QUANTITATIVE APPROACHES FOR IDENTIFYING ARCHAEOLOGICAL SITE OCCUPATION TYPES: A CASE STUDY FROM LATE HOLOCENE MENDOCINO COUNTY, CALIFORNIA

SAMUEL J. WILLIAMS
DEPARTMENT OF ANTHROPOLOGY, UNIVERSITY OF CALIFORNIA, DAVIS

Decisions regarding the classification of the use of an archaeological site often prove difficult to make, as many sites are singular locations lacking a sister site for comparison. Differentiating between short-term, long-term, and permanent occupation sites is a daunting task due to differential taphonomy and interpretation of a given set of material remains. Occasionally a site may be part of a series of related sites, which gives a unique opportunity to compare taphonomic processes, both at the individual site as well as across the collection of related sites. Here, we examine two shellfish assemblages from a Late Holocene series of occupations along the Mendocino County coast of northern California. One site, CA-MEN-829, has been tentatively assigned as a long-term occupation site. A second site, Bird Runner, is possibly contemporaneous and has a similar shellfish assemblage. Using MEN-829 as a baseline, we use a quantitative analysis to ascertain whether or not the molluscan assemblages of these two sites differ in the relative abundances of their species and then attempt to reject the null hypothesis that the two sites are indistinguishable. Although such an analysis on its own is limited in scope, its incorporation into a larger methodology of site function identification may prove it to be a powerful tool in resolving the occupation sequence of areas comprised of multiple sites.

The routes taken by the first people to enter the New World have been a matter of debate for quite some time. The first hypothesis posited an entry into the continent sometime around 13,000 B.P. through a corridor between the retreating Laurentide and Cordilleran ice sheets that had covered vast tracts of North America during the Last Glacial Maximum. These immigrants were associated with the Clovis stone tool technology, and therefore the hypothesis became known as the Clovis First model (Curry 2012).

The second hypothesis posits that entry into the continent was accomplished around 15,000 years ago using watercraft to skirt the West Coast of North and South America, known today as the Coastal Migration model (Curry 2012; Erlandson et al. 2007). With wider acceptance of the Coastal Migration hypothesis for the peopling of the New World, attention has begun to focus on the paleoshorelines of North and South America in an effort to document the sites associated with this putative route of entry (Curry 2012; Forster 2004; Jones 1991). Sites such as Monte Verde dated to 14,600 cal B.P. in Chile, Paisley Caves dated to 14,150 cal B.P. in Oregon, Arlington Springs dated to 13,000 cal B.P. in southern California, and MEN-1918 dated to 11,000 cal B.P. in northern California attest to the antiquity of this coastal migration and the growing importance of surveying and identifying sites along the West Coast of North America (Dillehay et al. 2008; Erlandson et al. 2011; Jenkins et al. 2012; Simons et al. 1985).

The northern coast of California would have played a pivotal role in the coastal route, offering many productive stop-off points to those who would have been passing through. One of these stop-off points occurred in what is present-day Mendocino County, where a break in the nearly continuous redwood tree line opened up into coastal prairie (Jones 1991; White 1989).

The antiquity of coastal occupation in the Mendocino area has been established with the aforementioned site near Caspar, known as MEN-1918 (Figure 1). It was here, 9 km south of MacKerricher State Park, that an 11,000-year-old projectile was discovered at the base of a midden, which at the time of deposition would have been approximately 2.5 km inland from the Pacific Ocean (Simons et al. 1985). The location of this site is midway between the Caspar Creek and Jug Handle Creek, which are likely close to their configurations in the terminal Pleistocene, and along with many other

Figure 1. Map of MacKerricher State Park (Freeze 2008).

streams and creeks that empty into the Pacific along this stretch of coast, which provided multiple estuarine environments that were likely draws for hunter-gatherers moving along this portion of the coast.

BACKGROUND

Part of a tectonically uplifted terrace, MacKerricher State Park is a roughly 13-by-1-km strip of land in Mendocino County on California's northern coast (Jones 1991; Simons et al. 1985; White 1989). It is bounded in the north by Ten Mile River and in the south by Pudding Creek. Its northern end is dominated by sand dunes, and its southern end is coastal prairie atop a series of bluffs that extend from roughly Laguna Point and Lake Cleone on its northern margin down to Pudding Creek. The cold California Current provides some of the world's most productive waters, which pass by the Mendocino coast on their way towards Baja California (Brink et al. 1991).

