FRESHWATER MUSSELS: AN ECOLOGICAL PERSPECTIVE FOR CALIFORNIA ARCHAEOLOGISTS

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ABSTRACT

Freshwater mussel remains are present in archaeological sites throughout California. In the past these shells have been used to determine prehistoric diet and in site-seasonality studies. Without research into the individual ecology of the bivalve species, the maximum research potential for these shells is not being met. This paper provides archaeologists with ecological background on the bivalve genera native to California (*Anodonta, Gonidea*, and *Margaritifera*) for use in studies of past environment, subsistence and settlement patterns.

Freshwater mussel shell is known to occur in archaeological sites throughout California. These mussels were used as raw material in the manufacture of tools, ornaments and buttons but were most commonly harvested as food resources. While freshwater shellfish have historically been perceived as a marginal resource, there is substantial archaeological evidence for significant prehistoric use of freshwater mussel, including dense mussel shell middens, throughout Washington, Oregon, Nevada and California.

The archaeological research concerning these freshwater mussel shell discoveries is characterized by laboratory studies of site seasonality, largely advanced by Jim Chatters of Ellensburg, Washington. The technique involves examining shell growth rings to determine the season of harvest. While valuable, the technique is limited in its applications in that it requires a substantial sample of intact shell and a reliable body of comparative ecological information for the species under study. Obtaining a body of comparative information poses a unique challenge for California archaeologists, as living populations of freshwater mussels, which thrive in our neighboring western states, have been almost completely obliterated by a loss of California habitat brought on by a variety of factors. As Chatters' work throughout Washington and in northeastern California (Chatters 1993, 1986), as well as Drews' work in Stillwater Marsh, Nevada (Drews 1988) and Hattori and Cannon's work in Oregon's Warner Valley (Cannon 1993) has proven, such ecological data is pertinent to a variety of archaeological studies. Yet this ecological data has neither been exhausted nor regularly incorporated into California archaeological research designs, which may be due in large part to the lack of available, comprehensible ecological manuscripts. The purpose of this paper is to briefly summarize some of the most basic ecological data available for the three freshwater mussel genera native to California (*Anodonta, Gonidea, Margaritifera*) in hopes of making that information more useful and accessible to California archaeologists.

Bivalves, of which clams and mussels are the primary members, are characterized by a soft tissue body segmented into two valves, through which they filter water and retain nutrients. In terms of general physiological characteristics, bivalves can be distinguished by their shells. All bivalve shell is composed of three layers: the periostracum, which is friable and often eroded away during depositional processes; a prismatic layer which is the shell's exterior; and smooth interior, referred to as the nacre. Each layer is made up of calcium carbonate ($CaCo_3$) crystals suspended in an organic matrix. The layers of clam shells are distinct, forming a hard chalky shell, while the layers of mussel shell are more integrated, resulting in a intensified prismatic exterior possessing a glass like structure (McMahon 1991). This distinction between freshwater clam and mussel can be made taxonomically by referring to *Unionaceans* as mussels and other freshwater bivalves as clams. The latter point raises the issue of taxonomy and there is as much confusion with the taxonomy of freshwater mussels as there is with any animal (California freshwater mussel taxonomy is outlined in Figure 1). The superfamily *Unionacea* (freshwater mussels) is divided into two families (*Unionidae* and *Margaritiferidae*). Three genera: *Anodonta, Gonidea*, and *Margaritifera*, occur in California (Burch 1975).

Freshwater mussels share a similar life-cycle and overall ecology. They begin life in a larval stage, when the larva or glychodia attach themselves in a parasitic relationship to certain species of fish. Following this larval stage juvenile mussels, which have the same physical characteristics as adults, form aggregate beds. Each species has a unique ecological niche, and beds in waters with specific sedimentation, chemistry, temperature, and general environment. Creating this niche allows the mussels to reach high reproductive levels, with the largest individuals and groups forming under optimum conditions. However, the distinctive needs of each species makes them highly sensitive to environmental change. Temperature, for instance, has been shown to have direct effect on growth rate; at temperatures below 10 degrees celsius, mussels will burrow into their surrounding sediments, regulating temperature and inhibiting their nutrient intake, therefore slowing metabolism (Pennak 1989). This sensitivity is reflected in the shells of all mollusks and is one of the tenants of site seasonality studies. The burrowing behavior also affects harvest,

