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Freshwater Mussel Remains from the Bilbo Basin Site, Mississippi, U.S.A.: Archaeological Considerations and Resource Management Implications

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ABSTRACT: Analysis of an assemblage of freshwater mussel (Unionidae) shell from the Bilbo Basin site (22GE512) in south Mississippi, U.S.A., provided data on mussel biogeography, shell dissolution, and shellfish exploitation at a short-term prehistoric site. Silt-sensitive species are rare, presumably a result of mussel adaptation to streams with loose, sandy substrates. Virtually all the shells examined show extreme erosion of the umbo, a feature noted in modern specimens as well and likely attributable to breaching of the periostracum through sand abrasion and subsequent dissolution of the shell in the acidic waters of the Pascagoula River. A decrease in shell size over time shows that human predation had a significant effect on mussel populations over a relatively short time span.

KEYWORDS: FRESHWATER MUSSELS (FAMILY: UNIONIDAE), UPPER MISSISSIPPI RIVER, SHELLFISH EXPLOITATION, ANTHROPOGENIC IMPACT, LATE WOODLAND PERIOD, MISSISSIPPIAN PERIOD

RESUMEN: El análisis de una muestra de almejas de río (Unionidae) procedente del Bilbo Basin site (22GE512) en el sur de Mississippi (U.S.A.), ha proporcionado información sobre la biogeografía, disolución de las conchas y explotación de los moluscos en un yacimiento prehistórico con un corto periodo de ocupación. Las especies propias de fondos de limo o fango son infrecuentes, presumiblemente en razón de la adaptación de estas almejas a cursos de agua con fondos arenosos y vágiles. La práctica totalidad de las conchas examinadas presentan un erosionado acentuado del umbo, un rasgo que también exhiben los ejemplares actuales seguramente como consecuencia de la abrasión del periostraco y posterior disolución de la concha en las aguas ácidas del río Pascagoula. La disminución del tamaño de la concha con el tiempo sugiere que la depredación humana ha podido tener un efecto marcado sobre las poblaciones de almejas en un periodo de tiempo relativamente corto.

PALABRAS CLAVE: ALMEJAS DE RÍO (FAMILIA: UNIONIDAE), CURSO ALTO DEL RÍO MISSISSIPPI, EXPLOTACIÓN DE MOLUSCOS, IMPACTO ANTRÓPICO, PERIODO LATE WOODLAND, PERIODO MISSISSIPIAN

INTRODUCTION

There is a growing awareness that faunal remains from archaeological contexts can provide biogeographical and community-level data useful for decision-making in contemporary natural resource management (e.g., Lyman & Wolverton, 2002). Perhaps no other class of faunal remains has received more attention in this regard than freshwater mussel (Unionidae) shells. Most studies using archaeological shell compare the remains to modern assemblages to illustrate the dramatic decreases in biodiversity brought about by modern human activities (e.g., Ortmann, 1909a; White, 1977; Metcalf, 1980; Parmalee *et al*., 1982; Parmalee & Bogan, 1986; Theler, 1987; Parmalee, 1988; Taylor, 1989; Parmalee & Hughes, 1993; Neves *et al*., 1997). Other studies have focused on expanding our knowledge of the original ranges of particular species (e.g., Murphy, 1971; Barber, 1982; Gordon, 1983; Warren, 1995; Peacock & Chapman, 2001; Peacock & James, 2002) and one (Williams & Fradkin, 1999) describes a new species which is known only from archaeological material. Such research provides a stark lesson. Although the more sensitive North American species began to decline in prehistoric times, arguably due to the effects of aboriginal land use (Peacock *et al*., 2005), there are no documented prehistoric extinctions or extirpations of any taxa. In contrast, mussel communities which were essentially stable for thousands of years (Bogan, 1990) have been massively altered by erosion and siltation, other forms of water pollution, stream channelization, impoundment, and other human impacts in recent times (Van der Schalie, 1938; Cvancara, 1970; Starrett, 1971; Imlay, 1973; Hartfield, 1987, 1993; Bogan, 1993). Freshwater mussels are recognized as being among the best indicator organisms for water quality (Fuller, 1974: 254; Imlay, 1982; Bogan, 1993: 604). Their precipitous decline over the last century is a sobering reminder of just how modified our biosphere has become. With proper consideration of preservation and cultural biases, archaeological assemblages can provide baselines for ecological reconstructionists working to undo such damage.

