Spring 2017
Volume 51
Number 1

Journal Of Northwest Anthropology

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Journal of Northwest Anthropology

Spring 2017 Volume 51 Number 1

Contents

Composed by Northwest Anthropology LLC, Richland, WA; Printed by CreateSpace. Missing issue claim limit 18 months. For back issues and catalogue of prices contact Coyote Press, P O Box 3377, Salinas, CA 93912. <http://www.californiaprehistory.com>

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Engendering the Past: The Status of Gender and Feminist Approaches to Archaeology in the Pacific Northwest and Future Directions

Tiffany J. Fulkerson

Abstract *Substantial contributions to the archaeological study of gender in the Pacific Northwest have been made over the past 30 years. Despite these advances, considerations of gender—particularly those which embrace feminist epistemologies—continue to be markedly lacking. This article surveys gender/feminist approaches to archaeology in the Pacific Northwest by examining archaeological studies of and references to gender in published and gray literature. It also explores regional trends in research presented at annual Northwest Anthropological Conference meetings from 1990 to 2016. Results suggest that a diversity of approaches to exploring gender have been taken, but there is considerable work to be done, particularly on the Southern Plateau, which has the least engagement with gender. Work is also needed in the realm of theory, where practitioners have been reticent to embrace feminism and its potential for emancipatory change. Archaeologists in the Northwest are well positioned to more effectively embrace gender and feminist perspectives in their practice, mitigate sexism/androcentrism, and contribute to contemporary discussions about queer/non-binary, female, and male dynamics.*

Introduction

Archaeological approaches to the study of gender are relatively young within the context of the discipline's theoretical and methodological history. These archaeological approaches have been influenced by the multiple "waves" of feminism (Geller 2009) and criticisms of gender bias in anthropology. Serious efforts to explore issues of gender in archaeology began in the 1980s with a small number of seminal works (e.g., Spector 1983; Conkey and Spector 1984; Gero 1985) and burgeoned with a series of articles, books, edited volumes, and conferences/symposia by the early to mid-1990s. North American researchers aiming to examine gender relations in the pre-contact and historic periods have turned to ethnographic literature, ethnohistorical resources, osteological data, iconography, and a diversity of other approaches to make inferences about past gender relations through material culture, features, spatial associations, and other archaeological contexts.

While the Pacific Northwest is no exception to areas in which gender has become a principal unit of analysis for some archaeologists, such studies continue to remain marginal for the vast majority of archaeology. The continuing inability of the archaeological "mainstream" to consider gender, and particularly feminist theory, in research and education "has resulted in the persistence of essentialist narratives of the past that fail to recognize the dynamic nature of gender constructs through time and space" (Bolger 2013:1). As gender has and continues to be an integral component of human behavior and identity, and permeates the very practice and praxis of archaeology, such lack of attention warrants further examination.

Method and Objectives

The objective of this article is to ascertain the current status of gender and feminist research in Pacific Northwest archaeology by providing a comprehensive survey of existing archaeological studies of, and references to, gender in the region, specifically within the Northwest Coast, Northern Plateau, and Southern Plateau culture areas. While researchers have long recognized the arbitrary nature of the culture area framework, it remains a useful heuristic device that allows for cultural synthesis across broad regional-scales (Lohse and Sprague 1998:11–12) which provides the basis for the divisions in this study.

Particular attention is given to the Southern Plateau because it is the most neglected area with respect to efforts to explore gender in the Pacific Northwest past. The Great Basin, an area contiguous with the Southern Plateau, which possesses a greater body of literature that is representative of some of the research conducted in other parts of North America, is also included in this survey.

Peer-reviewed articles, books, edited volumes, bulletins, and gray literature in the form of manuscripts, cultural resource reports, theses, and dissertations are included in this study in order to broaden the scope of research that is presented and to highlight the disparity between published and gray literature. The purpose of this exercise is not only to offer a baseline survey of gender research in the region, but also to highlight the dearth of literature on the subject and to provide an explicit call for archaeologists to consider gender and feminist approaches in their interpretations of the past while encouraging more research of this kind in the future.

A survey of the frequency of historic and pre-contact gender studies presented in posters and symposia at the Northwest Anthropological Conference is also provided. This is done with the purpose of demonstrating changing trends in archaeologists' interest in the subject of gender and to highlight the differences between peer-reviewed and non-peer-reviewed work.

The approach taken to explore references to gender in published and gray literature and conference abstracts involved searching for keywords including "gender," "women," "female," "feminine," "femininity," "two-spirit," "berdache," "queer," "male," "men," "masculine," "masculinity," "feminist," and "feminism." While it is possible if not likely that pertinent studies were missed during efforts to comb these various forms of literature and conference abstracts, this study represents a sincere effort to provide a comprehensive and inclusive review of existing archaeological studies of and references to gender to date.

Feminist and Gender Approaches to Archaeology

From its inception, gender approaches to archaeology were influenced by feminist scholarship and existing critiques of androcentrism (male centeredness) in anthropology, with the "Man the Hunter" trope of human evolution being one of the most obvious cases of such bias (Conkey and Spector 1984; Conkey and Gero 1991). Conkey and Spector's seminal 1984 paper, *Archaeology and the Study of Gender*, is widely regarded as the first explicit call for archaeologists to begin actively considering gender in their interpretations of the past. Many of the early efforts to engender archaeology centered on remedying sexism and androcentrism by finding and recuperating women in the past—something which Conkey and Gero (1997:415) referred to as "locate-the-women projects." Concurrent with these issues were concerns about gender equity in archaeological practice (Gero 1983, 1985; Conkey and Gero 1997; Wylie 1997; Conkey 2004; Gero 2009; Bolger 2013).

Theoretical and methodological approaches to feminist and gender archaeologies have markedly evolved since their origins. Numerous researchers (e.g., Conkey and Gero 1997; Wylie 2006, 2007; Engelstad 2007; Geller 2009; Conkey 2003, 2013) have cautioned against the growing disconnect between feminist practices and gender archaeology, which is regarded by some as an "ever-widening gap" between Second and Third Wave feminist perspectives (Bolger 2013:9). Geller (2009) criticizes that many archaeological studies that reference or explore gender "articulate dated ideas about women and epistemological frames that highlight duality and universality." These oppositions to feminism "stem from its imagined relationship with postmodernism, but conflation misconstrues feminism's sociopolitical commitment to emancipatory change" (Geller 2009:65). Attempts to depoliticize gender research through a refrain from explicit feminist perspectives, according to Engelstad (2007:228), neutralize gender archaeology and render it largely irrelevant to the mainstream (cf. Sørensen 2000).

Feminist approaches to archaeology have substantially contributed to the deconstruction of gender essentialism and exclusionary andro- and gyno-centric reconstructions of the past through addressing such problems as the uncritical application of ethnographies and gender attribution to material remains, as well as the failure of archaeologists to recognize sexuality and queer/non-binary identities. The practice of linking artifacts with gender, which Costin (1996) called "gender attribution," has been a recurrent issue in gender and feminist archaeologies (Conkey and Gero 1991:11–14; Dobres 1995; Costin 1996; Brumfiel 2006:42–45; Conkey 2013:115–117). Conkey (2013) criticizes that after 30 years of work, many archaeologists are continuing to rely on the "methodological crutch" of ethnographies and "are still all too readily held captive by empiricist handcuffs and gender attribution" (Conkey 2013:115).

The stronghold of the ethnographic approach in archaeological interpretations of gender is perhaps most readily apparent in studies of labor divisions (Geller 2009:65). Brumfiel (2006) has noted that ethnographic and ethnohistorical depictions of the division of labor reflect Western, typically male, biases which often obfuscate the reality and complexity of gender systems then and through time. The distribution of artifacts may not reflect the actual distribution of labor, and the act of ascribing artifacts or locations of production to specific genders inscribes a "separation of spheres" that is contingent on Western nineteenth century history (Brumfiel 2006:42).

Contemporary (± 10 years ago to present) approaches to feminist archaeology have advanced our understanding of embodiment, queer theory, sexuality, and intersectionality in studies of the past. Influenced by phenomenological approaches, current perspectives on the body in archaeology are replacing views of the "objectified body" with a concern for the production and experiences of lived bodies. The body is now seen as a site of lived experience and embodied agency, where the surface and interior are no longer separated (Perry and Joyce 2001; see also Joyce 2004 ;Joyce 2005:139, 152). Geller (2009) has employed the analytical concept of "bodyscapes" to encourage the interrogation of hegemonic interpretations of the body and to promote the use of queer theory as a method for examining subversive and alternative interpretations of ancient bodies (Geller 2005; see also Geller 2009:504).

Queer archaeology challenges and destabilizes rigid values of heteronormativity which call for conformity among sex and gender (Alberti 2013:88, 90–91). Queer practices draw upon Judith Butler's (1990, 1993) notion of performativity and build on her antithetical stance to boundaries between sexuality and gender (Dowson 2000a, 2000b; see also Voss 2009; Alberti 2013:89–90). Considerations of sexuality and the body have now expanded to include masculinity (Joyce 2004:85). The emerging archaeology of masculinity began in the 1990s (Joyce 2004:90) through the acknowledgement that while feminism has made clear that "men" have always been visible, their gender has been "unmarked" (Alberti 2006:401). Wilkie and Howlett Hayes (2006:253–254) have noted that the failure to "find men" is linked to the ongoing challenge of identifying the intersections and inseparability of race, class, gender, and other aspects of identity.

Debates concerning the situatedness of feminist archaeology within the theoretical expanses of archaeology and the social sciences have also emerged. In her attempt to navigate the theoretical landscape of archaeology, Hegmon (2003) broadly divided North American archaeology into two categories: the first is loosely organized around processual ideas while the second she calls "processual-plus," noting that gender archaeology is paradigmatic of the latter approach (Hegmon 2003:212, 216–221). Moss (2005) has cautioned against Hegmon's broad inclusion of feminist, Marxist, and postcolonial archaeologies under the "processual-plus" umbrella, noting that they defy the constraints of the label and have political implications for diverse stakeholders inside and outside of the profession (Moss 2005:581, 585–586).

Likewise, tensions have emerged from attempts to situate feminist archaeology within the confines of postmodernism and/or postprocessualism (e.g., Hodder 1991, 2012; ; see also McGuire 1993; Moss 2005; Geller 2009; Wylie 2012; Bolger 2013). Despite these theoretical differences, Wylie (1991:44), Conkey and Gero (1991:22, 24), McGuire (1993:133), VanPool and VanPool (2003), Engelstad (2007:226), and Hodder (2012:4), among others, have noted that such tensions and pluralities are productive if not essential to advancing our understanding of archaeology and for promoting critical and reflexive debate.

Archaeological Studies of Gender in the Pacific Northwest

Advances in the archaeological study of gender in the Pacific Northwest largely parallel developments elsewhere in the United States, with some notable exceptions. Unlike the American Southwest (Crown 2000) and Southeast (Eastman and Rodning 2001), there are no edited books dedicated to the subject for the Pacific Northwest. There are also no studies which comprehensively explore issues of sexuality, masculinity, queer theory, embodiment, or non-binary genders (cf. Moss 1999b for a discussion of the use of labrets by men and possibly alternative genders in the nineteenth century).

Similar to observations made by Conkey and Gero (1991:22), Bolger (2013:7), and others for the United States, no single theory or identifiable school of thought has risen to preeminence among gender approaches to archaeology in the Pacific Northwest. Conkey and Gero (1991:22) are careful to note that this lack of consensus is one of the successes of feminism in that it relies on multiple perspectives and tolerance or even promotion of dissenting viewpoints (see also Bolger 2013:7). Similar to the aforementioned criticisms of the gender/feminist divide made elsewhere, many of the studies that will hereafter be discussed lack explicit feminist epistemologies.

Kehoe (2013) offers a broad-scale overview of the archaeology of gender in western North America in which she addresses troubling stereotypes that have pervaded the understanding of pre-contact indigenous peoples in western North America, including the offensive myth of "squaw as drudge" and the unconsciousness of women and children (Kehoe 2013:544–545). Kehoe also discusses the dilemma of ethnographies, echoing the concern that (predominately male) ethnographers frequently gave precedence to male activities, devaluing the work of women in the process (Kehoe 2013:545). This study builds on Kehoe's review by offering a more inclusive survey of Northwest Coast, Northern Plateau, Southern Plateau, and Great Basin culture areas through the contribution of gray literature and additional peer-reviewed works.

The only edited journal volume dedicated to gender in the Pacific Northwest to date is Feminist Approaches to Pacific Northwest Archaeology, which appeared more than 15 years ago in the 1999 fall issue of *Northwest Anthropological Research Notes* (*NARN*) (Bernick 1999). The articles presented in this volume originated from conference papers delivered in the early 1990s and variously addressed issues of androcentrism and the remedial work of refocusing narratives on women (Moss 1999a:250). Bernick noted that part of the impetus for assembling the papers for publication was the "chilly climate" for women in archaeology in the Pacific Northwest and at large, asserting that this volume constituted "sincere efforts to help transform archaeology so that it can provide more accurate and better balanced understandings of the human past" (Bernick 1999b:180).

Beyond the contributions of gender approaches to archaeology in the region to date, recent book-length treatments of Native American societies which apply interdisciplinary frameworks that incorporate ethnographic, historical, and archaeological data to address conservation and indigenous concerns (e.g., Moss 2011, 2013; Prentiss and Kuijt 2012; Turner 2014; Yu 2015) have something to offer the archaeology of gender in the Pacific Northwest. These studies can be used to variously address perceptions of labor and diversity in the contributions to subsistence by various genders and age groups, exposing the myth of rigid and binary labor divisions in the process.

While the Pacific Northwest is well positioned to explore the past in a new feminist light, in part due to its richness of ethnographic and ethnohistorical literature (Moss 1999a:255) in combination with new interdisciplinary works which have the potential to temper simplistic and essentialist assumptions about age and gender, the dearth of explicit approaches to examining gender nearly 20 years after the observations by Bernick and Moss is of noticeable concern. This shortage of literature can be seen through the trends in topical research presented at professional conferences.

Conference Research Trends

A review of abstracts from the Annual Northwest Anthropological Conference (NWAC) proceedings from 1970 through 2016 made available through the *Journal of Northwest Anthropology* (*JONA*) and elsewhere suggests that researchers in the Northwest have consistently been reluctant to embrace archaeological considerations of gender (Table 1). While journal articles, books, edited volumes, and conferences/symposia helped to fuel a substantial amount of gender research throughout North America in the early 1990s, archaeologists in the Northwest remained relatively reticent on the subject (cf. Greaves 1999; Pratt 1999).

This position began to modestly change beginning in 2004 when nearly every annual meeting began to see a few historic and pre-contact era gender presentations a year—a trend which continues today. A review of these abstracts reveals that the Northwest Coast, Southern Plateau, and northern Great Basin have received a relatively comparable amount of attention (n = 6, 7, and 5, respectively), as have the historic (n = 14) and pre-contact (n = 12) periods.

Undoubtedly, some studies on gender in the Pacific Northwest past (e.g., Zacharias 1999; Bernick 1999a) have and continue to be presented in other forums. Nevertheless, as the principal anthropological conference for the Pacific Northwest, NWAC effectively represents shifts in the research interests of regional archaeologists. With a mere total of 25 presentations on the topic over the course of 25 years, it is clear that there is more work to be done.