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with collection more difficult when individuals are buried under the substrate. Other variations in environment can affect the life cycle of the animal: over-harvest can cause accelerated growth (Chatters 1986), over-sedimentation can rapidly obliterate a population, and inter-species competition (a topic requiring a paper all its own) plays a large part in the size and growth of a population. In general it is their specializations which both distinguish and limit California freshwater mussels.

No ecological discussion of freshwater mussels would be complete without mention of the Asian freshwater clam *Corbicula fluminea*. *Corbicula* was introduced to the Mississippi River in the early 1900's (McMahon 1991) and moved into California around 1946 (Taylor 1980). This clam is resistant to many environmental constraints and has played a major role in the loss of California freshwater mussel populations. An intense competitor for habitat, *Corbicula* now occupy most freshwater bivalve habitat in California. Perhaps it is due to their widespread abundance that *Corbicula* have been mistaken by archaeologists as freshwater mussels.

Three genera: *Anodonta*, *Gonidea*, and *Margaritifera*, occur in California. A brief discussion of their collective ecologies follows:

Three species from the genus *Anodonta* (referred to collectively as anodonts), occupy California habitats: *A. californiensis*, *A. oregonensis*, and *A. nuttalliana* (also referred to as *A. wahalmatensis*). More descriptive ecological information is available for anodonts as a whole than for each individual species. They are commonly called Swan mussels and their thin shell has a fluted shape and a toothless hinge which gives them their name. While most freshwater bivalves prefer shallow habitats, anodonts can be found at depths from 0.5 to 7 meters. They prefer the still, murky waters of slow moving rivers and lakes with warmer temperatures to accommodate their slow metabolic rate. California anodonts' natural habitat has for the most part been eradicated throughout the state; of the three native species thriving populations of *A. oregonensis* are most likely to be observed in northeastern California. To summarize Taylor (1980), California anodonts' historic range breaks down as follows:

A. californiensis: The Shasta and Pit Rivers, Central Valley and North Coast streams, the Pajaro-Salinas system, the Lahontan system, the Owens River, the Santa Margarita, Los Angeles and Santa Ana Rivers, South-Central coastal drainages near San Luis Obispo, the Salton Sea and various lakes, reservoirs and perennial streams.

A. oregonensis: Northeastern California in the Lower Klamath and Upper Klamath and Lost Rivers, and in Central California in the Middle fork of the Feather River and in lakes and slow rivers of the Sierra Valley and Plumas County.

A. wahalmatensis: The Pit River, Clear Lake, Blue Lakes, Crystal Springs Reservoir in San Mateo County, and in larger slow streams in the Central Valley north of the San Joaquin Valley.

Following their larval stage, free moving anodonts become partially embedded in silty sediments. They can be harvested by following the worm-like trail they leave behind as they move through the substrate, and scooping them up just below the surface. While dietary anodont shell is prevalent in many archaeological sites, it is probably too thin to have been used as a raw material for tool manufacture.

The genus *Gonidea* is represented by a single species, *angulata*. In contrast to the anodonts, very little ecological data exists for the California species, *Gonidea angulata*. Available information primarily concerns *Gonidea's* European counterpart, *Unio*. Now nearly eradicated in most of its original California range, *Gonidea angulata*, commonly referred to as the angled mussel, has a robust shell, with a slight hinge and distinct angled shape. *Gonidea* appears to have occupied an environment intermediate to that of anodonts and *Margaritifera*. It was most likely a river species and was probably able to tolerate moderate sedimentation. Existing populations are restricted to the northeastern portion of the state, but historically *Gonidea's* range would have included Upper and Lower Klamath, Lost and Pit Rivers, the Lower Eel and Lower Russian Rivers, North Coast streams, Clear Lake, Blue Lakes, the Pajaro River drainage, Ballona Creek and the Santa Ana River, mirroring many anodonta habitats but probably in creeks and rivers rather than lakes (Taylor 1980).