Importantly, such archaeological data can also provide insight on how limited environmental restoration funds should be targeted. Figure 1 shows the proportion of currently endangered or extinct mussel species (as listed in Williams *et al*., 1993) found in a sample of archaeological assemblages from eastern North America. Defining impact in terms of loss in biodiversity (cf. Minnis & Elisens, 2000), it is clear that mussel faunas from the main stems of major rivers in the interior Eastern Woodlands – e.g., the Tennessee and Cumberland Rivers – have been far more severely impacted than those of the upper Mississippi River Basin and lower Gulf Coastal Plain streams.

Geographical patterns at this scale presumably have underlying evolutionary explanations involving radiation and adaptation. The Upper Mississippi River region was recolonized by mussels following the end of the last glacial period. It can be hypothesized that generalist species were most successful in recolonizing this newly available habitat because they were able to out-compete more specialized species. These generalists are species that are tolerant of a wide range of environmental conditions and as such are the ones that are thriving today, in relative terms, while more sensitive species have been so dramatically reduced. On the other end of the geographical range under discussion, it can be hypothesized that mussel communities from the lower Gulf Coastal Plain were already adapted to streams with relatively heavy sediment loads and unstable substrates and thus have been less impacted by erosion and siltation in modern times (except where increases in sediment load have been sudden and dramatic – e.g., Hartfield, 1993).

These data have implications for biologists, ecologists, conservationists and land managers. First of all, those sensitive species that today are rare in lower Gulf Coastal Plain streams were equally rare in the past (e.g., *Arkansia wheeleri* and *Cyprogenia aberti* in the Ouachita River in Louisiana – Peacock & Chapman, 2001) for natural reasons. Therefore, trying to manage mussel populations in such as way as to cause those species to significantly increase in proportion would be trying to create a situation that never occurred naturally. Secondly, siltation in rivers like the lower Ouachita is probably not the same culprit in those instances where mussel declines are noted; rather, some other factor, such as chemical effluents or a decline in the host fish for glochidia (mussel larvae), is probably to blame. Clearly, long-term data can help modern conservation efforts by allowing scientists to better understand original population structures and by allowing them to better focus their efforts when causes for mussel declines are being sought. One role of environmental archaeology is to provide data and