Table 1. Archaeological Research on Gender Presented at Annual Northwest Anthropological Conference (NWAC) Meetings

Year	No. of Studies	Period[a]	Culture Area
1992	1	p	Northern Plateau
1993	1	P	Northwest Coast
2000	1	H	Northern Great Basin
2004	1 1	H/P P	Great Basin Southern Plateau
2005	1	P	Southern Plateau
2006	1 1	H H	Northern Plateau Northwest Coast
2007	1	P	Southern Plateau
2008	2	P	Northern Plateau
2009	2	H	Northwest Coast
2010	1	P	Northwest Coast
2011	1 1	H H	Southern Plateau Great Plains
2013	2 1	H H	Northern Great Basin Northwest Coast
2014	1 1	H P	Northern Great Basin North America
2015	1 1	H H	Southern Plateau Northern Great Basin
2016	2	P	Southern Plateau

[a] H = Historic, P = Pre-contact

This continuing lack of engagement with archaeological examinations of gender parallels an ongoing trend in which women are less frequently represented in the realm of peer-reviewed publishing (e.g., Gero 1985; Hutson 2002; Colwell-Chanthaphonh 2004; Bardolph 2014). A recent study comparing the frequency of female to male authors in *JONA* and *NARN* volumes by *JONA* editors Deward Walker, Jr. and Darby Stapp (2017) demonstrate that from 1967–2015, men have consistently outnumbered women in primary authorship.

While explanations for gender disparities in peer-reviewed publishing are beyond the scope of this article, the study by Walker, Jr. and Stapp in combination with this review of NWAC research trends demonstrates that archaeological studies of gender and peer-reviewed publishing by women remain underdeveloped in the Pacific Northwest. These gender disparities parallel equity studies which continue to document gender inequalities in the allocation of dissertation grant funds (Gero 2009), institutionalized sexism in academia (Geller 2016), the valorization of heterosexual masculinity in the disciplinary culture of archaeological fieldwork (Moser 2007), and the marginal representation of female authors and gender-explicit research in archaeological theory readers (Conkey 2007).

In order to gain a better understanding of the status of archaeological approaches to gender in the Pacific Northwest as they appear in peer-reviewed articles, books, edited volumes, bulletins, and gray literature to date, the following is a review of existing studies which address the issue in various capacities from in and around the Northwest (Tables 2, 3, and 4).

Great Basin

Many of the early archaeological inquiries into gender in the Great Basin (Table 2) were grounded in processual methods (Leach 1999:194), which continue to dominate approaches today. Numerous studies have focused on women's labor and economy which follows theoretically in line with the "Woman the Gatherer" countermodel, which emphasizes the integral role of women in food procurement and tool use (e.g., Slocum 1975; Dahlberg 1981; see also Jackson 1991:301). Examples of such approaches include studies by Jackson (1991) and Farris (1992) who have variously highlighted the contributions of women to subsistence economy and trade. More recent studies continue to engage in gender revisionist pursuits including Leach's (2007) analysis of gender behavioral patterns surrounding obsidian material procurement and use, and Kolvett's (2010) identification of gendered activities at a seasonal occupation camp.

Some behavioral ecologists have taken the perspective that women and men pursued different types of resources to achieve a variety of fitness goals. Zeanah (2004) has argued that a central place foraging model was employed by men in order to facilitate the foraging pursuits of women in resource-rich wetlands during the Late Archaic. Similarly, Elston and Zeanah (2002) and Elston et al. (2014) have suggested that men tended to seek out more high-variability, high-ranked resources while women pursued more low-variability, low-ranked resources during the Pre-Archaic. This system was thought to have ensured continual access to foods while allowing for the occasional and more widely distributed high-yield prey.

Such accommodations between sexes can be seen as a form of cooperation that mitigated conflicts between the subsistence interests of women and men. Brumbach and Jarvenpa (2007:173) point out that this interpretation contrasts with Hildebrandt and McGuire's (2002, 2003) hypothesis that women were provisioning for men who sought to "show-off" through prestige hunting. An earlier, and perhaps more gender cooperative interpretation of the past can be found in McGuire and Hildebrandt's (1994) study in which the authors argued that plant and animal procurement were the domains of heterogeneous task groups that incorporated men, women, and children during the California Milling Stone Horizon.

A recent contribution to the discussion of foraging models comes from Whelan et al. (2013) who used an opportunity cost model based on archaeobotanical data and return rates for plant foods to contend that shifts in settlement systems during the late Holocene influenced women to change their storage strategies. The authors suggested that an acorn-based storage system allowed women to better accommodate the childcare needs associated with a shift to a semi-sedentary settlement system (Whelan et al. 2013:662).

Stable isotope analysis has afforded opportunities to explore questions about gender, status, and consumption using contemporary analytical techniques, as evidenced by Coltrain and Leavitt's 2002 study of stable isotope and radiocarbon chemistry of individuals buried in the Great Salt Lake region. Significant differences in C4 intake were observed between sexes, which the authors attributed to corn consumption and, specifically, the consumption of maize beer among high status males (Coltrain and Leavitt 2002:474).

Table 2. Archaeological Studies of/References to Gender in Peer-Reviewed and Gray Literature by Culture Area, Great Basin

Region	Themes	Source(s)	Literature Type*
Great Basin	Women's economy	Jackson (1991), Farris (1992	B, PR
	Gender, status, and consumption	Coltrain and Leavitt (2002)	PR
	Land use, foraging/ hunting models, and gender task-groups	Hildebrandt and McGuire (2002, 2003), McGuire and Hildebrandt (1994)	PR, PR, PR
	Population, lithic material, and organization	Leach (2007)	B
	Gendered interpretations of space	Kolvet (2010)	M
	Gender, storage, and settlement	Whelan et al. (2013)	PR
	Behavioral ecology and sexual division of labor	Elston and Zeanah (2002), Zeanah (2004) Elston et al. (2014)	PR, PR, P
	Gender and rock art	Whitley (ed., 2001, 2000, 1998, 1994), Hays-Gilpin (2004), Ricks (1995), Bettinger (1991), Cannon and Woody (2007), Parkman (1994), Garfinkel (2013)	B, B, PR, PR, B, G, B, B, PR, B

*__B__ = book/book chapter in edited volume, **G** = gray literature, **M** = magazine/bulletin, **PR** = peer-reviewed article

Gender is an important topic in interpretive approaches to rock art (Whitley 2001a:35–36) and the Great Basin is no exception to areas in which gender lines of inquiry have been explored at rock art sites (e.g., Bettinger 1991; Parkman 1994; Whitley 1994, 1998, 2000; Ricks 1995; Whitley 2001b; Hays-Gilpin 2004; Garfinkel 2013). Examples come from Whitley (1998, 2000) and Hays-Gilpin (2004), who have used gendered symbolism to identify life cycle events at rock art localities (see also Hollimon 2009:2), and Cannon and Woody (2007), who have demonstrated that "women's work" was the dominant use of some rock art localities.

Of all the regions considered here, the Great Basin is one of the most advanced with respect to the methodologies used to explore issues of gender in archaeology to date. Studies from this region have been effective in incorporated gendered voices in processual and behavioral ecology frameworks. However, with the notable exception of certain rock art studies (e.g., Hays-Gilpin 2004), the reluctance of archaeologists to embrace explicitly feminist perspectives is glaring. Kehoe (2013) cautions that processual archaeology has had a difficult time looking for individual agency and social roles beyond those concerning reproduction. The processual commitment to general laws and regularities has a tendency towards reductionism (Kehoe 2013:555). Future Great Basin studies may benefit from exploring the social milieu and flexibility and expansiveness of hunter-gatherer behavior with respect to ecological, land use, and other concerns.

Northwest Coast

Feminist and gender approaches to archaeology on the Northwest Coast have centered on the themes of ecology, subsistence economy, household organization, mortuary practices, technology, and status (Table 3). Early considerations of gender are found in site reports by Ham et al. (1984) and Eldridge (1987) who attempted to identify male and female gendered objects in their respective assemblages. This approach has been criticized by Pratt (1999) who points to a degree of fluidity, flexibility, and cooperation in the daily tasks of Coast Salish culture.

Other early research includes Moss' 1989 dissertation on the archaeology and cultural ecology of the Angoon Tlingit and her subsequent 1993 study of shellfish use among the Tlingit. In the latter of these works, Moss documented conflicting evidence for the economic importance of shellfish, which she reconciled using an emic perspective that helped her to conclude that shellfish offered a low-cost food source for more women than men and for people of lower rank (see also Moss 2013). The relationship between gender and ecology is also central to Daniels' (2009) dissertation in which she developed a gendered optimal foraging model of pre-contact resource depression.

Contributions to the understanding of the relationship between gender and raw material procurement, manufacture, and use comes from Close's (2006) book, which examined the role of women in stone tool production and utilization at the English Camp site. Close's work highlights the value of applying a feminist perspective to reevaluate assumptions about the roles of women and men in behaviors surrounding lithic technology (see also Gero 1991). Bernick (1999a) has similarly employed a feminist perspective to address patriarchal biases in the Fraser delta.

Table 3. Archaeological Studies of/References to Gender in Peer-Reviewed and Gray Literature by Culture Area, Northwest Coast

Region	Themes	Source(s)	Literature Type*
Northwest Coast	Gender attribution to material objects	Ham et al. (1984), Eldridge (1987), Pratt (1999)	G, G, PR
	Gender, ecology, economy, and status	Moss (1989, 1993)	G, PR
	Optimal foraging theory and gender	Daniels (2009)	G
	Lithic technology and gender	Close (2006)	B
	Gender, status, and mortuary studies	Burchell (2003, 2006), Wright (2000)	G, PR, G
	Gender organization in households and non-domestic structures	Springer (2009), Springer and Lepofsky (2011)	G, PR
	Gender, status, and social complexity	Ames (2001)	PR
	Gender and labret wear	Moss (1996, 1999b), Shantry (2014), Ham (1982), Cybulski (2010)	B, PR, PR, G, B
	Women and ethnicity in the fur trade era	McAleer (2003)	G

*B = book/book chapter in edited volume, **G** = gray literature, **M** = magazine/bulletin, **PR** = peer-reviewed article

Additionally, implications for women's labor and production can, but have yet be drawn from the DhRp-52 (KDC 2010; Hoffmann et al. 2016) and Ozette village sites, where well-preserved organic remains have vast potential to produce more realistic and inclusive interpretations of the complexities of gender task differentiation (see Brumbach and Jarvenpa 2007:177).

A number of studies have utilized existing burial data to interpret gender through sexed skeletal remains and burial inclusions, including research by Burchell (2003, 2006) who identified more equal distributions of women and men in southern British Columbia burials in comparison to burials in northern British Columbia where men dominate in both number and grave inclusion frequencies. An earlier study by Wright (2000) found no clear differences in utilitarian and non-utilitarian grave inclusions by sex with the exception of carved spoons found in the graves of women at the Pender site (Wright 2000:91–92).

Others have considered gender from a historical perspective. Zacharias' (1999) re-analysis of historical documents led her to conclude that assumptions of sexual asymmetry among the Haida may be an advent of Western ethnocentrism. McAleer (2003) has analyzed the gender and ethnicity of fur trade era families in the Willamette Valley using archaeological ceramic materials.

Households offer a valuable pathway for exploring gender in the Northwest Coast (Ames 1994:103). Springer (2009) and Springer and Lepofsky (2011) have explored social identity among pithouses in the Harrison River Valley using archaeological attributes including faunal and botanical remains. Kramer (2000) has demonstrated the value of paleoethnobotanical data to interpret the relationship between gender and plant food intensification in the Willamette Valley.

Several researchers have examined the role of gender in the development and maintenance of inequality and social complexity, which is something that Moss (1996:81) has contended is frequently overlooked by archaeologists. In his exploration of the role of gender among high-ranking and low-ranking individuals, Ames (2001:2) has asserted that "an archaeology of Northwest Coast slavery is also an archaeology of gender and warfare." Moss (1996:81, 85) has interpreted ethnographic models of labret use as indicative of variations in gender and social inequality in different regions and periods of the Northwest Coast (see also Ham 1982; Cybuslki 2010; Shantry 2014). Moss (1999b) has also used labrets to challenge assumptions about the gendered associations of labret wear by referencing nineteenth century examples of labret use by men and possibly alternative genders.

Archaeological studies of gender on the Northwest Coast have been effective in demonstrating the flexibility and fluidity of task differentiation in the historic and pre-contact past as well as the potential to explore status and social identity through the use of spatial contexts and material remains. Still others have and continue to make inferences and assumptions about gender without considering it as a serious theoretical and analytical unit. This latter approach follows a model that is often unreflexive, Western, and normative in its assumptions (Conkey 2003:876). One of the challenges for archaeologists in the Northwest Coast and elsewhere, is to develop and promote an archaeology that considers its own partiality while also making full use of its potential to disrupt long-standing assumptions and teach new insights into the past and ourselves (Wylie 2007:214).

Northern Plateau

Some of the earliest studies of gender and archaeology on the Northern Plateau (Table 4) focused on contemporary equity issues and androcentric biases inherent in interpretations of the past. This includes Handly's (1995) study of the representation of women in Canadian archaeology; Bernick and Zacharias' (1995) review of the status, contributions and achievements of female archaeologists in British Columbia; and Greaves' (1999) analysis of microcore technology in the pre-contact period of the southern Interior Plateau of British Columbia.

Several researchers have relied on paleoethnobotanical and zooarchaeological methods to interpret the role of women in the past. This includes Croft and Mathewes' (2014) examination of birch bark artifacts from the Canadian Plateau in which the authors argued that plant-based artifacts associated with female economic pursuits are frequently missing from interpretations of past lifeways even though plants are commonly found in archaeological contexts when looked for (Croft and Mathewes 2014:84). Similar methodological approaches are found in Wollstonecroft's (2000) thesis on the paleoethnobotany of site EeRb 140, and Lindsay's (2003) exploration of the role of shellfish in women's gathering economies (see also Dietz's 2005 analysis of cooking features at the Bridge River site which has similar implications for women's labor).

Substantial contributions to the study of gender on the Northern Plateau come from Brian Hayden's Keatley Creek project, which was strongly influenced by success at the Ozette site and instrumental in stimulating research that incorporated botanical and faunal analyses of housepit floors to infer past lifeways and social dynamics in the region. Particularly influential to the Keatley Creek project was the ethnographic and ethnoarchaeological work of Alexander (1992, 2000) (Anna Marie Prentiss, personal communication).

Examples of archaeological approaches to gender at Keatley Creek include the works of Hayden (1997:69, 83) and Prentiss (2000:216) who have explored gender divisions in domestic spaces (see also Morin 2006), and Morin's (2010) analysis of periphery structures, which he has argued served as ritual locations that were potentially used as secret society houses or feasting areas dominated by local elites (Morin 2010:619–620). Barnett (2015:19) criticizes that Morin's (2010) interpretation and similar ones made by Hayden and others are rooted in aggrandizer strategy theories which emphasize "male dominance and control."