There is today a diversity of marine species along the littoral zones of the park and its associated haul-outs, including pinnipeds such as harbor seal (*Phoca vitulina)*, marine birds such as cormorants (*Compsohalieus)*, and a multitude of mollusks such as abalone (*Haliotis rufescens),* chiton (Polyplacophora), mussels (*Mytilus californianus*), and turban snails (*Tegula funebralis*), as well as a diverse array of pelagic fish and cetaceans (Jones 1991; White 1989).

The ethnographic history of the park is less straightforward. Although it is far from a consensus view, the Coast Yuki, whose language family comprises an isolate and is rumored to perhaps be a vestige of the original coastal migrations into the New World, were likely to have been present in the area prior to 2000 B.P., whereas the Northern Pomo likely entered the area between 2000 and 1500 B.P. (Golla 2007). Athabaskan groups likely made contact with groups in the area sometime after 1300 B.P., although it is not believed that they physically moved into the area now comprising MacKerricher State Park Golla 2007). The Coast Yuki and the Northern Pomo were both exploiters of the marine resources available at MacKerricher and likely followed similar subsistence patterns, despite their disparate cultural backgrounds (White 1989).

Archaeological surveys with limited excavation were undertaken in the park in 1926 and again in 1967, with follow-up spot surveys conducted during the 1960s and 1970s. Greg White returned to MacKerricher in 1988 for a 14-day excavation of nine separate sites within the park (White 1989). White took advantage of prior surveys, which had documented multiple shell middens along the length of the park. While completing his fieldwork, White quite correctly appreciated the middens as a valuable window into the demographic history of the people who had produced them. Many of his predecessors had dismissed the middens as a bothersome matrix to be discarded in the search for lithics and other more "valuable" artifacts (White 1988).

After much analysis, the occupations were largely grouped temporally and then classified into two main duration types: longer-term settlement and shorter-term settlement (White 1989), which I refer to as long-term occupation and short-term/processing sites throughout the rest of this study. The criteria White used to identify long-term occupation sites considered features such as repeated use of refuse heaps, which he argued was a result of trying to keep living and working areas clear of debris, as well as richness or range of taxa present in the faunal assemblages, both terrestrial and marine (White 1989). Further, evidence of structures such as postholes, house floors, and storage pits, along with a comparatively diverse assemblage of lithic tools, are also used to designate a site as long-term occupation. Short-term/processing sites are defined by criteria including continuous or "convergent refuse" heaps, which indicate a lack of concern about maintaining open areas for work or habitation, as well as discrete lenses of deposits with seasonally constrained faunal remains (White 1989). Further, lack of evidence of structures and comparatively homogeneous lithic tool assemblages are taken into consideration when designating a site as a short-term/processing site.

These classifications have come to play a large role in the interpretation of the last 2,000 years of occupation in MacKerricher State Park. As is evidenced by the archaeological record as well as some post-contact ethnographic accounts, different groups have used this stretch of coast in different ways.

Some passed through, simply camping out for a short time, utilizing the landscape on a smaller scale; some came to the coast to procure and process large amounts of marine resources, which were then hauled back inland towards the valleys of the Mendocino Range; and some lived for longer periods on the coast, utilizing more varied resources and producing more varied cultural remains with their families likely in tow. Correctly identifying occupation type of the sites found in MacKerricher plays a pivotal role in piecing together an accurate framework within which to discuss the cultural chronology of the sites that have been investigated thus far.

This chrono-cultural framework is much more than an exercise in archaeological theory, however. There is a sense of urgency in establishing a comprehensive survey, sampling, and documentation of archaeological sites throughout MacKerricher. The cultural resources at the park are currently under threat of being lost to coastal erosion due to sea level rise and have suffered further in the past when the site was home to a sprawling lumber mill during the late nineteenth and early twentieth centuries (White 1989). Such issues have added a sense of urgency to the analysis of the sites at the park, which in turn has made of utmost importance the development of a methodology to quickly survey, test, and then decide where to focus limited resources.