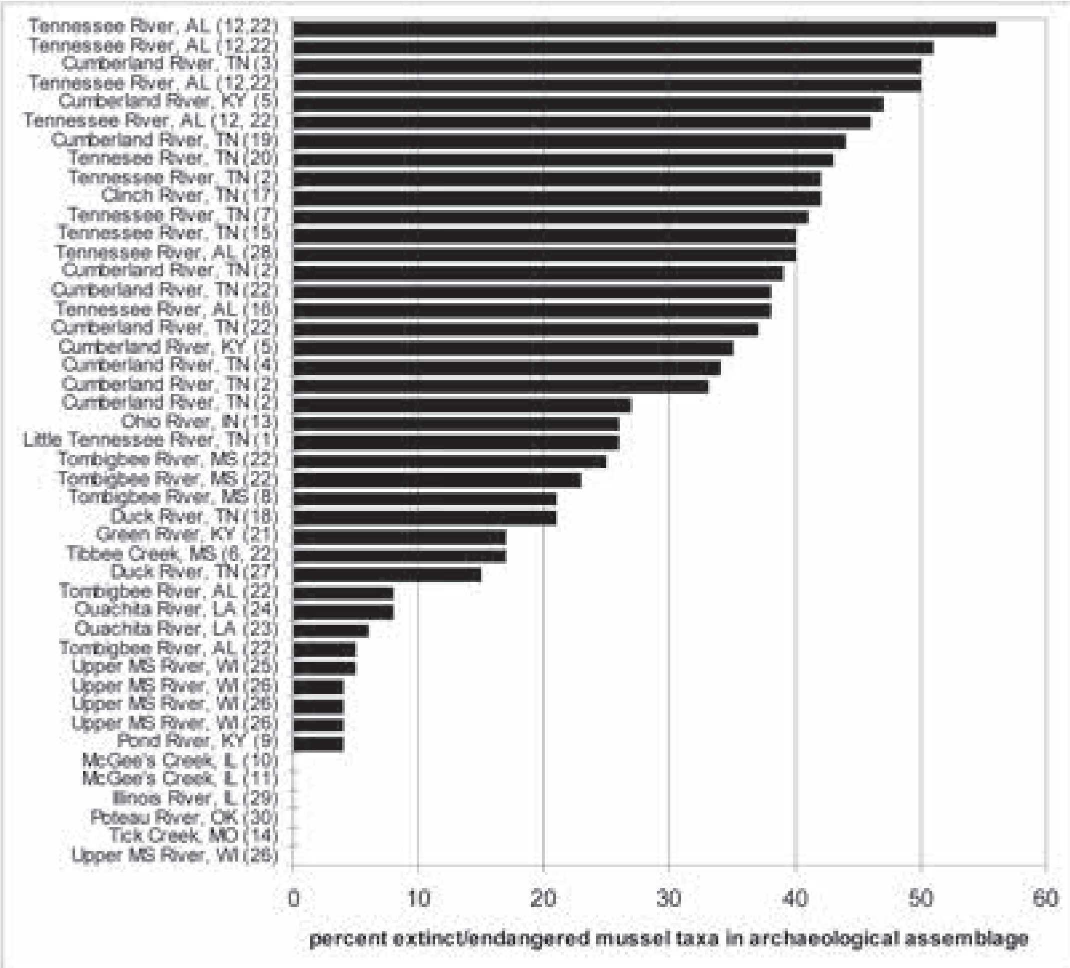

FIGURE 1

Proportions of archaeological mussel assemblages from eastern North America made up of taxa listed as endangered or extinct by Williams *et al*. (1993). References for assemblages are: (1) Bogan & Bogan (1985); (2) Breitburg (n.d.); (3) Breitburg (1983); (4) Breitburg (1986); (5) Casey (1987); (6) Hanley (1982); (7) Hanley (1983); (8) Hartfield (1990); (9) Kreisa (1991); (10) Matteson (1958); (11) Matteson (1959); (12) Morrison (1942); (13) Parmalee (1960); (14) Parmalee (1965); (15) Parmalee (1990); (16) Parmalee (1994); (17) Parmalee & Bogan (1986); (18) Parmalee & Klippel (1986); (19) Parmalee *et al*. (1980); (20) Parmalee *et al*. (1982); (21) Patch (1976); (22) Peacock (1998); (23) Peacock & Chapman (2001); (24) Saunders *et al*. (2005); (25) Theler (1986); (26) Theler (1987); (27) Turner (n.d.); (28) Warren (1975); (29) Warren (1995); (30) White (1977). State abbreviations are: AL – Alabama; IL – Illinois; IN – Indiana; KY – Kentucky; LA – Louisiana; MO – Missouri; MS – Mississippi; OH – Ohio; OK – Oklahoma; TN – Tennessee; WI – Wisconsin.

interpretations that are meaningful both in an evolutionary and in an applied context.

In this article, we describe an archaeological assemblage of freshwater mussel shell from the Bilbo Basin site (22GE512), a Mississippian-period site located on the Pascagoula River in George County, Mississippi, southeastern U.S.A. We compare the assemblage to modern mussel data, including a discussion of the erosion of living mussels in the acidic waters of the Pine Hills physiographic province. A decrease in the size of shells over time also is discussed, with a consideration of what constitutes prehistoric human «impact» and whether it is observable in the Bilbo Basin shell assemblage.