Barnett's recent 2015 dissertation, Indigenous Feminist Approaches to Archae-

Table 4. Archaeological Studies of/References to Gender in Peer-Reviewed and Gray Literature by Culture Areas, Northern and Southern Plateau

Region	Themes	Source(s)	Literature Type*
Northern Plateau	Participation of women in contemporary archaeology	Handly (1995), Bernick and Zacharias (1995)	PR, PR
	Gender, status, and mortuary studies	Schulting (1994, 1995)	G, B
	Women and plant/shellfish economies	Croft and Mathewes (2014), Wollstonecroft (2000), Lindsay (2003)	PR, G, G
	Lithic technology and gender	Greaves (1999)	PR
	Gender division of labor in the ethnographic and archaeological past	Prentiss and Kujit (2012); Alexander (1992)	B, B
	Gender organization in households and non-domestic structures in the Middle Fraser Canyon	Prentiss (2000, ed. 2013), Hayden (1997), Alexander (2000), Morin (2006, 2010), Barnett (2015)	B, G, B, B, G, PR, G/PR
Southern Plateau	Gender, status, and mortuary studies	Schulting (1994, 1995), Collins (1997)	G, B, G
	Gender and rock art	Hays-Gilpin (2004)	B
	Women's subsistence economy	Thoms (1989)	G
	Gender, economy, and spatial organization	Brauner (1976), Komen (2006a, 2006b)	G, G, PR

*__B__ = book/book chapter in edited volume, **G** = gray literature, **M** = magazine/bulletin, **PR** = peer-reviewed article ology, offers a substantial contribution to the discussion of household archaeology in the Middle Fraser Canyon. Barnett's dissertation comprises three individual papers, the first of which explores the "peripheral little houses" at Keatley Creek. Operating from an indigenous feminist perspective, Barnett argues that the artifact assemblages from these spaces are better representative of seclusion houses for women during their coming of age rites of passage (Barnett 2015:37, 134–135; see also Prentiss 2013 and Marucci 1999). Throughout her work, Barnett (2015:8, 18, 94–95, 99, 139) was careful to center her work around indigenous and feminist perspectives and to acknowledge the androcentric and Western biases which tend to dominate scientific and archaeological interpretations of the past (see also Conkey 2003).

Archaeological research on the Northern Plateau has demonstrated the interpretive value of paleoethnobotany and spatial organization in household and nondomestic structures for addressing gender and feminist concerns. Implicit in some of these studies is the heavy reliance on the "methodological crutch" of ethnographies to draw inference about human behavior. Barnett's (2015) dissertation offers a useful model for tempering twentieth century ethnographies with feminist and indigenous concerns in order to provide interpretations of archaeological data which consider diverse stakeholders. These stakeholders include First Nations who are frequently excluded from the production of archaeological knowledge (Watkins 2003; Atalay 2006).

Southern Plateau

Archaeological studies of gender on the Southern Plateau are considerably uncommon compared to other areas of western North America (see Table 4). There are only two known book publications that address issues of gender in the region's past (Schulting 1995; Hays-Gilpin 2004). Several dissertations (Brauner 1976; Thoms 1989; Collins 1997) and theses (Schulting 1994; Komen 2006a) have taken approaches that explore gender archaeologically. Currently there is only one known article (Komen 2006b) in a peer-reviewed journal that systematically addresses gender in the area. As there are currently no regional syntheses of archaeological gender research on the Southern Plateau, the following survey will provide the first comprehensive review of existing studies to date.

In her 2004 book, *Ambiguous Images: Gender and Rock Art*, Hays-Gilpin considered adolescent gender relations by comparing puberty rock art from the Columbia Plateau and Southern California. The author found marked differences in their roles and meaning, which she argued were a result of different cultural contexts for the changing status of young people. Hays-Gilpin demonstrated that rock art locations were sought out during vision quests for puberty initiation of males and females on the Plateau. She found that Plateau girls were granted freedom to paint any visions that appeared to them in dreams or activities undertaken during seclusion, while in Southern California, girls often painted rattlesnake designs and were limited to rattlesnake helping spirits (Hays-Gilpin 2004:110, 117, 124).

Alston Thoms has made noteworthy contributions to the understanding of cooking features, contending that "cook-stone features should be especially useful in informing us about the archaeologically understudied role of women in past land-use systems" (Thoms 2009:577). This is partially addressed in his dissertation on camas in the Pacific Northwest (Thoms 1989). While the mainstay of this research focused on developing an intensification model of root foods in the pre-contact period, Thoms used written accounts to explicate the role of women in geophyte acquisition, processing, and consumption, which has applications for the interpretation of women's labor at other sites with hot rock cookery.

As with the other culture areas discussed in this study, numerous researchers have compared sexed skeletal remains to gendered objects in their analysis of burial contexts (e.g., Osborne 1957; Sprague 1959, 1967; Stapp 1984). Later (1990s) approaches to mortuary studies focused on burials through a gendered lens that explored the intersections of labor, socioeconomic status, and sex. In Schulting's (1994, 1995) analysis of middle prehistoric to protohistoric burials in the Fraser and Columbia plateaus, artifacts were correlated with aged and sexed skeletal remains as part of an analysis of status differentiation.

Schulting observed a degree of variability between sexed skeletal remains and grave inclusion types. However, he noted that there was a stronger association between male-sexed individuals and utilitarian artifacts types that are ethnographically linked to men in comparison to female-sexed individuals, who were weakly correlated with artifacts attributed to women (Schulting 1995:156–157). Schulting also found that during the late prehistoric and protohistoric periods, male burials on average exhibited greater wealth than females, but that this difference decreased during the protohistoric period to the point where it became statistically insignificant. Schulting suggested that this trend may have been attributed to the increasing emphasis on the importance of marriage alliances during this time (Schulting 1995:184).

Collins (1997) analyzed many of the late period burials in her dissertation, where she utilized age and sex data of human remains and their burial inclusions to explore the nature and status of gender among Native American groups in the late prehistoric, protohistoric, and historic periods of the southern Columbia Plateau. Collins' results demonstrated that, similar to Schulting's research, it is not often possible to confidently separate female from male burials using utilitarian artifact classes. However, some weak statistical trends were observed. For example, during the late prehistoric and proto-historic periods, Collins found a weak statistical association between males and objects associated with hunting, wood working, and warfare, and women were weakly associated with food processing items (Collins 1997:265).

Conversely, Collins found much stronger statistical correlations between women and tools associated with clothing manufacture and the digging of root crops during the historic period. The results led her to conclude that these differences may have been a consequence of Euroamerican contact and that the economic roles of men changed more than women as a result of colonialism. In contrast to Schulting's analysis, Collins' results also suggested relatively equal status of women and men during the three time periods (Collins 1997:265–270).

Brauner's (1976) dissertation on the culture history of the Alpowa locality represents the earliest known attempt to explore gender through archaeology on the Southern Plateau and provides an early demonstration of the potential to examine gendered spatial distribution and household dynamics in domestic spaces. In his analysis and interpretation of houses 1, 2C, and 5, in addition to two intrusive pits at Alpowa site 45-AS-82, Brauner differentiated between women's and men's activities based on the representation of artifacts in specific contexts.

The predominance of female-related activity areas such as loci associated with basketry and sewing in House 2C was thought to indicate that women were the major functionaries within the household at Alpowa. In House 5, the presence of two identical task loci characterized by paired anvil stone and hopper-mortar bases was thought to represent two economically functioning females. Citing ethnographic work by Harry Turney-High, Brauner suggested that two intrusive pits containing burned annual plant stems may have represented afterbirth disposal in a manner done by the Flathead (Brauner 1976:91–93, 165, 171).

Komen's (2006a, 2006b) master's thesis and subsequent article published in the journal *Archaeology in Washington*, reexamined the archaeological record of the Stemilt Creek site (45-CH-302) in an effort to identify the "invisible woman" in the archaeological record and to highlight the economic contributions of women in domestic spaces. This was done through a comparison of existing ethnographic accounts with multi-dimensional models that integrated material, artifact, feature, and spatial analyses.

Komen has been critical of the influences of masculine bias in ethnographies and cautioned that ethnographic literature should serve as a general guide for cultural activities rather than as a strict and narrow definition of them (Komen 2006a:9). Komen observed that a wide variety of bone artifacts from Stemilt Creek were associated with traditionally female-oriented activities but that a spatial association between bone artifacts and women's specialized activities could not be identified through spatial analysis. Komen suggested that this observation was congruent with Kent's (1984) model for gender-specific activities in which the author argued that most activity areas are not monofunctional or gender specific (Komen 2006b:19–21).

A review of archaeological considerations of gender on the Southern Plateau to date highlights the limited yet notable efforts to make gender visible within the region. Similar to the approaches taken by Burchell (2003, 2006) and Wright (2000), studies by Schulting (1994, 1995) and Collins (1997) demonstrate the importance of integrating both sexed skeletal remains and grave goods to interpret aspects of gender. This practice contrasts with many Anglo-Saxon mortuary studies and burial analyses conducted elsewhere where gender assignments have frequently been made on the basis of grave goods alone, an approach which Arnold (2007:113) cautions leads to "circular reasoning at best and a complete misrepresentation of the evidence at worst."

A continuing dilemma observed by Geller (2005) is the tendency of archaeologists to conflate sex and gender through the process of inferring cultural constructs of gender through biologically sexed human remains, even when associated grave goods are incorporated into the analysis. Future bioarchaeological studies of gender would benefit from the approach promoted by Geller (2005:597, 599) in which burials are "queered" through the process of disentangling female/male and sex/gender binary oppositions with engagement with queer and feminist theory.

Brauner's (1976) analysis of gendered spatial distributions at Alpowa is noteworthy in that it represents one of the earliest attempts to make inferences about gender from archaeological data in the Pacific Northwest. Wilkie and Howlett Hayes (2006) have observed that the earliest considerations of gender among historical archaeologists were linked to households or domestic sites, "assuming a separation of public and private spheres by sex" (Wilkie and Howlett Hayes 2006:245). Spencer-Wood (2016) has recently criticized that most gender research in historical archaeology is not explicitly feminist. Future historical archaeological approaches to gender would benefit from engaging with feminist political agendas and post-colonial theories which critically evaluate patriarchal power dynamics and the complex gender and sexual relationships between colonizers and colonized (Wilkie and Howlett Hayes 2006:255; Spencer-Wood 2016:477, 488).

The archaeological approaches to gender undertaken by Hays-Gilpin (2004) and Komen (2006a, 2006b) demonstrate the utility of applying feminist theory in archaeological interpretations of gender. Hays-Gilpin's (2004) examination of the ideology and cosmology of adolescent gender relations demands attention to process, because, as Joyce (2004) has observed, no one conceives of a child as static and permanent: "archaeological work on childhood and aging may be one way of continuing the project of examining the formation, structuration, and resignification of embodied subjectivity as a dynamic experience" (Joyce 2004:91).

Komen's scrutiny and critical application of the ethnographic record is in keeping with feminist concerns about the patriarchal and androcentric biases inherent in ethnographic literature. Her observation of a lack of specialized gendered activity areas parallels numerous studies which question the segregation of gendered space in pre-contact dwellings (Brumbach and Jarvenpa 2007:181–185). Feminist approaches such as those taken by Hays-Gilpin and Komen, along with bioarchaeological approaches like the ones applied by Collins (1996) and Schulting (1994, 1995) provide a useful starting point for archaeological approaches to gender in the Southern Plateau moving forward.

Gender Demographics and Disciplinary Culture in Academia

While reflecting on the history of archaeological approaches to the study of gender in the Pacific Northwest, it is a worthwhile endeavor to consider the demographic composition and disciplinary culture within academic institutions that shaped and continues to shape the trajectory of gender research. A considerable number of the studies referenced in this review come from graduates of Washington State University (WSU). A review of theses and dissertations from the WSU Department of Anthropology from 1959–1980 reveals that males comprised 76% of archaeology graduates and 98% of archaeology graduate adivsors during the first 20 years of the department's history (Department of Anthropology, WSU 2016).

These figures have significantly changed over the last few decades. Women have gained considerably more representation in the department, and, as of 2017, comprise almost half (four out of nine) of the tenured/tenure-track archaeology faculty and 57% of the archaeology graduate student body (Andrew Duff, personal communication). In comparison, studies have demonstrated that women now account for nearly half of the PhDs awarded in archaeology as well as nearly half of the membership of the Society for American Archaeology (see Geller 2016:156). Northwest researchers, including Madonna Moss and Anna Marie Prentiss, have made notable contributions to our knowledge of gender systems among peoples of the past by influencing the direction of gender research and encouraging gender lines of inquiry among their graduate students (e.g., Kramer 2000; Marucci 2000; Damon 2012; Sloan 2013; Barnett 2015).

To this end, another area of consideration is the role of graduate students and archaeology graduates as active agents in shaping the future of Pacific Northwest archaeology through their research. Strengthening the body of literature on feminist archaeology will require greater engagement by graduate students and professional archaeologists to explicitly explore issues of gender through new and existing perspectives and methodological approaches in their research.

The reticence to engage in feminist archaeology reflects a disciplinary culture in which gender remains marginal to academic and professional interests. Geller (2016) recently observed that very few archaeology jobs explicitly advertise gender as a desirable research interest. This inhibits graduate students from specializing in gender because, as the current job market suggests, archaeologists are unlikely to receive financial compensation or social capital from their specialty. Geller also notes that this job market trend has direct implications for education. Since scholars integrate their research interests into the courses that they teach, the disinclination to hire researchers who specialize in gender may also mean that the topic goes largely unaddressed in the classroom (Geller 2016:157). The academic, intellectual, and professional cultivation of feminist archaeology requires a recognition of the "subtle" and "embodied" power differentials (Geller 2016:160–162), which discourage and impede gender and feminist pursuits.

Discussion and Conclusion

The review of feminist and gender approaches to archaeology presented in published and gray literature and the analysis of archaeological research on gender presented at annual Northwest Anthropological Conference meetings undertaken in this study points to a continuing lack of attention to gender in Pacific Northwest archaeology—a problem observed by Bernick (1999b) and Moss (1999a) nearly twenty years ago. A considerable number of the studies that were reviewed in this survey were from gray literature. While many of these works are often equally as important as peer-reviewed literature in their contributions to the discipline, they are all too frequently overlooked or rendered invisible, in part due to their limited accessibility.

Of the surveyed areas, the Southern Plateau is the least advanced with respect to the number and diversity of archaeological studies of gender in the Pacific Northwest. Disciplinary culture and the difficulties inherent in engaging in successful pursuits of gender in the past have no doubt helped to perpetuate and sustain the reluctance to embrace feminist archaeology in academic and professional settings. Despite these challenges, critical and reflexive applications of feminist epistemologies in archaeological inquiry can and should be undertaken.

Feminist archaeology is relevant to issues concerning not only the past, but also the present and future. It has vast potential to promote and effect social change by challenging existing hegemonic assumptions and the associated power structures that frequently reinforce patriarchal, colonial, and heterosexist beliefs about societies and people. The act of undoing preexisting premises and challenging what is known enacts an "active theory" which "unsettles," "un-does," and is "destabilizing" (Conkey 2007:296–297, 300). Feminist concerns with subtle and embodied power struggles have implications for diverse stakeholders including indigenous communities, cultural resource management, and the general public (see Moss 2005; Conkey 2005; Geller 2016), all of which are factions that are frequently excluded from the production of knowledge in academic spheres. Feminism's political commitment to emancipatory change reveals how gender structures operate, allowing archaeologists to act effectively against the inequalities which power structures perpetuate (see Wylie 1992:21).