It is here that I intend to put to use White's insight about the value of shell, which is quite well preserved in the middens in the park. Using samples from the middens around the park, I am working on a model that might lead to the following methodology. Sites with middens could be identified through survey and sampled with an auger to produce a core through the depth of the cultural layers that could then be quickly screened, sorted, and weighed in the field. Next, the samples would be plotted against a database of other samples from middens whose accompanying material remains have allowed for their identification as either short-term/processing sites or long-term occupation sites. If my current model is successful, the test samples should fall within a range of values that inform us about the putative function of the sites that produced them. This would allow for a less invasive way of cataloging the remaining sites in the park, while providing a potentially more resolved temporo-spatial picture of the complex palimpsest that is MacKerricher. This in turn would allow for the ability to test hypotheses requiring excavation with the foreknowledge of where the main deposits are located and to which cultural horizon at the park they belong. Finally, when a site is eventually lost without the possibility of excavation or recovery, this would ensure that there is some record of the character of the site's shell deposits and a fairly good indication of not just the site's functional use but perhaps also its temporal as well as cultural affinities.

This study attempts to test the feasibility of establishing a quantifiable metric for mollusk assemblages that correlates across site types. Here, I examine a molluscan assemblage from MEN-829, which has been identified as a residential occupation site, and compare it to a second molluscan assemblage from another site, Bird Runner, on the coastal prairie just to the south. Bird Runner has been putatively assigned as a short-term/processing site. If the assumption is correct, then there should be a reliable way to quantify the difference between the sites. If this quantification can be replicated and shown to hold true in its ability to distinguish between molluscan assemblages at other known and sampled sites, then the first part of the proposed methodology will have been accomplished.

METHODS

The 2012 field season at MacKerricher State Park was headed by Darren Andolina from UC Davis as part of the 2012 UC Davis archaeological field school. Following up on work initiated by Greg White, Andolina decided to focus on MEN-829, a mound comprised of a shell midden on the south end of the park, at the beginning of the coastal prairie zone. Excavations began on June 27, ultimately focusing on two units, N2/W10 and N5/W5. At unit N5/W5, a 1-x-2-m control unit, the decision was made to initiate 100 percent shell collection for further study. All samples were dry-screened using 1/8-in. mesh and bagged by level.

Table 1. Shell by percent composition for Bird Runner and MEN-829.

TAXON		MEN-829	BIRD RUNNER
Mytilus californianus	California mussel	80.22	92.12
Balanus spp. / *Semibalanus cariosus*	Barnacle	9.65	3.80
Tegula funebralis	Black turban snail	6.01	1.89
Katharina tunicata	Black katy chiton	1.84	0.77
Pollicipes polymerus	Gooseneck barnacle	0.60	0.04
Cryptochiton steleri	Gumboot chiton	0.57	0.76
Haliotis rufescens	Red abalone	0.52	0.27
Fissurelidae / Patellagastropoda	Limpet	0.23	0.10
Mopalia spp.	Mossy chiton	0.22	0.05
Nucella spp.	Dogwinkle	0.14	0.20
Brachyura	Crab	3.96×10^{-4}	2.42×10^{-3}

A second site, Bird Runner (trinomial designation pending), was located by survey about 0.5 km to the south-southwest of MEN-829. Excavation began at unit N0/W0, a 1-x-1-m control unit, on July 28. The decision was again made to initiate 100 percent shell collection. All samples were dry-screened using 1/8-in. mesh and bagged by level. The samples from both sites were brought back to camp, where species sorting was initiated. At the end of the season in August 2012, the remaining unsorted samples were returned to UC Davis for further processing. I completed the species sorting in March 2014. After sorting, Darren Andolina and I weighed the sorted samples by level for each site and then entered the results into a master database.

RESULTS

As unit N5/W5 at MEN-829 and unit N0/W0 at Bird Runner were of differing sizes, direct comparison of the shell weights at the two sites required some norming to control for volume. This was further complicated by the discovery of a feature in the southern end of unit N5/W5 at MEN-829 at approximately 50 cm below surface, which resulted in shell collection shifting to the northern 1-x-1-m end of the unit for the remainder of the excavation. The only way to norm this differential volume control was to convert the shell weights to percent composition by site. The results can be seen in Table 1.

Once the conversions were complete, I compared species richness and evenness at the sites. The richness, or number of taxa represented in the sample, was identical at the two sites. Upon visual inspection, the evenness, or the distribution of the taxa present, was different, albeit not strongly so. I then moved on to quantitative analyses of the two assemblages, in an effort to quantify the distance between the two shellfish assemblages.