THE BILBO BASIN SITE

The Bilbo Basin site is located on the Pascagoula River in George County, Mississippi (Figure 2). The Pascagoula flows directly into the Gulf of Mexico and lies between the Tombigbee-Alabama River watershed to the east and the Pearl River watershed to the west. It is one of the largest free-flowing rivers in the southeastern United States. It drains ca. 9,000 square miles of Mississippi and Alabama, an area mostly comprised of the Pine Hills (a.k.a. Piney Woods) and Coastal Meadows physiographic provinces; major tributary streams include the Leaf and Chickasawhay rivers and Black Creek. The Pine Hills province is very poorly known archaeologically, and researchers have only recently become aware of the richness and complexity of cultural remains there (Jackson *et al*., 2002). Prehistoric populations in the province seem to have peaked during the Late Woodland period, considered to last from ca. A.D. 500 to 1200 for the area (Jackson *et al*., 2002: 245); subsequent Mississippian-period agriculture-based settlements are more rare, although recent work has documented the presence of a substantial number of such sites along the Gulf Coast, ca. 40 km to the south (Blitz & Mann, 2000).

Limited testing was conducted at the site in the fall of 2003 by the University of Southern Mississippi. Three 1x1 m units were excavated in arbitrary 10 cm levels using quarter-inch screens. The site contained a dense shell deposit approximately 50 cm thick. Large numbers of artifacts and animal bone also were recovered, suggesting general

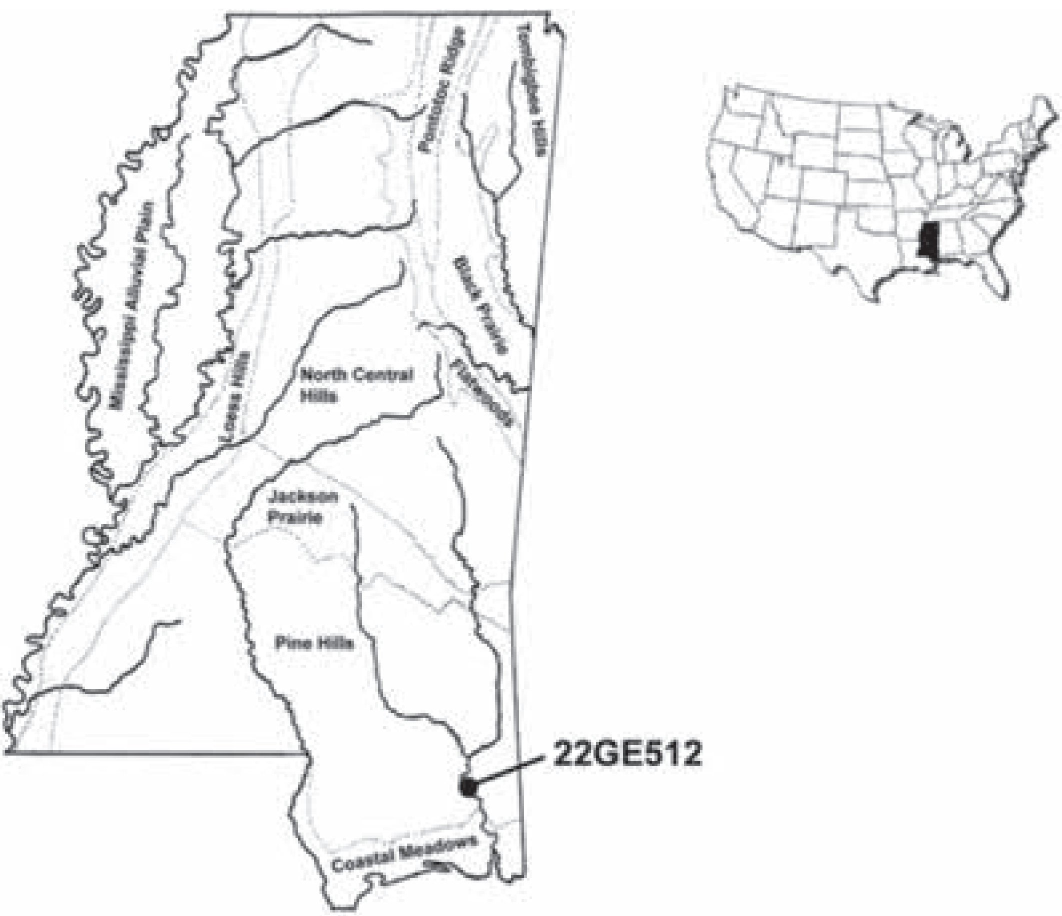

FIGURE 2
Location of the Bilbo Basin site, 22GE512, on the Pascagoula River in George County, Mississippi, U.S.A.