Moving forward, archaeological engagement with gender in the Pacific Northwest will advance by embracing overt feminist epistemologies in practice and theory. Practitioners are becoming increasingly aware that replacing androcentric models with gynocentric ones, or favoring the historically marginalized voices of women, children, and queer identities through the suppression of heterosexual and/or masculine voices, reinforces exclusionary tactics which feminism seeks to minimize. Rather, we must consider how gender is a "process" and "relational" in a manner that is inclusive and expands our understanding of everyday life—the micro-scale of archaeology—which, when added to macro-scale interpretations, can make for a more complete and multi-scalar archaeology (Conkey 2004:57–60).

Avenues that can and should be pursued more vigorously by archaeologists in the Pacific Northwest include issues of embodiment, non-binary genders, queer theory, sexuality, masculinity, and intersectionality. Perspectives which view the body as a site of "lived experience" (Joyce 2005:151) may help to circumvent the "binary straightjacket" (Bolger 2013:13) of female/male and sex/gender distinctions (Geller 2005). Queer theory, which engages with embodiment and is concerned with sexuality and challenging hegemonic and heterosexist discourses of gender, has been described by Bolger (2013:7) as "one of the most interesting and socio-politically informed aspects of gender prehistory." Increasingly, archaeologists are beginning to explore the subject of masculinity, which has largely been ignored, in part, due to criticisms of androcentric biases, which were and continue to be pervasive in feminist theory. The widening interest in diverse and complexly interacting identities has led to increasing application of intersectionality as an analytical unit in archaeological interpretations of the past. Bolger (2013:10) sees intersectional practice as a practical method of bridging traditional feminist concerns of women with postmodern interest in difference, diversity, and complexity.

Recently, Conkey (2013) has promoted two concepts advocated by Enloe (2004) in her exploration of the possible future of gender in the pre-contact past: "curiosity" and "surprise." Enloe's interest in the distinct lack of feminist curiosity challenges us to be more actively curious about the deeply troubling power structures that are maintained and dependent upon a continuing lack of curiosity (Enloe 2004:3; Conkey 2013:112). Complementary to "curiosity" is the notion of "surprise", which has the effect of destabilizing and throwing into confusion that which we take for granted and think we know (Enloe 2004:13–14; Conkey 2013:113–114). Conkey also invites us to consider the metaphors of "voice" and "sight." The questions we must answer, according to Conkey, are what are we "making visible" and what is the "voice" that is being given to the gendered past (Conkey 2013:116)?

Beyond the more abstract theoretical interests which concern feminist archaeology, it is important to emphasize that archaeological pursuits of gender have "significant implications for contemporary policy-making, for the shaping of public opinion, and even for our expectations of the new millennium" (Wicker and Arnold 1999:3). Spector (1998:49) has reminded us that archaeological inquiries into gender provide "the 'props' and the 'scripts' for museums, the media, textbooks, teachers and parents, about human origins, capabilities, developments, variation and change" (see also Nelson 2006:18). As has repeatedly been demonstrated by equity studies in contemporary archaeological practice, gender-focused research also prompts us, as a discipline, to look at the inequalities that permeate within it (e.g., Yellen 1983; Gero 1985; Wylie 1994; Zeder 1994; Handly 1995; Bernick and Zacharias 1995; Hutson 2002; Colwell-Chanthaphonh 2004; Moser 2007; Gero 2009; Bardolph 2014; Geller 2016).

Finally, as advances in the field of feminist archaeology progress, there is a growing need for research of its kind to become more transparent and public. Amid current debates of gender and sexual inequality in political, economic, professional and other social spheres of society along with a proliferation of websites, blogs, and social media pages and groups that portray feminism as abject, misandrist, or in some cases even a “mental illness,” it’s crucial that archaeologists do more to dispel myths and contribute positively to current world discussions. Practitioners of feminist archaeology should ask themselves how their research affects indigenous communities (Conkey 2013:109; Conkey 2005) and the public at large. The Pacific Northwest has the potential to serve as a platform for engaging various stakeholders in an engendered past, and through engendering human history, it can make substantial contributions to present-day policy, attitudes, and discourse.

ACKNOWLEDGMENTS

I am grateful to Darby Stapp for providing access to past volumes of *Northwest Anthropological Research Notes* and the *Journal of Northwest Anthropology*, which have proven invaluable to this study. I am thankful for Shannon Tushingham and Diane Curewitz from the Museum of Anthropology at Washington State University for providing access to essential resources and limited publications, and for the valuable commentary provided by Shannon Tushingham, Anna Marie Prentiss, and Madonna Moss who have helped to substantially improve this study. I would also like to thank Lillian Ackerman and Mary Collins for contributing critical information and feedback about the ethnographic and archaeological nature of gender on the Plateau, as well as Andrew Duff for providing statistical information on the representation of female and male faculty and graduate students at WSU and Jamie Litzkow for proofreading this work.

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Chemical Sourcing of Obsidian Artifacts from the Grissom Site (45-KT-301) to Study Source Variability

Anne B. Parfitt and Patrick T. McCutcheon

Abstract *The Grissom site (45-KT-301) is a late Holocene archaeological deposit in northeast Kittitas County, Washington. Ethnohistoric and historic evidence indicates that the site may reside near the historically recorded Kittitas Fair, or Che-lo-han, a gathering place for Native Americans. Given the proximity to a trade center and the presence of obsidian artifacts, the site exhibits potential to contribute information on obsidian movement and trade in the Pacific Northwest. Using an evolutionary archaeology framework, we undertook a systematic lithic analysis of 167 obsidian artifacts from the Grissom site, including an XRF analysis of a 30% sample. The purpose of this research was to identify whether the site may have been at or near a trade location, and to quantify relationships between source diversity, source locality, and lithic technology. We then compared the results to four previously identified patterns or models for Pacific Northwest obsidian artifact distribution. Eight nonlocal sources and two local sources were identified in the study, supporting the possibility that the site may have been located at or near a trade center. The source diversity in obsidian bifaces and flakes was found to be significantly higher than that of cores, most of which were from a local obsidian source. An inter-site comparison between the Grissom obsidian and the obsidian from three southern Cascade Mountain sites suggested that site-to-source distance was not the only factor driving obsidian occurrence, and instead source quality, trade relationships, or other influences likely contributed to obsidian source distribution at these sites.*

Introduction

Archaeological evidence has shown that humans have used the Columbia Plateau of the Pacific Northwest for millennia (Chatters and Pokotylo 1998), and evidence for obsidian utilization and trade is present as early as 10,180 RCYBP (Galm and Gough 2000). Obsidian artifacts found in the Pacific Northwest have been sourced to three primary regions, British Columbia, Oregon and Northern California, and Idaho. The majority of obsidian artifacts recovered in the Columbia Plateau region are derived from sources in Oregon (Galm 1994), and most of the obsidian artifacts along the Northwest Coast originate from Oregon and British Columbia (Carlson 1983). Obsidian found in Plateau archaeological sites, including those in Washington, generally makes up less than 1% of the total chipped stone assemblage at any given site, regardless of time period, and the ratio between formed obsidian tools and obsidian debitage tends to be very low (Galm 1994). Despite its scarcity in many sites, obsidian has often been used as evidence for trade and exchange (Galm 1994), due to the ability to geochemically source obsidian material and locate its approximate geographic origin. Recent research (McClure 2015; Meirendorf and Baldwin 2015; Kassa and McCutcheon 2016) has investigated the nature of obsidian distribution and utilization in areas of Washington state. This research has illustrated that archaeological obsidian occurrence in Washington, and the Plateau in general, appears to be influenced by multiple, complex variables impacting obsidian distribution both diachronically and synchronically (Galm 1994; Kassa and McCutcheon 2016).

Our research sought to ascertain data about past trade, exchange or migration patterns of Pacific Northwest Native American people who left obsidian artifacts at the Grissom site (45-KT-301), an upland prehistoric-historic archaeological site in the northeast corner of the Kittitas Valley. The site is located on the western edge of the Plateau culture area (Walker 1998), near a historically documented Native American gathering place and trade hub (Splawn 1917; Schuster 1975; Swagerty 1988; Ruby and Brown 1995; Shea 2012). It contains hundreds of obsidian artifacts, offering a unique opportunity to explore evidence for past trade, exchange, and movement of obsidian in the western Plateau.

The descriptions and comparative contexts in this study are based in an evolutionary archaeology theoretical framework that places obsidian distribution in the context of natural selection and cultural transmission mechanisms. The three primary objectives of the study are as follows: 1) Establish whether there is evidence for trade and/or exchange at the Grissom site, given the site's abundance of obsidian artifacts and the proximity to a historic trade hub; 2) Assess the nature of obsidian source diversity, source locality, and source-to-technology relationships at the Grissom site, then compare the results to previously established patterns of obsidian occurrence in the Pacific Northwest; 3) Interpret the obsidian occurrence at the Grissom site, and the ways in which the Grissom site does or does not conform with previous observations, in the context of natural selection and cultural transmission.

Theoretical Framework

Our approach to explaining the presence of obsidian at the Grissom site (45-KT-301) is based in evolutionary archaeological theory, which is an effective method for documenting subtle change in the archaeological record (Dunnell 1978a, 1978b, 1989; McCutcheon 1997; O'Brien and Lyman 2000; Eerkens and Lipo 2007; Kassa and McCutcheon 2016). Past research (Galm 1994; Mack et al. 2010; McClure 2015; Meirendorf and Baldwin 2015; Kassa and McCutcheon 2016) has demonstrated that obsidian occurrence in sites across the Columbia Plateau is variable and complex. Evolutionary archaeology theory uses variation as the subject of study, and that is why it is the appropriate framework for this research. Additionally, this theoretical framework offers an alternative to explaining variation in obsidian artifact occurrence beyond what others (Galm 1994; Mack et al. 2010; McClure 2015; Meirendorf and Baldwin 2015) have presented.

The two mechanisms principally responsible for sorting the variation in artifact traits are natural selection and cultural transmission (Dunnell 1978a, 1978b, 1989; O'Brien and Lyman 2000; Shott 2008). In the context of evolutionary archaeology, natural selection is the process by which different selective conditions in a physical environment (e.g., type of prey, variation in resources, resource availability, tool stone quality and availability) influence the ways in which humans create and modify material culture. Natural selection, or the grain of the environment, favors some artifact traits over others, resulting in differential representation of specific physical artifact traits (e.g., raw material, tool shape) (Dunnell 1978a, 1980; O'Brien and Lyman 2000). The effects of environmental pressures on a stone tool assemblage are manifested in the occurrence of different types of raw material (such as tool stone quality and fracture mechanics), raw material abundance as a function of transport costs, and resource accessibility (but see Brantingham [2003] for a discussion of a neutral model of stone tool procurement).

Cultural transmission is the process through which ideas are transferred within or between populations. Cultural transmission can occur vertically (passed down through time from generation to generation) or horizontally (ideas being borrowed or blended between or within contemporaneous populations) (Lipo et al. 2006). Vertical transmission can result in descent with modification within artifact traits through time, as people modify their strategies to better deal with changes in the environment around them (Lipo et al. 2006). When variation in the archaeological record does not appear to fall in line with what one would expect in terms of natural selection, horizontal cultural transmission may serve to explain the occurrence of certain neutral traits (Dunnell 1978b; Eerkens and Lipo 2007). These traits result from the trading of ideas (manifested in artifacts) that are not being acted upon by environmental pressures and are thus free to vary. One example relevant to the current study might be where in the past, specific obsidian sources could have been preferred over others based on ideas tied to raw material appearance or geography, rather than any particular material property that could be affected by the grain of the enviroment.

Obsidian Source Patterns in the Pacific Northwest

Four general models and patterns have been drawn from past obsidian research in the Columbia Plateau and Pacific Northwest (Kassa and McCutcheon 2016), in addition to previous research on general lithic material distributions outside of the Pacific Northwest. These regional observations, and variability therein, provide archaeological expectations for the Grissom site's (45-KT-301) obsidian artifacts. The first observation is that obsidian tool stone raw material abundance follows a monotonic decay curve, with the quantity of a raw material decreasing with increasing distance between the material source and the geographic location of a given archaeological site (Renfrew 1977). This pattern has been observed in a number of recent sourcing studies in the northern and southern Washington Cascade Mountains (McClure 2015; Mierendorf and Baldwin 2015). However, in other studies, the correlation between source abundance and site-to-source distance is either absent (Vaughn 2010) or variable (Kassa and McCutcheon 2016). This may suggest other mechanisms are at work than those that affect transport costs (e.g., cultural transmission [Eerkens and Lipo 2007], source exposure and quality, and cultural accessibility [Galm 1994]).

When studying lithic occurrence, the relationship between lithic source quality and technology is a key component (Andrefsky 1994; McCutcheon and Dunnell 1998; cf. Eren et al. 2014), as is the initial size and form of the procured raw material (Kuhn 1991; Andrefsky 2009). Andrefsky (1994) developed a model based on a study of tool stone availability (i.e., tool stone abundance and quality) and lithic technology. Tool stone quality relates to the ability of a raw material to be worked into a tool—this can be impacted by the presence of inclusions or the homogeneity of a material, with less homogeneous materials and those with many phenochrysts being more difficult to knap (Andrefsky 1994; Brantingham et al. 2000). Andrefsky's (1994) model suggests that low-quality material, whether scarce or ubiquitous, will generally be associated with informal, or expedient, lithic technology. Alternatively, high-quality material is predicted to occur as formal, or curated, technology when it is not readily available and as both formal and informal technology when it is abundant. Many Washington state obsidian types, including those local to the Grissom site, are considered to be low-quality material, whereas nonlocal obsidian (e.g., from Oregon) is more often associated with higher-quality sources (Galm 1994; McClure 2015; Mierendorf and Baldwin 2015; Kassa and McCutcheon 2016).

A third pattern identified in previous research is that artifacts from more distant sources are usually formed or finished tools, while local material often occurs as artifacts representative of all stages of stone tool manufacture, including informal and formal tools, debitage materials, and lithic cores (Andrefsky 1995; Beck et al. 2002; Eerkens et al. 2007). For example, Eerkens et al. (2007) predict that formed tools and small (<10 mm in diameter), late-reduction stage flakes will generally have higher source diversity and will be from sources located further away, while large (>10 mm in diameter) flakes and other debris produced earlier in the tool making process will have lower source diversity and be from closer sources. They attribute this pattern to the likelihood that that the majority of a tool's manufacture occurs at or nearby its source, and as a tool travels further from its source location, it is often already partially or fully formed (e.g., Beck et al. 2002), resulting in higher source diversity within artifacts representative of late-stage stone-tool manufacture (Eerkens et al. 2007). However, Eerkens et al. (2007) note that factors such as trade or tool stone quality may produce exceptions to this pattern. One such exception can be seen with the Newberry Volcano and Obsidian Cliff sources in central Oregon, where pieces of raw material often appear to have been shaped into transportable forms (e.g., large blanks) at or near the quarries, before being carried long distances (Connolley et al. 2015).

Lastly, change in obsidian source diversity in Pacific Northwest sites has been shown to be variable over time. In some studies, researchers demonstrated that the diversity of obsidian sources in a site appears to decrease over time and become more localized, a pattern that has been observed in lithic assemblages from the Beech Creek site (45-LE-415) (Mack et al. 2010) and at sites near the Malheur headwaters, Oregon (Cadena 2012). This pattern of decreasing source diversity and localization may occur as population sizes rise and the mobility of groups becomes limited (Earle 1994). However, Kassa and McCutcheon (2016) have suggested that source diversity may increase through time at Northern Mid-Columbia River Valley sites that were near expanding trade centers. From the studies noted above, it is clear that there are no readily-identifiable, straight-forward patterns for obsidian occurrence in the Pacific Northwest region. The variability of obsidian occurrence in this region is why an evolutionary archaeology theory approach is a necessary and sufficient means for explaining why obsidian occurs where and when it does.

