. VEN-1 was compared with Santa Barbara complex sites which reportedly lack, in addition to other items, pitted stones and shellfish resources (Wallace 1954:118). The inference is that VEN-1, with many pitted stones,

contains relatively more marine shell compared with Santa Barbara complex sites lacking pitted stones.

MNT-281 and MNT-282 also appear to represent shellfish collecting within primarily rocky intertidal coastal regions. Mussel and abalone shell are the most abundantly recovered shellfish (Pohorecky 1976; Moratto 1984:239).

As this section correlates the presence of pitted stones with the exploitation of shellfish from rocky intertidal habitats and specifically with *Tegula* sp. it is necessary to review the intrasite structure of shell middens. Although *Tegula* sp. shell is not identified from the Little Harbor Site (SCAI-17), Meighan (1959:402) identifies a shift in the proportion of *Haliotis/Mytilus* spp. which favors *Mytilus* sp. as one moves upward through the midden. Meighan believes this is caused by the over-exploitation of the favored shellfish (*Haliotis* sp.) through time to the point of serious depletion of this resource. When this occurred, the inhabitants gathered other shellfish and when this strategy did not provide sufficient food, the inhabitants abandoned the site. At North End Shelter (SCLI-1178) the percentage of *Haliotis* sp. and *Tegula* sp. alternates several times within the deposit. Salls identifies alternating levels of *Haliotis* sp. and *Tegula* sp. within the midden at Eel Point Dune (SCLI-43; Salls 1990:85, 1992:-165), and the same occurs within middens at SCLI-1318, SCLI-1319, and SCLI-1325 (Raab and Yatsko 1992:28). Similar relationships between different shell species have been noted elsewhere (McKusick 1959; Reinman 1964; Botkin 1980). Perhaps this alternating shellfish exploitation helps explain the horizontal clustering of pitted stones observed by Hines (1986:-46) if indeed these stones were used to process *Tegula* sp. shell.

PREVIOUSLY ATTRIBUTED USES OF PITTED STONES

Cole and Deuel (1937) referred to pitted stones from the Illinois area as "acorn anvils" and

Fenenga and Wallace (personal communications, 1994), and Hoover and Sawyer (1977:39) called pitted stones "acorn crackers." Hines (1986:24) observes that it is possible they were used to crack acorns at the San Simeon Creek Sites. Beardsley (1954:32) also suggested that they were used to crack acorns and that they may have been used in pairs, one as an anvil and the other as a hammerstone, with the pits serving as finger grips. As shown in Figure 4, Beardsley (1954:35) classified pitted stones as a type of pestle due to the grinding wear, but remarked the "...pitted hammerstone [appears] to be a link between sites fronting the open ocean, which is hardly consistent with the proposal of a specialized function in cracking acorns." Beardsley then proposed that they may have been used as hammerstones or net sinkers.

The majority of pitted stones contain edge battering, and their use as hammerstones is undeniable. Concerning the pitted stones of Scripps Estates (Shumway et al. 1961:80):

Two show signs of battering...and it seems rather probable that these...cobble were used as tools for grinding and for gentle pounding; for these purposes the shallow pits would have served effectively as thumb-and-finger holds.

In addition to battering, grinding is often found on pitted stones. Two of the pitted hammerstones from SCAI-17 "...would be considered manos except for the pits pecked into the center of each side" (Meighan 1959:396). Meighan continued that it "...is not impossible that these...are actually reworked manos..." but classifies them as a second type of pitted hammerstone. Meighan (1959:396) then attempted to correlate the occurrence of pitted stones with abalone, since this mollusk necessarily requires tenderizing. Pounding would create pestle-like wear on the artifact, much like the specimen illustrated in Figure 3. The pits then would be ideal for holding with wet fingers as they would serve as finger grips (Meighan 1959:396). Perhaps the natives of San Simeon required only one finger grip, explaining why the majority of pitted stones found there only contained one pit. The mollusk tenderizing

theory, however, is reiterated by Greenwood (1972) and Moratto (1984:108-109, 129).

Wallace (1954:114), however, was amazed at the large number of pitted stones found at the little Sycamore Site (VEN-1) and believed the quantity indicated a function other than the flaking or pecking of stone implements. Pitted stones "...may have been employed in smashing molluscan shells in order to extract the meat" (Wallace 1954:114).

Still, Hoover and Sawyer (1977:39) suggested the use of pitted stones as anvils for bipolar flaking and Gibson (1979:11) believed pitted stones were used for direct percussion flaking of chert.