The genus *Margaritifera* is represented in California solely by the species, *margaritifera* or freshwater pearl mussel, and its associated subspecies *margaritifera falcata*, distinguished by the slightly different color of its nacre. This pearly interior was widely used in the manufacture of shell buttons around the turn of the century, which has resulted in a greater ecological knowledge of margaritifera than any other freshwater mussel species in California. Chatters has done extensive work with the species during the course of seasonality studies (Chatters 1993, 1986). *Margaritifera* has a thick shell with a characteristic hinge and prefers clear, fast moving waters with a loose, gravelly substrate. Following their larval stage in which the preferred host is a trout species (Taylor 1980), the mobile juveniles seek beds at depths of 0.5-1.5 feet, usually under the shelter of a rock outcrop. Their range in California includes the Lower Klamath River, the Smith River, Goose Lake, the Pit River, North Coast streams, trout streams throughout the Central Valley, Clear Lake, the Upper Kern River, the Lahontan system, and streams in the southern Santa Cruz mountains, where they are now probably extinct in the San Lorenzo River (Taylor 1980). Once bedded, *Margaritifera* become sessile or immobile. Their bed community is unique; the *margaritifera* form age-specific communities, aggressively excluding individuals of other ages from joining. Under optimum conditions the mussels are quite prolific and can bed in groups of up to 10,000. These extensive beds make for easy harvest. However, the age-specific beds cannot be replenished, and over-harvest can obliterate a population.

Though the ecological information presented here is brief, it highlights how the individual ecologies of California freshwater mussels might be used to broaden the scope of related archaeological studies. Ecological data has already been incorpo-

rated into specialized archaeological studies of seasonality and it is just as important to bring that data into general studies of subsistence and environmental reconstruction. In fact, because freshwater mussels inhabit specific ecological niches, their shells are ideal indicators of past environmental composition. Some examples of incorporating ecological data into archaeological investigations include, Biosystems Analysis Inc.'s 1994 examination of CA-SAC-85 where a sample of *Anodonta* and *Margaritifera* were used to support the reconstruction of the prehistoric Beach Lake waterway and at several sites on the Pit River in Shasta County where Chatters' comparisons between modern populations and the archaeological record show that gonidea now occupy the waters previously inhabited by margaritifera (1986); or at CA-YOL-182 where the presence of both anodonts and *Gonidea* suggests a mixed subsistence strategy (Melton nd).

Finally, there is hope that new applications will be developed. Biosystems Analysis Inc.'s collection of a large sample of *Gonidea angulata* shell last year from CA-YOL-182 during the Ceylon Park Project provides opportunity for more detailed examination and further insight into the ecology of this little known species and may offer reasons for its impending extinction. General characteristics of freshwater mussels need to be explored. For instance, perhaps the fact that accelerated growth caused by over exploitation can be observed in the archaeological record.

In sum, by focusing on the ecological needs of each of these native freshwater mussel species, California archaeologists can maximize the research potential of a shell-bearing site, ultimately working towards more fully developed archaeological inquiries.

Notes

In the process of researching this paper it has come to my attention that although, as I have pointed out, populations of freshwater mussels have been almost completely obliterated in California, none of the native species I mention are included on the California Endangered Species List. The fact that they have not been included on this list does not justify collection of living populations for study; an alternative exists! I am grateful to Bob Van Zyke and Elizabeth Coules, Invertebrate Zoologists at the California Academy of Sciences in San Francisco, for use of their excellent comparative collection of freshwater bivalve shells from across California, and strongly recommend this collection as an invaluable resource for all students of California freshwater mussels.

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Figure 1. California Freshwater Mussel Taxonomy

CLASS - Bivalvia					
SUBCLASS - Pelecypoda					
ORDER - Naidoidea					
SUPERFAMILY - Unionacea					
FAMILY-	Unionidae			Margaritiferidae	
GENUS	Anodonta		Gonidea	Margaritifera	
SPECIES	oregonensis	californiensis nuttalliana	angulata	margaritifera	
SUBSPECIES					falcata