The Grissom Site's Archaeological Context

The Grissom site (45-KT-301) is located in the northeast corner of the Kittitas Valley in Washington state, and was excavated in the late 1960s and early 1970s by Central Washington University (Shea 2012). The site is located in the traditional territory of the Kittitas people (Schuster 1998). Radiocarbon dates procured by previous researchers (McCombs 2003; Lubinski and Partlow 2012; Vassar 2012) have resulted in an age range of approximately 1875 cal BP to the historic period, setting the site within the Late Period of Plateau cultural chronology, specifically within the middle (500 B.C. to AD 500–1000) and late (500–1000 AD to 1720) sub-periods of this chronological designation (Chatters and Pokotylo 1998). While a comprehensive investigation into site function has yet to be completed, past research on the site assemblage indicates evidence of resource extraction (plant and animal remains) and bone and stone tool manufacture and maintenance (McCombs 2003; Shea 2012; Vassar 2012).

Records from excavations at the Grissom site note extensive stratigraphic disturbance and bioturbation (Shea 2012), and radiocarbon assay research (McCombs 2003; Lubinski and Partlow 2012; Vassar 2012) has supported evidence for stratigraphic mixing and loss of integrity. While heavy disturbance within the site strata makes temporal analyses difficult, ongoing obsidian hydration research at the Grissom site has provided a tentative look at changes in obsidian source diversity through time. Burris (2015) submitted 35 obsidian artifacts (all of which had previously been submitted for XRF analysis as a part of this study) from the Grissom site for obsidian hydration analysis, and was able to look at the change in obsidian source diversity through ordinal-scale time by comparing the occurrence of geochemical sources with hydration thickness rim data. Based on this evidence, Burris (2015) suggests that obsidian source diversity increases through time at the Grissom site, rather than decreasing or staying constant.

Ethnohistoric and historic records describe the Kittitas Valley as a location where large groups of Native Americans gathered annually, particularly the Kittitas, Yakama, Klickitat, Taitnapam, and Wanapam (Schuster 1998), and the gathering location is well known to communities in the Kittitas Valley (Glauert and Kunze 1976). In 1814, Alexander Ross entered the valley of the Yakima River with the purpose of trading for horses at an extensive gathering of Native American people, which he describes as extending “more than six miles in every direction” (Ross 1855:21). Swagerty (1988:Figure 1) documents a trade hub in this same area, and labels it the Kittitas Fair. In other resources, this gathering area is noted as Che-lo-han (Splawn 1917; Schuster 1975; Ruby and Brown 1995; Shea 2012). It is possible that the gathering Alexander Ross came across in 1814 was the same annual gathering that has been documented in subsequent records. Additional ethnographic sources have documented the presence of a Kittitas Village, known as Ch’iláxan (Schuster 1998), or Tc’iláxan (Ray 1936), located approximately six miles south of the Grissom site (Shea 2012). The term Che-lo-han may be an anglicized version of this village name (Shea 2012).

Whether the Grissom site is affiliated with the annual Che-lo-han gathering (Shea 2012), or the Kittitas Fair, is unknown. However, Splawn (1917) documented the exact placement of Che-lo-han, which is identical to the location of the Grissom site (Shea 2012). This evidence, in addition to local, historical accounts of Native American gatherings in the vicinity of the Grissom site (Henderson 1970; Hamilton 1982), likely influenced the decision to conduct subsurface testing there (Shea 2012). The site’s location, in conjunction with historic and ethnographic records of the area, indicate that there is a strong possibility that the Grissom site was located very close to the Che-lo-han gathering, or may indeed represent the gathering itself.

Analytical Strategy

While the stratigraphic nature of the Grissom site has been compromised by disturbance, radiocarbon dates provide a temporal bracket from approximately 1875 cal BP to the historic period (McCombs 2003; Lubinski and Partlow 2012; Vassar 2012). Therefore, all analyses of the Grissom artifacts, and comparisons to other archaeological sites, were completed by treating the Grissom site as one temporal unit, i.e., a late period archaeological deposit. The results of overall source diversity and locality at the Grissom site were compared as a whole to regional expectations for obsidian artifact distribution.

A total of five strategies were used to address the nature of the Grissom site's (45-KT-301) obsidian occurrence. To understand the site's relationship to a past trade center, we examined obsidian source diversity. A localized, low source diversity would suggest that obsidian occurrence was a result of past use of a local tool-stone source, while a high source diversity would be better explained as a result of the Grissom site being located at or near a trade hub (e.g., Minor 2013; Kassa and McCutcheon 2016), or at least functioning in a capacity (i.e., residential village) in which people were moving a variety of materials into the site. In order to assess the Grissom obsidian occurrence in the context of established regional observations (discussed above), we compared source abundance with respect to distance to ascertain whether the sources followed a monotonic decay curve, compared the observed macroscopic characteristics of the geochemical sources to assess the relative tool-stone quality of identified local and nonlocal obsidian sources, and examined the occurrence of geochemical sources across stone tool technological attributes (e.g., object type and reduction classes) to describe relationships between tool technology, obsidian source diversity, and obsidian source locality. Last, we contextualized the Grissom site obsidian occurrence, specifically in terms of monotonic decay, by comparing our results to three other sites with obsidian source data. The results of these analyses were then considered in relation to the mechanisms of natural selection and cultural transmission.

Technique and Sample Selection

<u>*XRF Analysis Samples*</u>

Our sample consisted of 167 obsidian artifacts from 21 excavation units across the Grissom site (45-KT-301) (Figure 1). Of these, 51 artifacts were selected for X-Ray fluorescence (XRF) analysis. Samples were chosen to represent units from the northern, central, and southern sections of the site, and units with higher counts of obsidian were allotted higher numbers of samples. Samples were required to be at least one centimeter in diameter and one millimeter in thickness (Northwest Research Obsidian Laboratory 2013). Additional parameters were used to select XRF samples in a way that would effectively provide information on the relationship between geochemical sources and lithic technology, specifically regarding object type and tool stone material characteristics. Therefore, after requirements of space, unit representation, and artifact size were met, the highest preference for sample selection was given to bifaces, then cores, then flakes, and then chunks. Lastly, the differences in physical characteristics were considered when selecting sourcing samples in an attempt to represent the macroscopic variability found within the obsidian artifacts.

Lithic Analysis

A set of paradigmatic classifications adapted from McCutcheon (1997) were used to describe the variability in stone tool manufacture and use across obsidian sources for the Grissom site obsidian artifact sample. A paradigmatic classification consists of pre-defined dimensions, each containing a set of mutually exclusive attribute states. The mutual exclusivity and unambiguity of the attribute states helps to limit internal contradiction and also attempts to curb observer bias (O'Brien and Lyman 2000). The classification of an artifact in this manner results in a 'paradigmatic class,' which is a string of numbers that correspond to each attribute state for that artifact. This method of classification allows one to track subtle variation in artifact assemblages, by looking at which numbers (i.e., which attribute states) are changing and which ones are staying constant. Paradigmatic classifications have been used extensively in Washington archaeological studies since the 1970s (Dancey 1973; Dunnell and Lewarch 1974; Dunnell and Campbell 1977; Dunnell and Beck 1979; Campbell 1981; Dampf 2002; Vaughn 2010; Kassa 2014; Ferry 2015; Lewis 2015) in order to address specific research questions and to compare changes in lithic technology and function at inter- and intra-site scales. During the analysis, the following

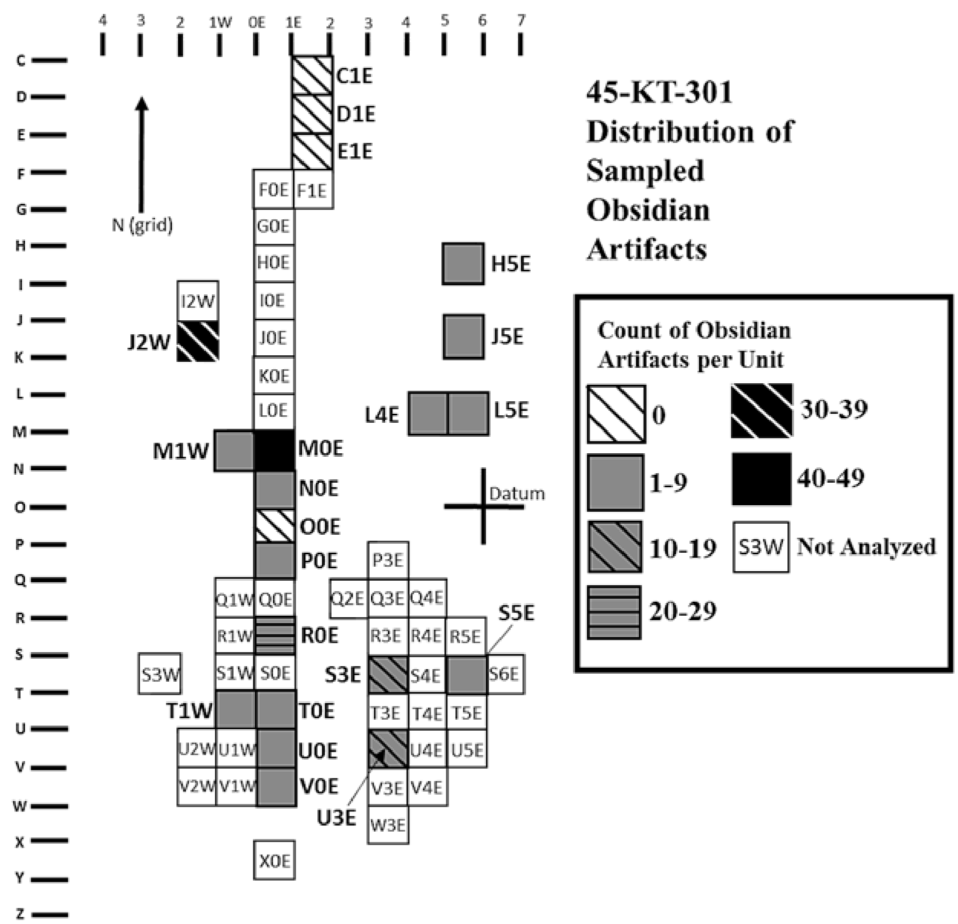

Figure 1. Site Map of 2 x 2 M Units Excavated at the Grissom Site, with Obsidian Count Data. Map Modified from Shea (2012).

information was recorded: technological, functional, and raw material classification codes; maximum dimension, weight, and color. During the macroscopic analysis of the artifacts, we used a binocular dissecting microscope at x20 and x40 magnifications. The classifications that are relevant to the following results section (technological and rock physical properties) are presented in Tables 1 and 2.

Statistics

The Spearman's Rank Correlation Analysis test was used to statistically describe the degree of correlation between two ranked variables (i.e., source abundance and site-to-source distance). Past research (e.g., McCoy and Carpenter 2014) has shown varying results when using artifact frequency versus artifact weight against distance from a source. This test was conducted on both artifact counts and artifact aggregated weight, in order to ascertain the degree of correlation between source abundance and

Table 1. Technological Classification (Adapted from McCutcheon 1997)

I. Type of Fragment

0. **Biface**: two-sided rock exhibiting negative flake scars only, which were initiated from the edge of the rock.
1. **Flake/Flake Fragment**: rock exhibiting attributes of conchoidal fracture, especially positive flake scars, bulb of percussion, eraillure scars, and/or point of impact.
2. **Chunk**: rock exhibits noncortical surfaces but does not exhibit attributes of conchoidal fracture.
3. **Cobble**: rock that exhibits unbroken, cortical surfaces.
4. **Core**: rock exhibiting noncortical surfaces with attributes of conchoidal fracture with only negative flakes scars.
5. **Spall**: A "flake" shaped chunk that exhibits evidence of thermal shock (e.g., potlidding, crazing, crenulation, etc.).

II. Amount of Cortex: cortex is that part of a rock that is the outer layer that forms as a transition zone between the chert body and its bedrock matrix (Luedtke 1992:150).

1. **Primary**: covers external surface (or dorsal side in the case of flake/flake fragments) of rock (with exception of point of impact, in the case of a flake).
2. **Secondary**: external surface has mixed cortical and noncortical surfaces.
3. **Tertiary**: not cortex present on any surface, except point or area of impact.
4. **None**: no cortex present on any surface.

III. Presence of Wear: damage to an object's surface as a result of use.

1. **Absent**: no evidence of wear present on any surface of rock.
2. **Present**: wear is present on at least one surface.

IV. Other Modification

1. **None**: no attrition other than that explained by wear.
2. **Flaking**: Fragment removed by conchoidal fracture.
3. **Grinding**: Surfaces smoothed by abrasion.
4. **Pecking**: irregular or regular patterns of attrition due to dynamic nonconchoidal fracture.
5. **Incising**: linear grinding.
6. **Other**: types of modification not described above.

V. Materal Type

1. **Chert**: includes all cryptocrystalline silica (CCS), composed of one of the forms of quartz.
2. **Obsidian**: non-crystalline igneous glass with a bright, vitreous luster.
3. **Igneous**: all igneous rocks excluding obsidian (basalt, andesite, etc.).
4. **Other**: carbonate and unidentifiable materials.

Table 1. (cont.)

VI. Platform Type: area struck to cause flake removal

1. **Cortex**: refers to cortical platforms.
2. **Simple**: platforms with only one flake scar.
3. **Faceted**: platforms with more than one flake scar.
4. **Bifacial, unfinished**: platform is bifacially flaked, exhibiting a single stratum of flake scars.
5. **Bifacial, unfinished, wear present**: platform is bifacially flaked, exhibiting wear superimposed over a single stratum of flake scars.
6. **Bifacial, finished**: platform is bifacially flaked, exhibiting several strata of flake scars.
7. **Bifacial, finished, wear present**: platform bifacially flaked, exhibiting wear superimposed over several strata of flake scars.
8. **Potlids**: typically small, round flakes with convex side with the point of force located at apex of convex side.
9. **Fragmentary**: platform is absent; "missing data."
10. **Not Applicable**: (e.g., bifaces, cores, chunks, etc.).
11. **Pressure Flakes**: Platform is very thin, bulb of percussion is intact, but very diffuse; this platform occurs on small flakes.
12. **Technologically Absent**: results from indirect percussion where a precursor focuses the force such that as the flake is detached an additional flake from the ventral side removes the bulb of percussion.

VII. Completeness (Adapted from Sullivan and Rozen 1985)

1. **Whole Flake:** Discernible interior surface and point of force apparent; all margins intact; no broken edges.
2. **Broken Flake:** Discernible interior surface and point of force apparent; margins of object exhibit step fractures (> 60°).
3. **Flake Fragment:** interior surface discernible, but point of force is not apparent.
4. **Debris:** interior surfaces not discernible.
5. **Other**: e.g., bifaces, cores, etc.