The pit in a pitted stone is pecked or battered and is not ground. This precludes pitted stones from being hopper mortars or doughnut stones in an early stage of manufacture. Grinding wear on the face of pitted stones often occurs and it is probable that pitted stones were used to process food items in the same manner as manos and pestles. Circumferential battering is also common indicating that pitted stones were used as hammer-stones. The stones in question, therefore, may have had multiple uses and it is best to consider pitted stones a multi-functional tool when additional wear is present.

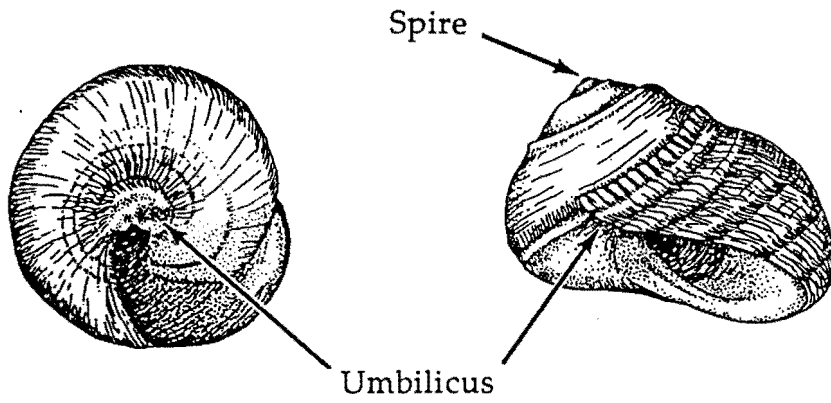
TEGULA SP. SHELLFISH WITHIN THE ROCKY INTERTIDAL ZONE

The relationship of pitted stones with the open coast has been noted previously (Beardsley 1954; Meighan 1959; Moratto 1984) and its relationship with *Haliotis* sp. proposed (Meighan 1959). It is likely that pitted stones were utilized in more ways than just smashing mollusks (Wallace 1954:114) or tenderizing them (Meighan 1959; Greenwood 1972; Moratto 1984). However, the presence of pitted stones on sites near the open coast, and more specifically, on sites near an open rocky coast, is undeniable. With a few exceptions,

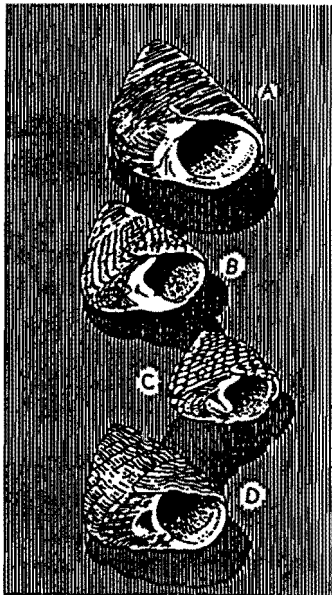
remains of the turban or top shell, *Tegula* sp., a small marine gastropod, are often located in large quantities within middens containing pitted stones. Moreover, Raab (1988:14) notes that *Tegula* sp. recovered from San Clemente Island sites appear to have been deliberately crushed.

The word tegula is Latin for tile and the genus is so named because the finely beaded sculpture of the shell surface resembles roof tiles (Rehder 1981:383). In California, there are five and perhaps six species of tegula that are found intertidally amidst rocks and marine algae along the open or partially protected coast. The following discussion has been adapted from Hill and Tompkins (1954), Hedgpeth (1961), Morris (1966), McLean (1978), and Rehder (1981). *Tegula funebris* (the black tegula) is found from British Columbia to Baja California and grows to approximately 4.0 cm (Figure 5). *T. eiseni* (the banded tegula; formerly *T. ligulata*) is found from Monterey to Baja, grows to approximately 2.5 cm and is found subtidally as well as intertidally. *T. gallina* (the speckled tegula) grows to approximately 4.0 cm and is found from the San Francisco area to Baja, the largest specimens being found in the southern portion of their distribution. *T. brunnea* (the brown tegula) is found from Mendocino County to the Santa Barbara area and grows to nearly 5.0 cm. The brown tegula is found as a Pliocene fossil in the San Pedro area (Morris 1966:63). *T. aureotincta* (the gilded tegula) grows from 2.0 to 4.0 cm and is found from southern California to Mexico. The sixth tegula, *T. pulligo* (the dusky tegula) is found from Alaska to Santa Barbara Island and grows from approximately 2.0 to 4.0 cm. Morris (1966:64) believes the dusky tegula is found in moderately deep water although Rehder (1981:382) states they are found on the rocks intertidally. The similar speckled species are differentiated by the presence in *T. eiseni* of an open umbilicus, absent in *T. gallina*. *T. aureotincta* contains a gold or orange tint around its open umbilicus from which it derives its Latin name. Shell size and weight of *Tegula* sp. shellfish collected from Sunset Cliffs, San Diego, California are listed in Table 2.