After reviewing multiple approaches, I decided to use a diversity measurement to compare the assemblages. I chose the Shannon Diversity Index, as it reflects a composite of richness and evenness, reflecting entropy in the dataset, thereby providing more information about the species composition of an assemblage than just counts or percentages alone (Shannon 1948). The Shannon Diversity Index (H) is calculated as

$$H = -\sum_{i=1}^{R} p_i * ln(p_i)$$

where R is the richness (total number of taxa present) and p_i is the proportion of the assemblage represented by the i^{th} taxon. The result for MEN-829 was 0.77 and for Bird Runner was 0.39, which indicates that MEN-829 had a slightly more even distribution of taxa. As Bird Runner's score is roughly 50 percent that of MEN-829, it is quite apparent that the two sites are different from each other. I must also point out that the H values can be sensitive to small values of p_i, which introduces a small amount of uncertainty into the results for Bird Runner.

Table 2. Shannon Diversity Index values for the six sites used for comparison with Bird Runner and MEN-829 index values.

SITE	H	LOCATION	FUNCTION	B.P.
MEN-829	0.7691	Bluffs	Long-Term Occupation	Unknown
MEN-422C	0.7649	Bluff Adjacent	Long-Term Occupation	610 ±50
MEN-828-S2	0.6024	Bluffs	Long-Term Occupation	1930 ±80; 1760 ±70
MEN-427	0.4000	Dunes	Short-Term/Processing	1840 ±80
Bird Runner	0.3919	Bluffs	Short-Term/Processing	Unknown
MEN-422B	0.3147	Bluff Adjacent	Short-Term/Processing	220 ±50

Due to this potential uncertainty, I decided to follow up the Shannon Diversity Index with a second diversity measure, the Simpson Diversity Index, in order to check for consistency. This index is different from the Shannon index in that it measures dominance, or the degree of concentration when individuals are classified into types (Simpson 1949). This means that larger values of p_i contribute more to the final result with less pull exerted by extremely small values of p_i. The Simpson Diversity Index (λ) is calculated as

$$\lambda = \sum_{i=1}^{R} p_i^2$$

where R is the richness (total number of taxa present) and p_i is the proportion of the assemblage represented by the i^{th} taxon. The index result for MEN-829 was 1.52 and for Bird Runner was 1.18, again indicating that MEN-829 had a slightly more even distribution of taxa. Here, there is roughly a 22 percent difference between the two index values, which more confidently demonstrates that the two sites have characteristically different assemblages.

Next, I proceeded to obtain H and λ values for a number of sites from around MacKerricher that were excavated by Greg White in 1988 and for which there was 100 percent shell collection. I used four additional sites, two of which were putative long-term occupation sites (MEN-828-S2 and MEN-422C), as well as two putative short-term/processing sites (MEN-427 and MEN-422B). The sites were sampled from both the northern and southern portions of the park. The sites and their corresponding H values appear in Table 2 and Figure 2.

ANALYSIS

The index values that were obtained for all of the sites segregate distinctly into two clusters, with an average value $\bar{H} = 0.71$ for the long-term occupation sites and $\bar{H} = 0.37$ for short-term/processing sites. This nearly 2:1 ratio for long-term occupation site versus short-term/processing site generates clear results which allow us to distinguish between the two site types. MEN-829 fell within the long-term occupation cluster, and Bird Runner fell within the short-term/processing occupation cluster.

The Simpson Diversity Index values showed a similar clustering, albeit with one outlier, MEN-422C, whose H value was within the range of the other long-term occupation sites. The results can be seen in Table 3.

It is not yet clear why the assemblage at MEN-422C produced such a large λ value, and further analysis is under way. It is possible that there is some type of sampling error present in the assemblage that has yet to be detected. The results of the Simpson test did produce an interesting result that has promising implications if it turns out to hold true. Neither MEN-829 nor Bird Runner has yet been dated using absolute methods. However, temporally diagnostic lithics were recovered at MEN-829 which indicate a possible correlation with MEN-422C. MEN-829 and MEN-422C are nearest neighbors in both data sets, which could indicate that these tests are able to capture temporal or cultural affinities as well as occupation type. Bird Runner and MEN-427 are also nearest neighbors in both data sets. No temporally diagnostic lithics were recovered from Bird Runner, and so its age is not yet known. It will be quite