VIII. Thermal Alteration

0. **No Heating**: no attributes of thermal alteration exhibited.
1. **Lustrous/Nonlustrous Flake Scars:** object exhibits lustrous flake scars either intersecting or juxtaposed to nonlustrous flake scars.
2. **Lustrous Flakes Scars:** lustrous flakes scars only, where the luster is equivalent to that exhibited on objects exhibiting mode 1 above.
3. **High-Temperature Alteration**: object exhibits potliding, crazing, and/or crenulated surfaces (as defined in Purdy 1974).

IX. Reduction Class

1. **Initial Reduction:** cortex present on dorsal surface.
2. **Intermediate Reduction:** simple/ non-complex: dorsal surface: exhibits few arrises from prior flaking and all are of the same scale.
3. **Terminal Reduction:** complex dorsal surface: exhibits two or more arrises and displays two or more scales of prior flaking.
4. **Bifacial Reduction/Thinning**: Complex surface, lipped striking platform; striking plat form is sub-parallel with long axis of flake (rather than being more or less perpendicular to long axis) and carries away a bit of bifacial edge with it.
5. **Bifacial Resharpening:** worn platform: bifacial edge is palpably smooth from chipping/ abrasion/polish (compared by feel with other edges on same piece).
6. **Not applicable:** Debris, flake fragments, cobbles, cores, bifaces, spalls.

Table 2. Rock Physical Properties Classification

I. Material Type

1. **Chert**
2. **Obsidian**
3. **Fine Grained Igneous**
4. **Other**

II. Cortex-Grain Size

1. **Crypto-crystalline:** individual grains not visible even under a microscope.
2. **Aphanitic:** individual grains not visible to naked eye.
3. **Fine-grained**: small, evenly distributed individual grains visible to naked eye.
4. **Coarse-grained:** large, interlocking grains.
5. **No cortex present**

III. Cortex: Solid Inclusions

1. **Present**: particles present that are distinct from the rock body (e.g., oolites, sand grains, filled cracks, grains, fossils, minerals).
2. **Absent**: particles are absent from the rock body at 40X magnification or lower (unaided eye).
3. **No cortex present**

IV. Void Inclusions

1. **Present**: areas devoid of any material are present in the rock body (e.g., vugs, fossil and mineral casts, unfilled cracks).
2. **Absent**: areas devoid of any material are absent from the rock body at 40X magnification or lower (unaided eye).
3. **No cortex present**

VI. Cortex: Distribution of Solid Inclusions

1. **Random**: the distribution of inclusions is irregular and not patterned in any fashion.
2. **Uniform**: the distribution of inclusions is unvarying and even throughout the rock body.
3. **Structured:** the distribution of inclusions is patterned or isolated within the rock body.
4. **None**: inclusions are absent from the rock body at 40X or lower magnification (unaided eye).
5. **No cortex present**

VII. Cortex: Distribution of Void Inclusions

1. **Random**: the distribution of inclusions is irregular and not patterned in any fashion.
2. **Uniform**: the distribution of inclusions is unvarying and even throughout the rock body.
3. **Structured**: the distribution of inclusions is patterned or isolated within the rock body.
4. **None**: inclusions are absent from the rock body at 40X or lower magnification (unaided eye).
5. **No cortex present**

VIII. Groundmass-Grain Size

1. **Crypto-crystalline**: individual grains not visible even under a microscope.
2. **Aphanitic**: individual grains not visible to naked eye.
3. **Fine-grained**: small, evenly distributed individual grains visible to naked eye.
4. **Coarse-grained**: large, interlocking grains.

IX. Groundmass: Solid Inclusions

1. **Present**: particles present that are distinct from the rock body (e.g., oolites, sand grains, filled cracks, grains, fossils, minerals).
2. **Absent**: particles are absent from the rock body at 40X magnification or lower (unaided eye).

X. Groundmass: Void Inclusions

1. **Present**: areas devoid of any material are present in the rock body (e.g., vugs, fossil and mineral casts, unfilled cracks).
2. **Absent**: areas devoid of any material are absent from the rock body at 40X magnification or lower (unaided eye).

Table 2. (cont.)

XI. Groundmass: Distribution of Solid Inclusions

1. **Random**: the distribution of inclusions is irregular and not patterned in any fashion.
2. **Uniform**: the distribution of inclusions is unvarying and even throughout the rock body.
3. **Structured**: the distribution of inclusions is patterned or isolated within the rock body.
4. **None**: inclusions are absent from the rock body at 40X or lower magnification (unaided eye).

XII. Groundmass: Distribution of Void Inclusions

1. **Random**: the distribution of inclusions is irregular and not patterned in any fashion.
2. **Uniform**: the distribution of inclusions is unvarying and even throughout the rock body.
3. **Structured**: the distribution of inclusions is patterned or isolated within the rock body.
4. **None**: inclusions are absent from the rock body at 40X or lower magnification (unaided eye).

distance using multiple datasets. This test generates an r_s value, which ranges from -1 to 1, with either end of the range indicating a perfect negative correlation (-1) or positive correlation (1). An r_s value of zero indicates no correlation at all. The two-tailed null hypothesis for the test is that there is no correlation between source abundance (quantified using either artifact weight or artifact count) and site-to-source distance. For all tests, a significance level of .05 was used when determining whether to reject or not to reject the null hypothesis. Depending on the number of ranked pairs, the statistical significance for the test was determined with either the critical value for Spearman's r_s, or with the t-test for Pearson's correlation coefficient (Vanpool and Leonard 2011).

Background on Inter-site Comparison Sites

Three southern Cascade sites were used to place this study into a broader regional context, and to further explore the environmental and cultural factors influencing the distribution of obsidian across the Pacific Northwest. These comparison sites were chosen for two reasons. First, while the lithic artifacts for each of these sites were originally analyzed with varying classification schemes, Vaughn (2010) compiled data from each of the sites to complete a common lithic attribute dataset, which employs technological, functional, and material traits similar to those applied in the current analysis. Second, these sites were selected because each of them has a large sample of XRF-sourced specimens. The similar classification data and abundance of sourced obsidian at each of these sites allows for comparison with the Grissom assemblage, in terms of obsidian tool technology, source diversity, and relationships between source abundance and site-to-source distance.

The Beech Creek site (45-LE-415) is a southern Cascade Mountains site. Luminescence dating on sediment samples taken from near the base of the cultural stratum at Beech Creek resulted in a likely depositional age of 9700–8700 cal BP, while charcoal dates from within the cultural stratum range in age from 5290 to 1540 cal BP (Mack et al. 2010). For his comparison of stone tool attribute frequencies, Vaughn (2010) used data from McClure (1992), which is based on a sub-sample of 741 pieces of obsidian. Multiple excavations at the Beech Creek Site (McClure 1992; Hughes 1993; Mack et al. 2010) have resulted in the XRF analysis of 111 obsidian artifacts.

The majority of the cultural remains at the Sunrise Borrow Pit Ridge (45-PI-408) site date between 4,000 and 470 cal BP (McCutcheon et. al., in preparation), and excavations at this site uncovered 17,418 pieces of chipped stone. As of 2015, 6,691 lithic artifacts were analyzed from this assemblage, 84 of which were obsidian. Thus far, 61 pieces of obsidian have been sourced from 45-PI-408. The Tipsoo Lake (45-PI-406) site has not been placed in a temporal context as it exhibits extensive stratigraphic disturbance, and no chronological assessments have been made as of yet. A total of 867 lithic artifacts were recovered from this site, including 36 pieces of obsidian, 32 of which were sourced (Vaughn 2010).

Results

Obsidian Sources Present at the Grissom Site

A total of 10 unique obsidian sources were identified in the 51 sourced artifacts from the Grissom site (45-KT-301) (Figure 2, Figure 3, Table 3). Of these sources, two are located less than 50 miles from the site, two are located in southern Washington, one in Idaho, and the remaining five are in central Oregon. In our discussion of these sources, the designation of 'local' and 'nonlocal' sources is modeled after that in Kassa

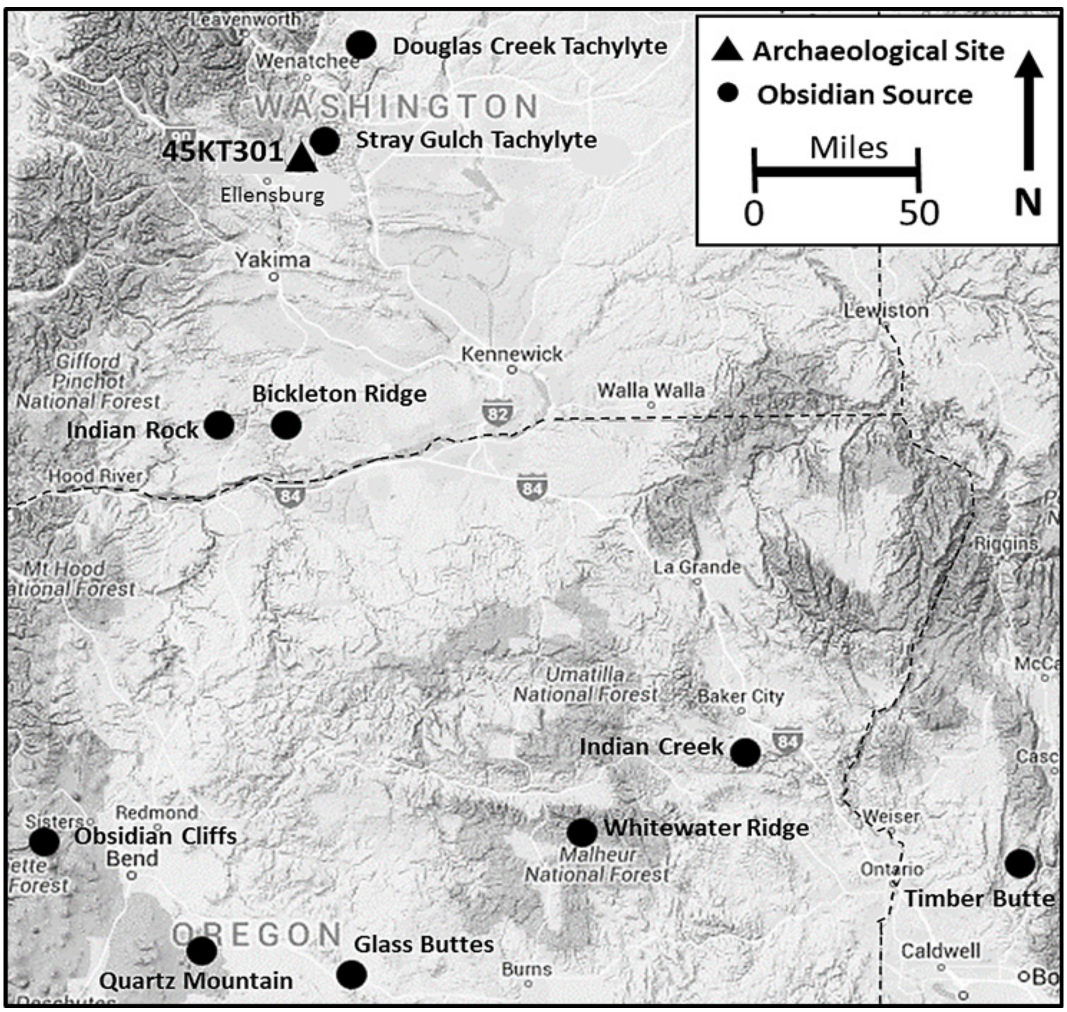

Figure 2. Map showing location of Grissom site (45-KT-301) and obsidian sources represented at the Grissom site. Base map from Google Maps (2015), obsidian location data from Northwest Obsidian Laboratory (2015).

and McCutcheon (2016), where sources located within the Northern Mid-Columbia Region are designated as local, while sources located outside of this region are defined as nonlocal.

Stray Gulch Tachylyte is the most common obsidian material type at the Grissom site, and comprises one third of the obsidian artifact sample analyzed with XRF. The Indian Creek source contributed approximately 25% of the obsidian artifact sample. The sources Bickleton Ridge, Indian Rock, Whitewater Ridge, and Timber Butte range in frequency from approximately 6% to 14%, with the remaining four sources each occurring at 2%. A Spearman's Rank Correlation statistic was conducted to determine whether the occurrence of sources followed a monotonic decay curve (Table 4). When used with artifact counts, the test does not reject the null hypothesis. However, when conducted with artifact weight, this test rejects the null hypothesis, indicating a moderate, negative correlation between the two variables where sources farther away from the Grissom site occur in lower weights than closer sources.

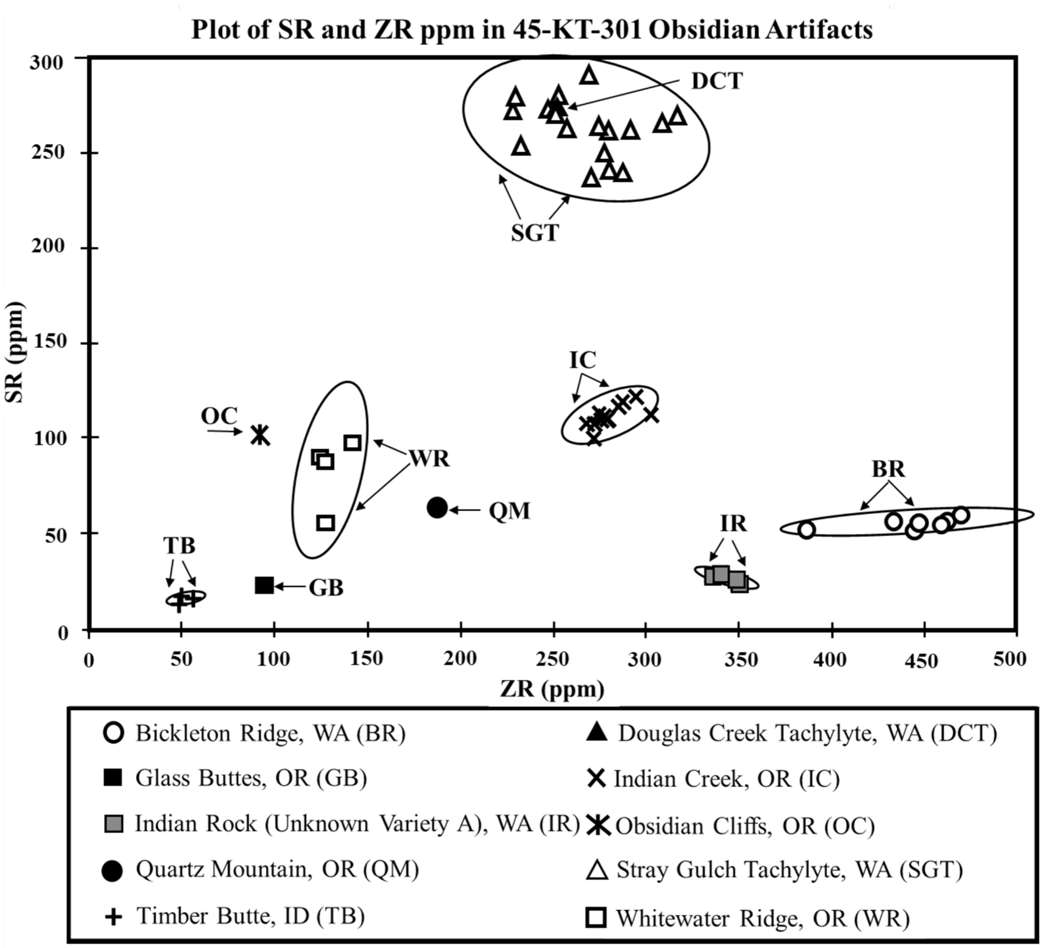

Figure 3. Strontium (SR) and Zirconium (ZR) ppm plotted for all 51 sourced artifacts, adapted from Skinner (2014) and Skinner and Thatcher (2013a, 2013b). Ellipses represent 95% confidence levels. Obsidian source abbreviations listed on graph.