Tegula funebris from Alamitos Bay



(Illustration by Janice Fisher in Reish 1968:27)



- A. *Tegula funebris* (Black Turban)
- B. *Tegula eiseni* (Speckled Turban)
- C. *Tegula gallina* (Banded Turban)
- D. *Tegula aureotincta* (Gilded Turban)

(Illustration by Sam Hinton in Hedgpeth 1961:24)

Figure 5. *Tegula sp.* shells of the rocky intertidal zone.

Table 2. *Tegula* sp. Size and Weight Measurements

Species	(mm) (g)				(mm) (g)				(mm) (g)			
	Height	Diameter	Operculum	Weight	Height	Diameter	Operculum	Weight	Height	Diameter	Operculum	Weight
<i>Tegula eiseni</i>	13.93	15.92	5.19	2.2	13.23	15.93	5.54	1.5	13.98	16.56	5.70	1.8*
"	14.04	16.43	5.25	1.7	13.69	15.58	5.21	1.3	15.02	16.21	5.00	1.8
"	16.23	16.33	5.46	2.1***	15.25	16.56	5.14	2.1	16.26	16.25	5.41	1.9
"	14.30	15.29	4.82	1.8	16.94	16.38	5.25	1.9	15.10	17.14	5.43	1.6*
"	11.50	14.45	4.49	1.1	15.04	16.02	5.33	1.8	18.41	18.75	5.58	2.9***
"	15.59	16.47	5.25	2.1	15.02	17.24	5.23	1.9**	14.03	15.40	4.68	1.6
"	15.98	15.16	4.81	1.4*	14.40	15.55	4.67	1.4	14.14	14.75	4.72	1.6
"	11.63	14.23	4.66	1.2	14.51	16.23	4.87	1.7	15.81	15.49	4.81	1.8
"	--	14.71	4.63	****	16.44	17.17	5.18	1.4**	15.34	17.20	5.48	2.1
"	12.53	15.91	5.08	1.2	13.44	15.41	4.83	1.3	12.95	15.90	4.82	1.4
"	16.26	17.46	5.80	1.7	13.25	15.11	4.78	1.3	12.82	15.29	4.94	1.5
"	12.96	14.93	4.90	1.4	14.49	15.32	4.76	1.7	14.40	15.97	4.72	1.7
"	12.77	15.63	4.82	1.4	14.09	16.72	5.42	1.7**	17.15	16.16	4.95	2.0
"	15.08	16.20	5.15	1.7	14.35	16.66	4.96	1.7	13.63	16.35	4.69	1.5
"	12.29	14.56	4.53	1.1	13.23	14.75	4.78	1.3	13.81	15.74	4.78	1.4***
"	14.55	16.07	5.15	1.8	13.23	15.13	4.64	1.3	15.62	16.19	5.16	2.1
"	13.34	16.25	5.02	1.5	13.33	16.01	5.02	1.5	12.47	14.94	4.71	1.2*
"	13.53	15.43	4.72	1.4***	13.56	15.98	5.02	1.5	15.41	15.68	4.99	1.7
"	14.56	16.28	4.88	2.0	12.21	16.33	4.95	1.6	12.19	14.33	4.57	1.2
"	13.57	15.57	4.94	1.5	13.69	16.45	5.29	1.7	14.78	16.53	5.08	2.1
"	13.43	15.39	4.81	1.5	13.00	16.11	5.00	1.4	15.84	16.51	5.15	2.2
"	13.10	14.45	4.72	1.2	13.56	16.38	5.15	1.3**	13.39	17.36	5.13	1.7***
"	15.01	17.09	5.08	2.4	13.61	15.49	4.90	1.4*	13.41	15.51	4.72	1.5
"	13.75	15.10	4.78	1.3*	14.13	16.71	5.10	1.9	12.19	14.69	4.85	1.0**
"	14.82	17.36	5.39	2.0	--	16.63	5.13	****	13.44	15.39	4.82	1.3
"	--	15.90	5.23	****	14.40	16.84	5.28	1.9	--	14.59	4.77	****
"	13.47	16.58	5.13	1.4*	--	15.95	4.78	****				
<i>Tegula funebris</i>	32.10	29.59	9.79	10.3	26.92	26.13	9.09	7.3	24.23	24.48	9.18	5.0
"	25.55	25.17	8.92	6.8*	19.16	20.12	7.27	3.2	18.68	21.70	7.37	2.9*
"	19.41	21.67	6.90	3.1**								
<i>Tegula aureotincta</i>	22.80	25.42	8.55	5.5	20.95	24.02	7.97	5.2	17.56	20.04	6.05	2.7
"	26.04	26.75	7.93	5.5**								