habitation debris, but these remains have not yet been analyzed. Charred plant material from Unit N1025 E1033, Level 5, was submitted for radiometric-standard dating and produced a 2-sigma calibrated date range of 790-660 B.P. (Beta-217101), or A.D. 1160-1290. Mussel shell from a shell-tempered sherd recovered from the same unit and level was AMS radiocarbon dated and returned a calibrated 2-sigma range of 920-700 B.P. (Beta-217099), or A.D. 1030-1250. There are no visible stratigraphic breaks, suggesting that the deposit accumulated relatively rapidly.

MUSSEL ASSEMBLAGE CHARACTERISTICS

The general lack of knowledge concerning archaeology in the Pine Hills is mirrored by a lack of modern mussel research. The Lower Gulf Coastal Plain is very poorly understood where mussel biogeography, systematics, fish hosts, and other topics are concerned (Heard, 1970; Haag & Warren, 1997). The Bilbo Basin site assemblage provides an excellent opportunity to characterize mussel faunas as they existed in the area prior to modern impacts.

A total of 25,898 valves was recovered from the site, of which 17,562 (68%) were identifiable to species (Table 1). This is a relatively low proportion of identifiable valves as compared to other archaeological assemblages in the region (e.g., Peacock, 2000), an indication that the assemblage is in rather poor condition. Despite the poor condition of the shell, a minimum of 14 taxa was identified from the three units. The assemblage, while rich, is not even. One species, *Quadrula refulgens*, makes up just over 60% of the total identifiable valves. Combined, *Q. refulgens* and *Fusconaia ebena* make up 90% of the identifiable valves, while no other species comprises even 5%. This pattern of dominance by a few species is typical of «stressed» environments; in this case, the stress likely results from water acidity (see discussion of shell dissolution below).

There is little in the modern mussel literature against which the Bilbo Basin data can be com-

Excavation Unit	N1025 E1033						N1025 E1034				N1027 E1040				
	L.1	L.2	L.3	L.4	L.5	L.6	L.3	L.4	L.5	L.6	L.1	L.2	L.3	total	% of identifiable
Amblema plicata	2	24	42	90	85	5	16	24	76	9		6	19	398	2.27
Elliptio crassidens	2	12	26	73	44	1	10		30	4			8	210	1.20
Fusconaia cerina			2	41	12			6	13					72	0.41
Fusconaia ebena	26	304	634	1,129	1,193	68	293	620	829	12	4	26	22	5,160	29.38
Glebula rotundata			2	3	7	2			4	1			1	20	0.11
Lampsilis straminea claibornensis		2			1									3	0.02
Lampsilis teres			1											1	0.01
Megalonaias nervosa		1			1									3	0.02
Plectomerus dombeyanus	2	9	237	214	103	6	27	36	115	20			27	796	4.53
Pleurobema beadleianum			9	39	50	5	6	24	43				2	181	1.03
Quadrula apiculata			1											1	0.01
Quadrula nobilis		2	5	27	24	4		11	31				7	111	0.63
Quadrula refulgens	39	522	1,174	1,764	1,950	122	581	1,182	1,780	286	5	57	1136	10,598	60.35
Tritogonia verrucosa					2			2	3				1	8	0.05
unidentifiable	19	758	1,272	1,292	1,224	70	621	810	1,285	1		309	675	8,336	
Total	90	1,635	3,406	4,672	4,696	283	1,554	2715	4,209	333	9	398	1,898	25,898	

TABLE 1

Freshwater mussels identified from the Bilbo Basin site (22GE512). The shell was obtained from the University of Southern Mississippi, Hattiesburg; no shell from Levels 1 and 2 of Unit N1025 E1034 was in the collection obtained.

pared. Miller *et al*. (1986) report very low species diversity in the Tangipahoa River, southwest Mississippi, where only five species (*Fusconaia flava*, *Q. pustulosa* [= *refulgens*], *Elliptio crassidens*, *Tritogonia verrucosa*, and *Villosa* sp.) were reported. They note that the «Tangipahoa River fauna live in water at the extreme lower end of the range of dissolved calcium concentrations usually reported for the freshwater Mollusca» (p. 22), i.e., that there were «extremely low dissolved calcium levels» in the river, making it a stressed environment similar to the lower Pascagoula River. The low diversity in their sample is also doubtless a result of sample size, as they obtained only 266 mussels in total.