Table 3. Primary XRF Data for the 51 Sourced Grissom Artifacts[a]

			Trace Element Concentrations (ppm)				
Entry Number	Catalog Number	Geochemical Source	RB	SR	Y	ZR	NB
52	667	Bickleton Ridge, WA	211+/-3	52+/-1	63+/-2	444+/-3	46+/-2
105	3046	Bickleton Ridge, WA	206+/-3	53+/-2	60+/-2	386+/-3	48+/-2
159	3855	Bickleton Ridge, WA	213+/-3	57+/-2	61+/-2	462+/-3	45+/-2
109	7531	Bickleton Ridge, WA	233+/-3	60+/-2	63+/-2	469+/-3	48+/-2
152	8825	Bickleton Ridge, WA	221+/-3	55+/-1	62+/-2	458+/-3	49+/-2
161	9536	Bickleton Ridge, WA	212+/-3	57+/-2	60+/-2	433+/-3	42+/-2
89	9547	Bickleton Ridge, WA	219+/-2	56+/-2	62+/-2	447+/-3	45+/-2
51	15152	Douglas Creek Tachylyte, WA*	57+/-2	274+/-3	47+/-2	252+/-3	20+/-2
82	9543	Glass Buttes, OR	84+/-2	23+/-1	51+/-2	95+/-2	11+/-1
1	299	Indian Creek, OR	95+/-2	112+/-2	61+/-2	277+/-2	18+/-1
3	327	Indian Creek, OR	93+/-2	110+/-2	59+/-2	279+/-3	17+/-1
61	1173	Indian Creek, OR	91+/-2	110+/-2	62+/-2	276+/-3	18+/-2
55	1577	Indian Creek, OR	93+/-2	112+/-2	61+/-2	279+/-3	16+/-2
63	1791	Indian Creek, OR	81+/-2	100+/-2	54+/-2	272+/-3	17+/-2
57	3706	Indian Creek, OR	100+/-2	117+/-2	63+/-2	285+/-3	17+/-2
151	7741	Indian Creek, OR	93+/-2	113+/-2	60+/-2	303+/-3	17+/-1
117	8062	Indian Creek, OR	89+/-2	108+/-2	58+/-2	268+/-2	18+/-1
130	8672	Indian Creek, OR	96+/-2	120+/-2	65+/-2	287+/-3	16+/-2
149	9366	Indian Creek, OR	100+/-2	122+/-2	64+/-2	294+/-3	18+/-2
46	15000	Indian Creek, OR	88+/-2	108+/-2	59+/-2	272+/-2	18+/-1
49	15001	Indian Creek, OR	91+/-2	113+/-2	60+/-2	274+/-2	19+/-1
34	318	Indian Rock (Unknown Variety A), WA	123+/-2	28+/-1	50+/-2	336+/-3	44+/-2
58	319	Indian Rock (Unknown Variety A), WA	141+/-2	24+/-1	52+/-2	350+/-3	48+/-2
106	3116	Indian Rock (Unknown Variety A), WA	142+/-2	29+/-1	54+/-2	340+/-3	47+/-2
116	8009	Indian Rock (Unknown Variety A), WA	144+/-2	26+/-1	55+/-2	348+/-3	49+/-2
45	2378	Obsidian Cliffs, OR	74+/-2	103+/-2	17+/-1	91+/-2	8+/-1

[a]Table adapted from Skinner and Thatcher (2013a: Table A-1), Skinner and Thatcher (2013b: Table A-1), and Skinner (2014:Table A-1).
*Originally listed in Skinner and Thatcher (2013a) as "Unknown Tachylyte A."

Table 3. Primary XRF Data for the 51 Sourced Grissom Artifacts[a] (cont.)

Entry Number	Catalog Number	Geochemical Source	Trace Element Concentrations (ppm)				
			RB	SR	Y	ZR	NB
108	7531	Stray Gulch Tachylyte, WA	48+/-2	280+/-4	51+/-2	253+/-3	18+/-2
77	8131	Stray Gulch Tachylyte, WA	64+/-2	262+/-3	53+/-2	279+/-3	19+/-2
78	8140	Stray Gulch Tachylyte, WA	63+/-2	291+/-3	54+/-2	269+/-3	21+/-2
7	9099	Stray Gulch Tachylyte, WA	65+/-2	262+/-3	54+/-2	291+/-4	22+/-2
164	9336	Stray Gulch Tachylyte, WA	57+/-2	264+/-4	55+/-2	274+/-4	20+/-2
162	9536	Stray Gulch Tachylyte, WA	55+/-2	242+/-4	54+/-2	280+/-4	19+/-2
131	9767	Stray Gulch Tachylyte, WA	46+/-2	254+/-3	48+/-2	232+/-3	17+/-2
132	9936	Stray Gulch Tachylyte, WA	59+/-2	250+/-3	55+/-2	277+/-3	20+/-2
100	13713	Stray Gulch Tachylyte, WA	51+/-2	272+/-4	46+/-2	228+/-3	17+/-2
103	13730	Stray Gulch Tachylyte, WA	58+/-2	273+/-4	47+/-2	247+/-3	18+/-2
24	14717	Stray Gulch Tachylyte, WA	72+/-2	270+/-3	62+/-2	316+/-3	25+/-2
31	14770	Stray Gulch Tachylyte, WA	53+/-2	240+/-4	58+/-2	287+/-4	21+/-2
44	14982	Stray Gulch Tachylyte, WA	71+/-2	266+/-3	58+/-2	309+/-4	23+/-2
48	15000	Stray Gulch Tachylyte, WA	47+/-2	263+/-4	51+/-2	257+/-3	18+/-2
53	15040	Stray Gulch Tachylyte, WA	52+/-2	279+/-4	47+/-2	229+/-3	15+/-2
157	15245	Stray Gulch Tachylyte, WA	53+/-2	237+/-4	55+/-2	270+/-4	23+/-2
158	15245	Stray Gulch Tachylyte, WA	55+/-2	270+/-4	50+/-2	251+/-3	18+/-2
60	1132	Timber Butte, ID	169+/-3	17+/-1	41+/-2	50+/-2	34+/-2
143	15224	Timber Butte, ID	169+/-2	15+/-1	42+/-1	49+/-1	35+/-2
160	7688	Timber Butte, ID	189+/-2	17+/-1	45+/-2	56+/-2	34+/-2
168	79	Whitewater Ridge, OR	115+/-2	98+/-2	22+/-2	142+/-2	5+/-2
4	329	Whitewater Ridge, OR	110+/-2	88+/-2	23+/-1	127+/-2	10+/-1
35	842	Whitewater Ridge, OR	123+/-2	56+/-1	31+/-1	127+/-2	13+/-1
139	15184	Whitewater Ridge, OR	109+/-2	90+/-2	23+/-1	125+/-2	9+/-1

[a]Table adapted from Skinner and Thatcher (2013a: Table A-1), Skinner and Thatcher (2013b: Table A-1), and Skinner (2014:Table A-1).
*Originally listed in Skinner and Thatcher (2013a) as "Unknown Tachylyte A."

Table 4. Count and Weight of Sourced Obsidian Artifacts from the Grissom (45-KT-301) Site and the Results of the Spearman's Rank Correlation Analysis

Obsidian Source*	Ranked Distance from 45KT301	Count	Aggregated Weight (g)
Stray Gulch Tachylyte, WA (SGT)	1	17	41.43
Douglas Creek Tachylyte, WA (DCT)	2	1	1.76
Bickleton Ridge, WA (BR)	3	7	24.63
Indian Rock (Unknown Variety A), WA (IR)	4	4	7.64
Indian Creek, OR (IC)	5	12	12.58
Whitewater Ridge, OR (WR)	6	4	6.1
Obsidian Cliffs, OR (OC)	7	1	0.33
Quartz Mountain, OR (QM)	8	1	0.29
Glass Buttes, OR (GB)	9	1	2.34
Timber Butte, ID (TB)	10	3	1.54

Spearman's Rank Values	Count	Weight
r_s-value	-.494	-.685
Critical Value (α =0.05)	.648	.648
Bracketing p-values	$.1<p>.2$	$.02<p>.05$
Null Hypothesis	Failed to Reject	Rejected

*abbreviations used below in all graphs

Note: Critical values and *p*-values for Spearman's r_s were obtained from Zar (1984).

Macroscopic Characteristics

After comparing the XRF results of the sourced artifacts with the macroscopic data for those same artifacts, it was evident that some obsidian sources had distinctive macroscopic characteristics, while others looked very similar in terms of color, translucency, and frequency of inclusions. As the presence of inclusions (or a lack thereof) can be an indication of raw material quality (Andrefsky 1994; Brantingham et al. 2000), the frequency of solid inclusions observed for each source is discussed below. Void inclusions, also an indication of quality, are not discussed as they were not present in the sourced artifacts. The two local obsidian sources identified within the Grissom

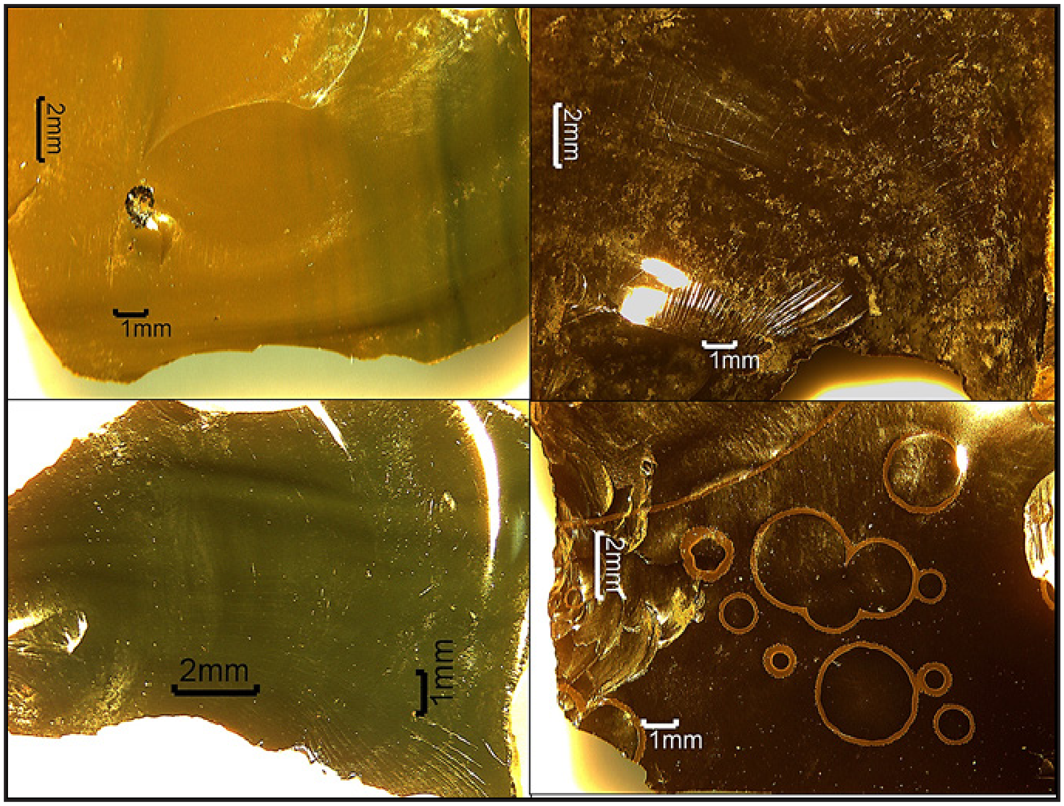

Figure 4. Macroscopic variation in Grissom site artifacts from the Stray Gulch Tachylyte source.

site artifacts were Stray Gulch Tachylyte (Figure 4) and Douglas Creek Tachylyte. In general, tachylyte is of poor quality for flint knapping due to a high concentration of phenocrysts (Skinner 2009), however, the Stray Gulch Tachylyte source is of unusually high quality (Craig Skinner, personal communication). Round, black, randomly distributed solid inclusions occurred in 76% of the sourced Stray Gulch Tachylyte artifacts, ranging from 1 mm to 1/2 cm in diameter. Unlike the Stray Gulch Tachylyte source, the Douglas Creek source does not usually exhibit inclusions (Craig Skinner, personal communication), however, the Douglas Creek tachylyte specimen in the Grissom assemblage did exhibit randomly distributed, solid, round black inclusions <1mm in diameter that make up <10% of the groundmass.

Regarding nonlocal obsidian artifacts from the Grissom site, all of the Indian Rock (Unknown Variety A) artifacts exhibited solid inclusions, as did half of the Whitewater Ridge samples. In both sources, the inclusions were randomly distributed, angular, and clear in color, ranging from one to two mm in diameter, and making up less than 10% of the groundmass. Artifact samples sourced to Quartz Mountain and Timber Butte exhibited a complete lack of solid inclusions, while the Glass Buttes sample and 25% of the Indian Creek samples exhibited solid inclusions. The sample from Obsidian Cliffs contained randomly distributed, clear inclusions up to two mm in diameter, and approximately 29% of the samples sourced to Bickleton Ridge contained randomly distributed, black inclusions one to two millimeters in diameter. Figure 5 shows an example of the macroscopic variation within several of these

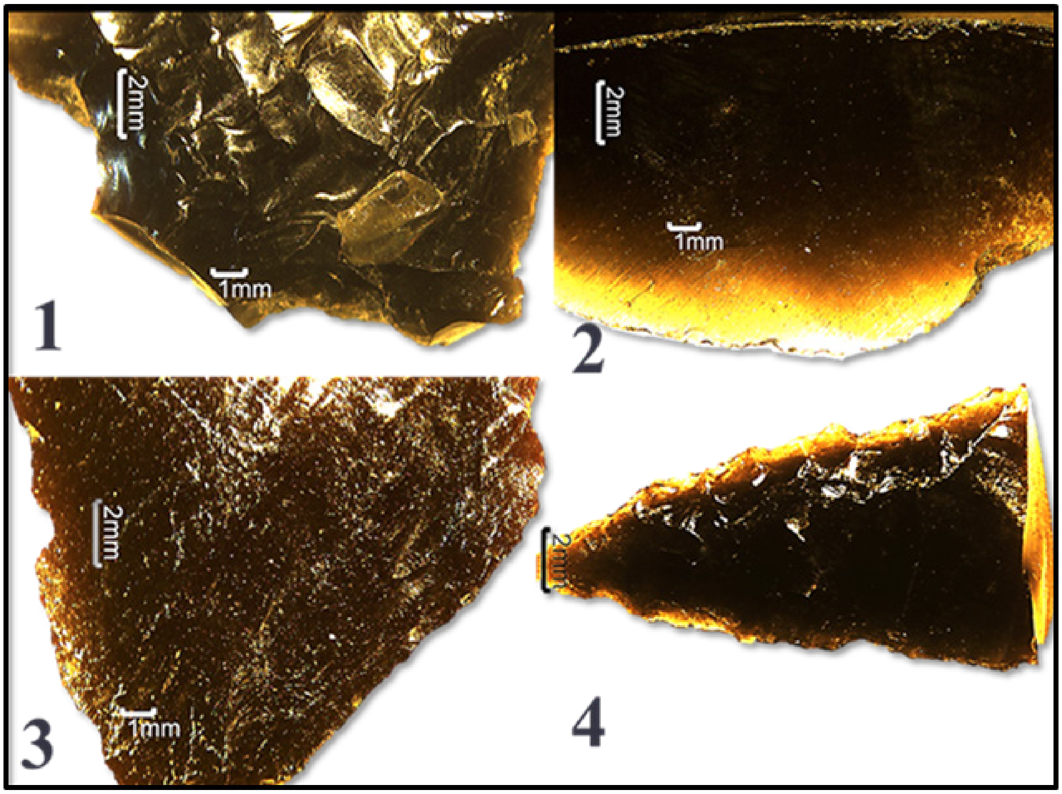

Figure 5. Photos of Grissom site (45-KT-301) nonlocal obsidian artifacts. 1) Biface fragment sourced to Whitewater Ridge, OR; 2) Flake sourced to Indian Creek, OR; 3) Flake sourced to Bickleton Ridge, WA; 4) Biface fragment sourced to Quartz Mountain, OR.

nonlocal sources. The local sources on average appear to have a higher proportion of randomly distributed solid inclusions than the nonlocal sources, with the exception of the Indian Rock (Unknown Variety A) source and those sources with a sample size of only one. These results seem to be consistent with observations from others (Galm 1994; McClure 2015; Mierendorf and Baldwin 2015; Kassa and McCutcheon 2016), which suggest that the majority of obsidian sources in Washington are of lower knapping quality than many of the obsidian sources in Oregon.