* 1 small hole in shell

*** Bryozoan growth on interior of shell

** 2 small holes in shell

**** Missing spire

(Empty Shells Collected from Sunset Cliffs, San Diego, California)

Within Table 2, asterisks are used to indicate imperfections in the shells collected. Generally, the more asterisks, the more decomposed the shell. One small hole in a shell may indicate that the shell has just begun to decompose, or it may indicate a shell freshly killed by a shell-boring gastropod (*Thais* sp.). Two holes in a shell indicate a more fragmented condition. *Tegula* sp. shells with more than two holes were not measured because of the potential weight alteration due to the loss of shell. Bryozoan growth on the interior of the shell indicates that the shell lay subtidally for a long period of time following the mollusk's death. A missing spire indicates that although width and operculum opening measurements appear valid; weight should not be taken into consideration. For the purposes of this discussion, only those shells without holes or other imperfections were considered for the following generalizations.

Fifty-eight *T. eiseni*, four *T. funebris* and three *T. aureotincta* shells were sufficiently complete for the generation of arithmetic means using the data within Table 2. The largest shells were *T. funebris*, with an average height of 25.6 mm, diameter of 25.08 mm, opercular opening of 8.83 mm and, weight of 6.45 g. *T. aureotincta* contained an average height of 20.44 mm, diameter of 23.16 mm, opercular opening of 7.5 mm, and weight of 4.5 g. The smallest shells were *T. eiseni* with an average height of 14.08 mm, diameter of 15.86 mm, opercular opening of 4.98 mm and weight of 1.6 g. *T. funebris* is the only tegula to exhibit a diameter less than height, indicating that *T. eiseni* and *T. aureotincta* are relatively broad. If shell weight is related to biomass within *Tegula* sp. then *T. funebris* will contain by far the most meat, as its shell weight is more than four times that of the average *T. eiseni* shell.

It might be noted that the sizes of the various tegula are similar to the diameter of pits on coastal pitted stones. This is not to say that they are dissimilar in size from various acorns and nuts.

Tegula sp. shellfish are herbivorous, grazing upon the encrusting or mat forming marine algae

(Ricketts and Calvin 1952:395; Carefoot 1977:122). They are found abundantly (Ricketts and Calvin 1952:83; Gordon 1985:207) and have "...stout, thick shells" (Rehder 1981:381). Densities of *Tegula funebris* can reach 800 individuals per square meter (Carefoot 1977:123). Major predators are starfish (*Pisaster* sp. and *Leptasterias* sp.) but they can also be preyed upon by the various species of *Thais*, the dogwinkle (Ricketts and Calvin 1952:395, Figure 134; Paine 1969). Paine (1969) identified a few individual *Tegula funebris* that were 30 years old, but noted that after five or six years they leave a life of relative safety, high within the intertidal zone, to find more abundant food subtidally and within proximity of their mortal enemies.

Because *Tegula* sp. shellfish are abundant intertidally among the rocks, they are a potential food source. Although small, their abundance, the ease with which they are gathered, and their ability to survive extended periods out of water, make them an ideal source of food. As Erlandson (1988:106) stated about the mussel (*Mytilus* sp.), their location is predictable, and they can be collected by all group members including women, children, and aged individuals. Raab (1988:14) has also noted these facts concerning *Tegula* sp. shellfish gathering.