Hartfield (1987) provides a list of endangered, threatened, and «special concern» mussel species in Mississippi. None of the Bilbo Basin site species are threatened or endangered. This is in keeping with the continental-scale biogeographical patterns discussed above. The lack of valves from the genera *Toxolasma*, *Villosa*, and *Utterbackia*, all found in the Pascagoula today (Jones *et al*., 2005), may be due to preservation biases differentially affecting these small and/or thin-shelled species.

SHELL EROSION

Mussel shell consists of three layers: an outer, proteinaceous layer, the periostracum; a middle prismatic layer composed of calcium carbonate; and an inner nacreous layer, also of calcium carbonate. The periostracum serves an important function in protecting the inner shell layers from abrasion by sediments and erosion by organic acids. Upon loss of the periostracum, shell dissolution begins (cf. Hunter, 1990) and, if the shell is completely eroded through, the mussel normally is invaded by bacteria or is consumed by predators and perishes. In some situations, the animals apparently can persist for some time, although the reasons for this are unclear (cf. Howells *et al*., 1996:3; Paul Hartfield, U.S. Fish and Wildlife Service, personal communication 2005). Loss of periostracum above the umbo, in the oldest part of the shell, is a common feature of old individuals in a variety of settings (Murray & Leonard, 1962:15; Parmalee, 1967: 9; Parmalee & Bogan, 1998: 8). However, periostracum loss also can be a marker of water pollution and/or increased abrasion resulting from human-induced siltation (Simpson, 1899; Ortmann, 1909b; Williams, 1969; Yokley, 1973; Fuller, 1974; Houp, 1993; Miller *et al*., 1993), especially if mussels of all ages are being so affected. Such a phenomenon could be the first indication that pollutants have entered a stream.

Mussel shells recently collected from sandbars in streams in the Pine Hills physiographic province of southern Mississippi display periostracum loss and considerable erosion of the umbonal portion of the shell (Figure 3). Informal discussions with local residents suggested various possible sources of pollutants, including industrial waste facilities, paper mills, and jet fuel exhaust from the military air exercises frequently conducted in the area. More formally, a report by the Mississippi Department of Environmental Quality (2005) documents elevated levels of mercury, likely attributable to atmospheric deposition, in some parts of the Pascagoula River, and lists potential anthropogenic sources for the pollutant including wastewater facilities, water treatment plants, laundries, and other «improvements». Although atmospheric and point-source pollutants other than mercury are not specifically mentioned, the potential for their presence in the river is clear.

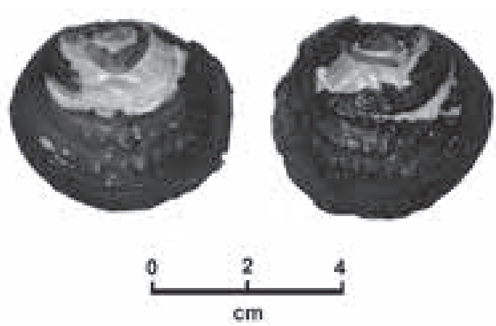

FIGURE 3

Modern left and right valves of *Quadrula refulgens* from Black Creek, Perry County, Mississippi, showing loss of periostracum and erosion of the umbos.

Examination of shells from the Bilbo Basin site clearly indicates that the pronounced erosion visible on mussels today is a natural feature in the province rather than being the result of modern pollutants or human-induced siltation. Virtually every valve for the site, regardless of size, shows marked erosion of the umbo, with many shells being completely eroded through, exposing the interior of the shell (Figure 4). This finding suggests that mussels in the Pascagoula River were able to live for some time after their umbos had been eroded through. Alternatively, the collection method employed by the prehistoric shellfishers may have produced both living and dead animals. In either case, it appears that little or no discrimination was being made in the selection of such mussels by the prehistoric inhabitants of the Bilbo Basin site.