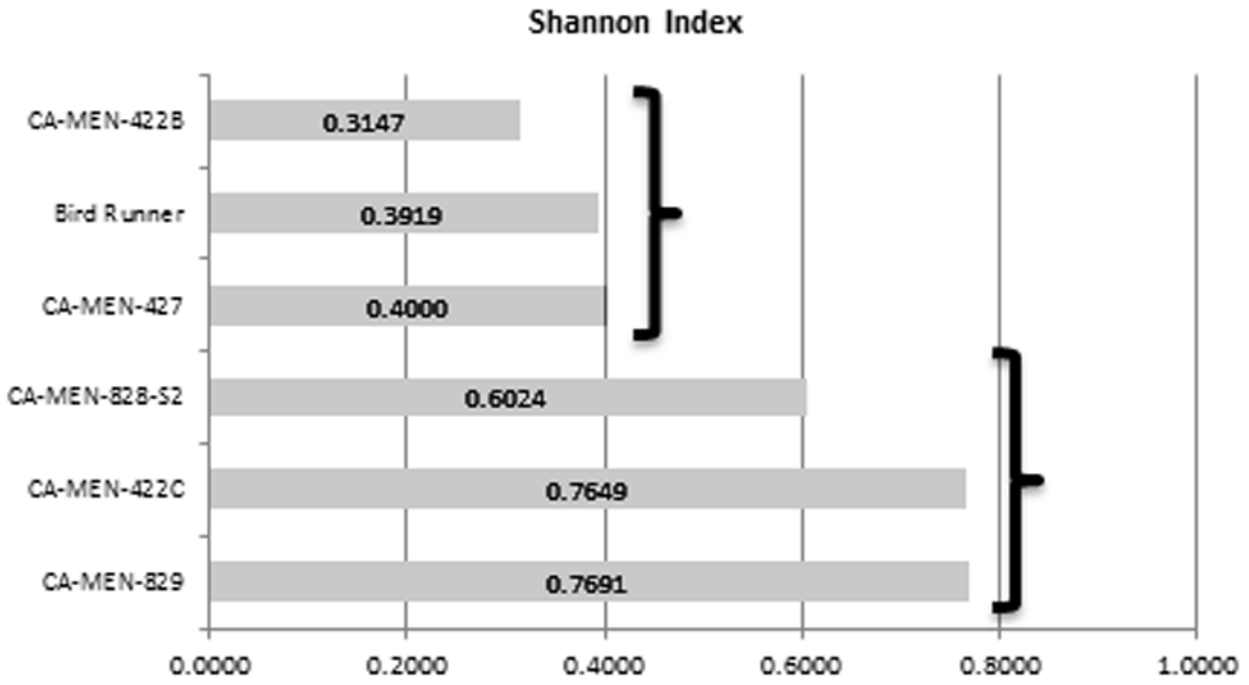

Figure 2. Histogram of H values showing clustering by site type. MEN-422 B, Bird Runner and MEN-427 cluster as short-term/processing sites, whereas MEN-828 S2, MEN-422 C and MEN-829 cluster as long-term occupation sites.

Table 3. Simpson Diversity Index values for the six sites used for comparison with Bird Runner and MEN-829 index values.

SITE	λ	AGE (B.P.)
MEN-422C	2.0357	610 ± 50
MEN-829	1.5222	Unknown
MEN-828-S2	1.3899	1930 ± 80; 1760 ± 70
Bird Runner	1.1758	Unknown
MEN-427	1.1735	1840 ± 80
MEN-422B	1.1590	220 ± 50

interesting to see whether it, too, matches its nearest neighbor, in which case further analysis to identify a trend will become warranted.

DISCUSSION

We use many lines of evidence to establish site type, including lithic tool diversity, seasonality indicators, structural remains, and the temporo-spatial relationships of features located within the site. All of these determinations involve full-scale excavation and are costly and ultimately destructive to the sites. Using diversity indices, I have been able to show that the evenness of taxa within a shellfish assemblage produces values that reflect the function of that site: more evenness indicates long-term occupation sites, and less evenness indicates short-term/processing sites.

The results of this study demonstrate that it is possible to quantify the shellfish assemblages at MacKerricher State Park in a meaningful way, which then allows for comparison with other sites in the park whose occupation type has previously been assigned. The next step is to expand the number of sites

in the model so that this identification process can be refined. If it holds up as well as this preliminary study suggests, then a robust framework can be developed, which would allow for the next phase of this methodology to be tested, namely testing for the minimum sample size needed to accurately generate a diversity index value. If this sample size can be miniaturized sufficiently, a small core sample of each remaining midden in the park would be all that it would take to quickly identify the remaining sites in the park with minimal invasiveness.