During late January of 1994, while collecting empty *Tegula* sp. shells at Sunset Cliffs near San Diego, California, a live individual *T. eiseni* and a tegula shell containing a hermit crab (*Pagurus* sp.) were accidentally gathered. The live *Tegula eiseni* along with the hermit crab were unknowingly transported in a plastic bag for several hours, then thoroughly washed in fresh water and set under a heat lamp with a fan. After more than an hour under the heat lamp, during which time the majority of empty shells were completely dried, these two individuals were observed and set aside. More than 30 hours after having been collected, both were returned to a rocky patch of coastline. Following their return to seawater, they were observed for several minutes. The hermit crab scurried away and the *T. eiseni* reacted favorably, adhering to the rock where it was

placed after coming out of its shell to adjust to its surroundings. Neither appeared to suffer any immediate ill effects from their journey. Aboriginal inhabitants could have used this to their advantage, collecting hundreds of *Tegula* sp. and by keeping them moist, they may have been able to store them for several days, increasing their usefulness as a food resource. It is possible that *Tegula* sp. could have been carried many miles to a site, while still remaining fresh. This would make *Tegula* sp. a likely candidate to be gathered on a long shellfish collecting trip, rather than being overlooked for larger molluscan species which would offer more protein. Reinman (1964:59), however, predicted that larger mollusks were utilized first as a food resource before the smaller shellfish were gathered. Overexploitation and subsequent depletion of the larger abalone, therefore, may have served to increase the rate at which *Tegula* sp. shellfish were gathered. Several *Tegula* sp. may have looked just as good as an abalone to a hungry gatherer. Again, there are many middens on San Clemente Island which contain predominantly *Tegula* sp. shell (Yatsko 1987; Raab and Yatsko 1992:34).

In addition to being able to survive extended periods away from seawater, *Tegula* sp. do not adhere strongly to the rocks where they are found. They do not need to be pried off as do abalone, limpets, chitons, barnacles, or even the mussel (*Mytilus californianus*) considered by Erlandson (1988).

Aside from previously listed sites containing pitted stones, many prehistoric middens contain *Tegula* sp. shell. On San Nicolas Island at SNI-16, *Tegula* sp. was the third most commonly recovered shell (Reinman 1964:55) and *Tegula* sp. also occurs on SNI-11 and SNI-79 (Reinman 1964; Koloseike 1969:156). At San Mateo Point (ORA-22), *Tegula* sp. is the second most commonly occurring shellfish (Cook and White 1977; Romani 1980). At the Malaga Cove Site (LAN-138) in Palos Verdes, it is present from the initial occupation level, over 25 feet below the present ground level (Walker 1951:41). *Tegula* sp. is also present at ORA-134 (Chace et al. 1967) and

further north, from the shell middens in the dunes of Año Nuevo Point (Gordon 1985:23).

It is possible that pitted stones occur south of the California border. *Tegula* sp. shellfish are known from the Baja California coast (Morris 1966:63-64) and from the Sea of Cortez (Steinbeck and Ricketts 1941:212). If the pitted stone was used to process *Tegula* sp. then it is possible that if these mollusks were utilized as a food resource, pitted stones may yet be found on sites south of the United States border.

TEGULA SP. PROCESSING

"By Italians these snails (*Tegula* sp.) are considered fine food. They are cooked in oil and served in the shell, the bodies being removed from the shells with a pin as they are eaten." (Ricketts and Calvin 1952:23)

Mark Raab and his research assistants experimented with *Tegula funebris* processing (Raab 1988:13-15; Raab and Yatsko 1990:20-23). They found that after cooking for 10 minutes in boiling water, the mollusk could be extracted from the shell and then consumed. They found that *T. funebris* compares favorably in taste with abalone and other shellfish. Raab and Yatsko found the average shell weight of the *T. funebris* was 2.59 g (compare with Table 2), while the cooked meat averaged 0.47 g. Although seemingly small, the sheer number of *Tegula* sp. shells within middens on San Clemente Island indicates that the native population considered them edible.

As previously mentioned, *Tegula* sp. shell within middens is nearly always deliberately broken (Raab 1988:14) but not burned (Raab and Yatsko 1992:23). Raab and Yatsko believe that shells were crushed and boiled in sort of a *Tegula* sp. soup. Perhaps the natives were creating their own style of bouillabaisse, mixing *Tegula* sp. with whatever else was gathered including abalone and other molluscan species. It is probable that they consumed marine algae and additional flora not recovered archaeologically. It is this sort of

opportunistic gathering that is characteristic of the coastal aboriginal population.

Merely boiling the shellfish does not release the *Tegula* sp. snail (Raab 1988:14) and once boiled the mollusk must be pulled from the shell. Without boiling, however, it is nearly impossible to pull them from their shell. On San Clemente Island, where firewood is scarce (Huey 1992:77), it would have been to the advantage of the native population to first extract the snails and then cook them, thereby conserving firewood. It is possible that where firewood was not scarce, *Tegula* sp. shellfish may have been processed by boiling and then pulling them from their shell, making pitted stones unnecessary.