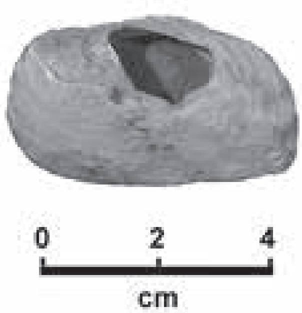

FIGURE 4
Right valve of *Plectomerus dombeyanus* from the Bilbo Basin site showing severe erosion of the umbonal portion of the shell.

A BRIEF CONSIDERATION OF ANTHROPOGENIC IMPACT

Shellfish remains are sometimes used in discussions of prehistoric human environmental impact when changes in faunal composition are noted (e.g., Peacock *et al*., 2005). More commonly, researchers have noted changes in the sizes of shells over time, with a decrease in shell size frequently being characterized as evidence of «impact» or «overexploitation». The apparent effects of human exploitation on the size and/or age structure of shellfish faunas has been noted for marine, brackish and freshwater species (e.g., Swadling, 1976; Quitmyer *et al*., 1985). Although the duration of occupation at Bilbo Basin is unknown, the relative thinness of the shell deposit and the lack of visible stratification argue that the shell deposit was built up over a relatively brief period of time (cf. Quitmyer *et al*., 1997: 837). This remains to be verified through absolute dating and detailed artifact analysis, but it can be hypothesized that, if changes in shell size are visible at the site, such changes are more likely to be an effect of human predation rather than environmental change, given the likelihood that they occurred over a short period of time.

Various measurements have been used to characterize the structure of freshwater mussel populations, and these have been adapted by archaeologists. Warren (1975), for example, presents a number of measurements that can be taken on shell interiors, on features that often are preserved on archaeological shell. One useful measurement is the distance between the anterior and posterior adductor scars, as this is a direct reflection of shell length, one of the metrics most commonly used by biologists analyzing modern mussel populations (e.g., Miller & Payne, 1993). In cases where archaeological shell is too fragmented, other measurements have been used, such as the distance between the lateral teeth and the pallial line (Peacock, 1998, 2000).

The shell from the Bilbo Basin site presented a special problem in this regard. Virtually every shell is broken along the posterior margin, possibly for meat extraction or because of natural breakage or both. In addition, the ventral margin of many shells is partially or completely broken away, up to and often including the pallial line. The severe erosion of the umbonal area of most valves also precluded some measurements. After examination of numerous specimens, a measurement was finally chosen that could be made on the great majority of valves: the distance from the bottom (ventral margin) of the pedal protractor scar to the shell margin above the pseudocardinal teeth.

This measurement was made on all measurable right valves of *Fusconaia ebena* from Unit N1025 E1023. The resultant data are summarized in Table 2; mean values are plotted in Figure 5. The sample sizes vary substantially between the six arbitrary levels, with Levels 1 and 6 having particularly small samples. Despite this, there is a clear reduction in shell size over time. This was noted informally for other species as well, an indication that the trend toward smaller shells is real and not an artifact of sampling error. This was verified statistically when a t-test (two-sample assuming unequal variances, 5% alpha) comparing the *F. ebena* metric data from Levels 1 and 6 produced a significant t-score of 3.58 (critical one-tail value = 1.71).

Although prehistoric human exploitation of mussels at the Bilbo Basin site led to a decrease in the size of the animals over what appears to be a relatively short period of time, can this be consid-

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Mean	17.93	18.74	19.85	21.47	21.19	22.33
Range	12.64-22.90	12.97-23.75	9.23-29.97	13.89-31.19	13.14-32.56	16.73-29.27
s.d.	3.11	2.25	2.85	3.11	3.12	3.35
95% C.I.	1.84	0.44	0.37	0.37	0.30	1.55
n:	11	98	225	271	410	18

TABLE 2

Data on interior shell measurements for Fusconaia ebena (right valves only) from Unit N1025 E1033, Bilbo Basin site. Measurements were from the ventral margin of the pedal protractor scar to the shell margin above the pseudocardinal teeth. All measurements are in millimeters.