The wider implications of the development of this type of methodology at MacKerricher State Park are palpable. Its implementation in the realm of cultural resource management and site preservation should prove quite valuable. Its use in the study of newly discovered sites on the coast is also plausible, not just in California but around the world. Shell is an integral part of the analysis of a site's history and, as this study has further validated, contains quantifiable information not only regarding the subsistence mode and occupation type of its former inhabitants, but possibly about its temporal and cultural affinities as well.

ACKNOWLEDGEMENTS

I would like to thank Teresa Steele, Mark Grote, Jelmer Eerkens, and Robert Bettinger for their insight, encouragement, and support. I would also like to thank Paleo Group at UC Davis for their comments and suggestions as well as the 2012 UC Davis archaeological field school participants who helped in the procurement and initial sorting of the shellfish used in the study. Most of all, I would like to thank Darren Andolina, without whom this project would not have been possible.

REFERENCES CITED

Brink, K. H., R. C. Beardsley, P. P. Niiler, M. Abbott, A. Huyer, S. Ramp, T. Stanton, and D. Stuart
1991 Statistical Properties of Near-Surface Flow in the California Coastal Transition Zone. *Journal of Geophysical Research: Oceans* 96:14693-14706.

Curry, Andrew
2012 Ancient Migration: Coming to America. *Nature* 485:30-32.

Dillehay, Tom D., C. Ramirez, M. Pino, M. B. Collins, J. Rossen, and J. D. Pino-Navarro
2008 Monte Verde: Seaweed, Food, Medicine, and the Peopling of South America. *Science* 320:784-786.

Erlandson, Jon M., Torben C. Rick, Todd J. Braje, Molly Casperson, Brendan Culleton, Brian Fulfrost, Tracy Garcia, Daniel A. Guthrie, Nicholas Jew, Douglas J. Kennett, Madonna L. Moss, Leslie Reeder, Craig Skinner, Jack Watts, and Lauren Willis
2011 Paleoindian Seafaring, Maritime Technologies, and Coastal Foraging on California's Channel Islands. *Science* 331:1181-1185.

Erlandson, Jon M., Torben C. Rick, Terry L. Jones, and Judith F. Porcasi
2007 One If by Land, Two If by Sea: Who Were the First Californians? In *California Prehistory: Colonization, Culture, and Complexity*, edited by Terry L. Jones and Kathryn A. Klar, pp. 53-62. AltaMira Press, Lanham, Maryland.

Forster, Peter
2004 Ice Ages and the Mitochondrial DNA Chronology of Human Dispersals: A Review. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 359:255-264.

Freeze, Dennis F.
2008 *Mendocino Outdoors*. Edited by M. S. Park. Monolith Press, Mendocino, California.

Golla, Victor
2007 Linguistic Prehistory. In *California Prehistory: Colonization, Culture, and Complexity*,

edited by Terry L. Jones and Kathryn A. Klar, pp. 71-82. AltaMira Press, Lanham, Maryland.

Jenkins, Dennis L., Loren G. Davis, Thomas W. Stafford, Jr., Paula F. Campos, Bryan Hockett, George T. Jones, Laura Scott Cummings, Chad Yost, Thomas J. Connolly, Robert M. Yohe II, Summer C. Gibbons, Maanasa Raghavan, Morten Rasmussen, Johanna L. A. Paijmans, Michael Hofreiter, Brian M. Kemp, Jodi Lynn Barta, Cara Monroe, M. Thomas P. Gilbert, and Eske Willerslev

2012 Clovis Age Western Stemmed Projectile Points and Human Coprolites at the Paisley Caves. *Science* 337:223-228.

Jones, Terry L.

1991 Marine-Resource Value and the Priority of Coastal Settlement: A California Perspective. *American Antiquity* 56:419-443.

Shannon, Claude E.

1948 A Mathematical Theory of Communication. *Bell System Technical Journal* 27:379-423, 623-656.

Simons, Dwight D., Thomas N. Layton, and Ruthann Knudson

1985 A Fluted Point from the Mendocino County Coast, California. *Journal of California and Great Basin Anthropology* 7:261-269.

Simpson, E. H.

1949 Measurement of Diversity. *Nature* 163:688.

White, Gregory G.

1988 Shells as Bones: Results of Investigations at Nine Coastal Shellmiddens, MacKerricher State Park, Mendocino County, California. Paper presented at the Society for California Archaeology Northern Data Sharing Meeting, Sacramento.

1989 *A Report of Archaeological Investigations at Eleven Native American Coastal Sites, MacKerricher State Park, Mendocino County, California*. California State Parks, Sacramento.