In February of 1994, in an effort to test the effectiveness of crushing *Tegula* sp. shells in order to extract the mollusk, while simultaneously replicating a *Tegula* sp. crushing tool, two fist-sized cobbles were obtained from the San Diego area. One of the rocks was a consolidated sandstone and the other was a volcanic material. The two rocks were taken to the open ocean-facing tide pools of Sunset Cliffs, San Diego, and during a medium tide, were used to crush three species of tegula found living there. *T. funebris* and *T. aureotincta* were the largest, but by far the most common was *T. eiseni*. *Tegula* sp. possess sturdy shells, structurally much like a pyramid, but the shells were easily broken with the cobbles, even though the cobbles lacked pits for finger grips. Individual *Tegula* sp. were placed spire downward on one rock, the "anvil," while a blow was delivered with the other rock, the "hammerstone." The rocks were used interchangeably. Shells were broken usually with one or two blows. The mollusk was then easily extracted from the shell and was saved in a plastic bag. After each blow and until crushed, the spire of each shell dug into the anvil and after approximately 30 specimens were crushed the sandstone cobble had obtained a pronounced pit, which under any circumstance, could be considered a pitted stone. The volcanic cobble showed some pecking but was far from being considered pitted. Since each rock was alternately used as hammerstone and anvil, each received

approximately the same amount of use. Considering the small number of *Tegula* sp. shells broken during this procedure, it is likely that after crushing several hundred, or even thousand *Tegula* sp. shells, even the more dense volcanic cobble would eventually contain a pit. Although the multi-functional pitted stone may have also been used prehistorically to pound abalone, to grind seeds, or to pulverize small rodents (Yohe et al. 1991) and fish (Kroeber 1925:409), it is now hypothesized that pitted stones found on prehistoric coastal sites were formed and used to process *Tegula* sp. shellfish as a food resource.

Recently, a sample of the dried remains of the *Tegula* sp. collected during this experiment was submitted along with two prehistoric pitted stones (from SCLI-847, San Clemente Island) to Margaret Newman of the University of Calgary for blood protein analysis. The results of this analysis are pending, but may assist in providing a new theory concerning the multi-functional pitted stone and its use in processing *Tegula* sp. shellfish on coastal sites.

NOTES

I was first introduced to pitted stones by Dr. E. Jane Rosenthal during a discussion of "problematical" artifacts after having raised a question as an undergraduate in the archaeology lab at California State University, Long Beach. In those days, lively and sometimes heated discussions often occurred while we pondered the use of prehistoric tool types. My first contact with pitted stones came as a result of being allowed to assist with the excavation of SCLI-1178 (North End Shelter) during the 1985 UCLA field season on San Clemente Island. I am grateful to both Dr. Douglas Armstrong and Janet Scalise for this opportunity, even though my assistance was of a limited nature. Recently, during a conversation concerning pitted stones with Roxana Phillips, I was informed that the Mesa College students collected many of these artifacts as part of the field classes conducted from 1975 to 1980 on San Clemente Island. Judy Berryman, Coreen Chis-

well, and Andy Yatsko (NAS, North Island) assisted by providing the opportunity to photograph pitted stones from the Mesa College collections and Andy allowed their removal for additional photographs and study. Andy also provided valuable literature concerning his and Dr. Mark Raab's efforts to reconstruct aboriginal *Tegula* sp. processing. Had the Northridge earthquake of 1994 not occurred, Dr. Raab himself would have undoubtedly assisted. Phil Hines provided me with a copy of a valuable paper documenting pitted stones from the San Luis Obispo area. Reference material was also gratefully accepted from Jan Pisciotta, which inspired further thought on the subject of *Tegula* sp. shellfish. Franklin Fenenga and Bill Wallace both offered their knowledge of literature and areas where pitted stones occur, as well as valuable ideas concerning their use. I also thank Dennis Gallegos for comments and the use of Gallegos & Associates laboratory equipment. Ed Baker and Ron Bissell also provided comments. Larry Tift was instrumental in helping obtain samples of *Tegula* sp. from the intertidal region of Sunset Cliffs, San Diego, California. Finally, I thank my wife Diane Valko for her editorial comments and help with figures. Without the support of the aforementioned individuals, this paper would not have been possible.

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