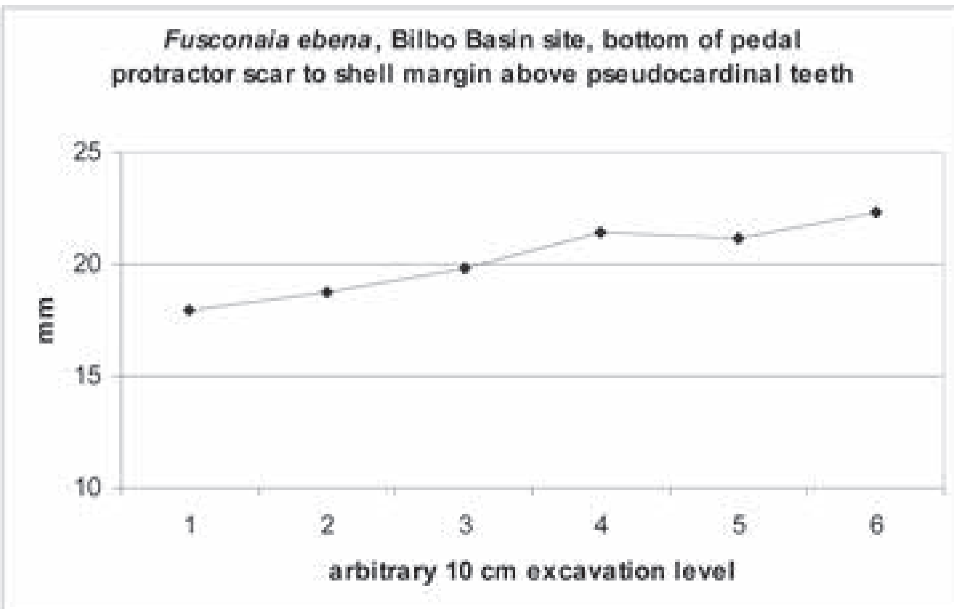

FIGURE 5

Averaged data on interior shell measurements for right valves of *Fusconaia ebena* from Unit N1025 E1033, Bilbo Basin site.

ered «impact»? That, of course, depends on one's definition. Remarkably few articles on human environmental impact actually state what is meant by the term; rather, there is an implicit assumption that change has happened that is detrimental in some way, or impact is simply equated with change without consideration of whether that change was positive or negative for the environment or for the people involved. This is problematical, as some human actions can have a positive result on the local environment, at least where resources exploitable by humans are concerned (e.g., King & Graham, 1981; Doolittle, 1992). Peacock (2008:87) has recently provided the following definition:

Impact is…defined as any action by a biological agent that reduces the productive potential of a given area for a period of time longer than the life span of that biological agent. Productive potential can be characterized as the capability for biomass production (e.g., Simmons 1989:13-14). This definition qualitatively differentiates impact from low-level environmental change that can result from innumerable human actions such as simple trampling along trails…and from anthropogenic change that actually increases the productivity of an area, such as burning and pruning…It also implies something that will leave measurable traces in the archaeological/ geological records. Impact is change that is detrimental at some measurable scale.

By this definition, the reduction in mussel sizes noted at Bilbo Basin would probably not be considered impact. Although selection pressure brought about a measurable change in the fauna, the potential for biomass production was not altered. Much more theoretical work needs to be done on issues such as impact and overexploitation, what such terms mean, and what evidence human actions so characterized would leave in the archaeological record. Linking archaeological measures of occupational duration (e.g., Peacock, 2004) with changes in zooarchaeological assemblages will be a necessary step in this regard.

CONCLUSIONS

The large assemblage of freshwater mussel shells from the Bilbo Basin site has provided data on past population structures, mussel biogeography, shell alteration due to environmental factors, and the effects of past human resource exploitation. The range of topics touched upon in this paper is indicative of the value of prehistoric shellfish remains. Other topics covered in other papers in this volume also can be addressed using mussel valves from the innumerable shell-bearing sites in the southeastern United States. We hope that this volume will stimulate further research and will encourage archaeologists to retain all of the shell they recover from excavations in the region.

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