Lithic Technological Frequencies and Obsidian Source Diversity

To assess the relationship between lithic technology and source occurrence and diversity, we looked at the geochemical source frequencies across lithic object type and reduction class. In our sample of 167 artifacts, flakes comprised 73%, followed by chunks (11%), cores (8%) and bifaces (7%). Of the analyzed whole and broken obsidian flakes, 70% exhibited initial reduction characteristics, while 27% showed intermediate reduction and just 3% exhibited terminal reduction.

The distribution of sources represented within the 44 sourced bifaces, whole and broken flakes, and cores is illustrated in Figure 6. Bifaces and flakes exhibit the greatest source diversity and are crafted from seven sources. A comparison of the geochemical source diversity for bifaces and cores shows that bifaces are made from a wider variety of sources (n = 7) than the cores (n = 2). All of the cores were from

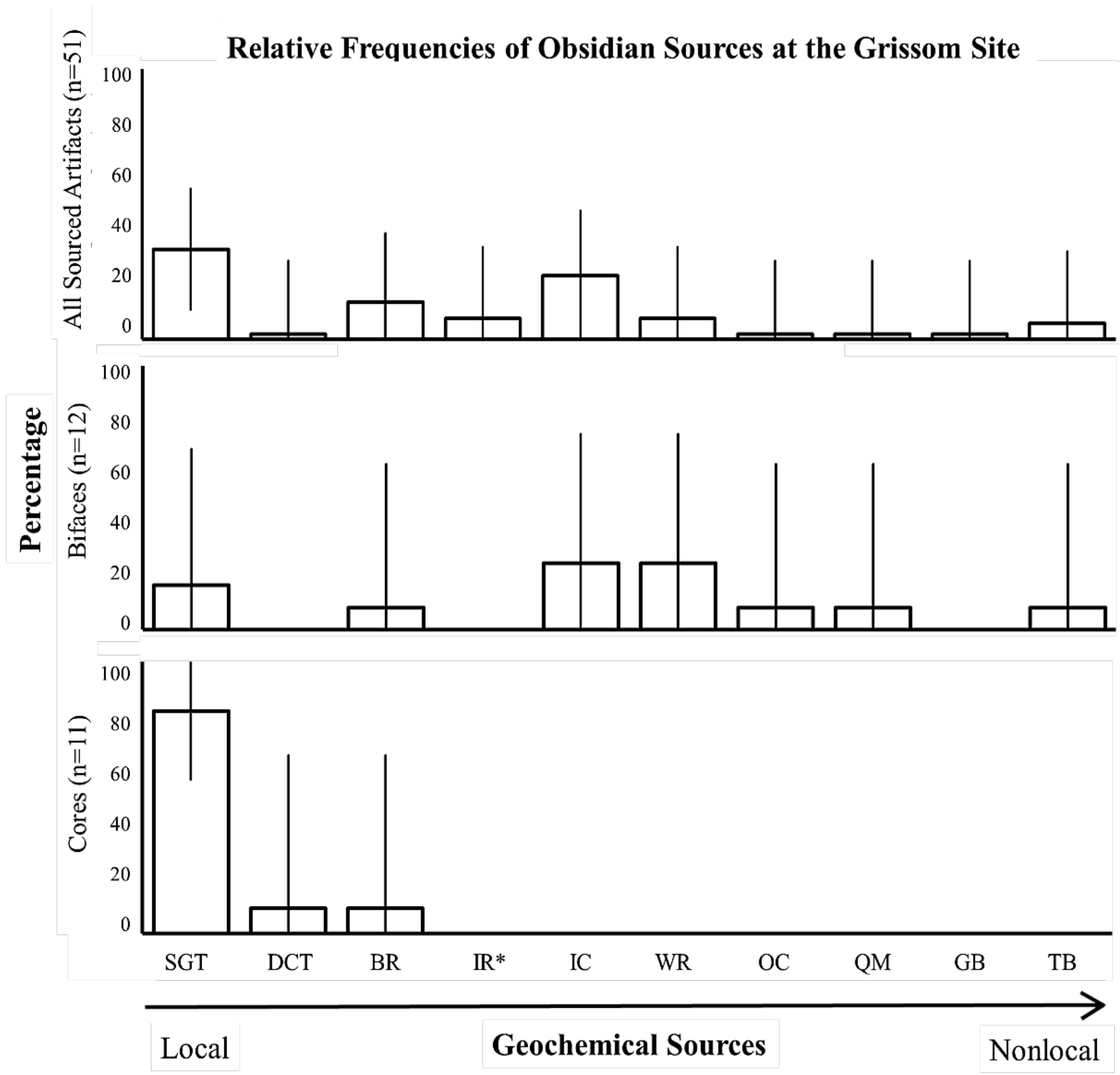

Figure 6. Sources are organized left to right by proximity to the Grissom (45-KT-301) site. Error bars represent 95% confidence intervals.

local sources, while only 17% of the bifaces were derived from local sources. The distribution of obsidian sources with respect to lithic technology becomes more noteworthy when looking at flake reduction classes. Out of the 21 whole and broken flakes analyzed with XRF, 57% were assigned to initial reduction, 38% were assigned to intermediate reduction, and 5% to terminal reduction. Of the initial reduction flakes that were sourced, half of them came from the Stray Gulch Tachylyte source, while the remainder came from Bickleton Ridge (8%), Indian Rock (17%), Timber Butte (17%), and Glass Buttes (8%). The intermediate flakes were sourced to Bickleton Ridge (12.5%), Indian Rock (62%), Indian Creek (12.5%), and Whitewater Ridge (12.5%), while the one terminal flake came from Indian Creek. To assess flake size in the context of source diversity (after Eerkens et al. 2007), we plotted the distribution of size and weight classes for the 74 initial and intermediate reduction flakes. All of the sourced initial and intermediate flakes from the Grissom site were 15 millimeters or greater in size (Figure 7), meaning that they would be considered 'large' flakes in the context of Eerkens et al. (2007).

Figure 7. Large, nonlocal flakes from the Grissom (45-KT-301) site. From left to right: Indian Creek, OR; Indian Rock, WA; Timber Butte, ID; and Indian Creek, OR. Scale is in centimeters.

Inter-Site Comparisons

We selected three southern Cascade sites with which to compare to the Grissom site (45-KT-301) in terms of obsidian artifact technology and source diversity, and to further test for the occurrence of monotonic decay. These three sites are the Beech Creek Site (45-LE-415), the Sunrise Ridge Borrow Pit site (45-PI-408), and the Tipsoo Lake site (45-PI-406). When the relative frequencies of obsidian object types are compared for each of the four sites, flakes dominate each sample, ranging from 83% at the Grissom site to 100% at the Tipsoo Lake site. With the exception of Tipsoo Lake, all of the sites contained obsidian bifaces, which constitute 2% of the sampled obsidian at the Sunrise Ridge Borrow Pit site, 8% at the Grissom site, and 16% at the Beech Creek site. The Grissom site sample was the only one containing obsidian cores (9%).

The location of the obsidian sources and sites is presented in Figure 8, and counts of sourced obsidian artifacts from each site are presented in Table 5. A total of 16 unique sources are identified in the four sourced obsidian subsamples. The sites with the highest source diversity present are the Grissom site, with 10 sources, and the Beech Creek site with seven sources, followed by the Sunrise Ridge Borrow Pit site (six sources) and the Tipsoo Lake site (five sources). At Beech Creek, over 75% of the samples were derived from the local Elk Pass source, and the remaining samples were sourced to Newberry Volcano, Obsidian Cliffs, Whitewater Ridge, Cleman Mountain, Tule Spring, and Wolf Creek. At the Sunrise Ridge Borrow Pit site, half of the sourced obsidian artifacts came from Obsidian Cliffs and one third came from Quartz Mountain, followed to a much smaller degree by Glass Buttes, Indian Creek, and Bickleton Ridge. Within the Tipsoo Lake assemblage, 47% of the sourced obsidian is from Newberry Volcano, followed by Obsidian Cliffs, Whitewater Ridge, Elk Pass, and Bickleton Ridge.

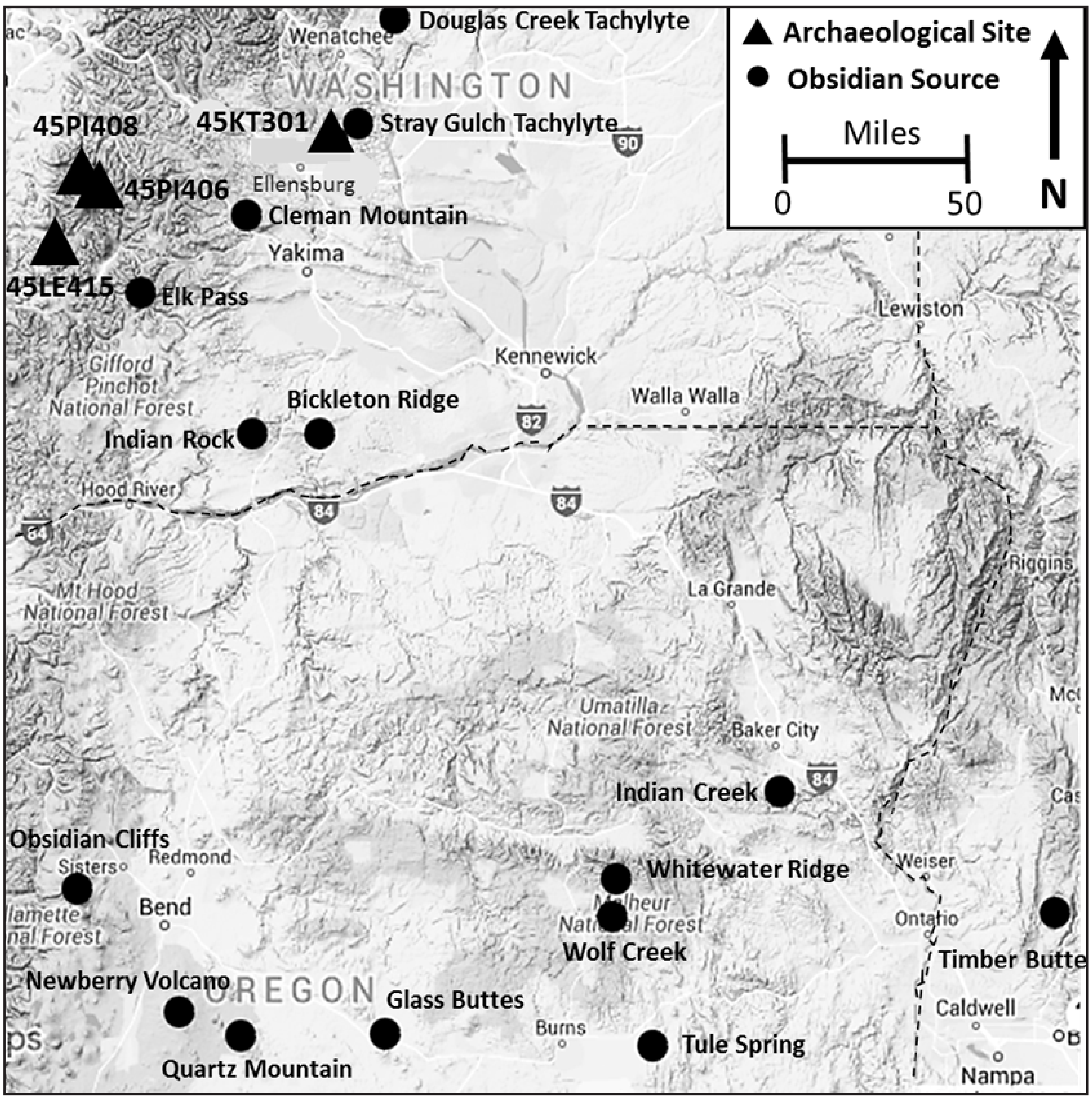

Figure 8. Geochemical source map of all sources represented in the four site assemblages: Grissom (45-KT-301), Beech Creek (45-LE-415), Sunrise Ridge Borrow Pit (45-PI-408), and Tipsoo Lake (45-PI-406). Source location data from the Northwest Research Obsidian Laboratory (2015).

To test the statistical significance of the patterns observed in Table 4, we conducted a Spearman's Rank Analysis test on the counts of the obsidian artifacts in each site (Table 6). This test was conducted in two ways. The test was run first with all of the obsidian sources represented in the study, regardless of whether they were present at each site. In this test, sources were listed as having a count of 0 for those sites at which they were not present. We then ran the Spearman's Rank test again for each site using only sources present at that site, the results of which are in the bottom half of Table 6. In either case, the null hypothesis could not be rejected for any of the sites, meaning that there does not appear to be a significant correlation between the distance from a source and source count. This holds true both when counts of zero are included and when they are not.

Table 5. Count and Aggregated Weight of Obsidian Artifacts for the Inter-Site Spearman's Rank Analyses

Obsidian Source	45-KT-301	45-LE-415	45-PI-408	45-PI-406
	Count | Weight (g)	Count | Weight (g)[a]	Count | Weight (g)	Count | Weight (g)
Stray Gulch Tachylyte, WA	17 | 41.43	0	0	0
Douglas Creek Tachylyte, WA	1 | 1.76	0	0	0
Elk Pass, WA	0	86 | 70.51	0	3 | .079
Cleman Mountain, WA	0	1 | X[b]	0	0
Bickleton Ridge, WA	7 | 24.63	0	1 | .38	2 | .4
Indian Rock (Unknown Variety A), WA	4 | 7.64	0	0	0
Indian Creek, OR	12 | 12.58	0	1 | .04	0
Whitewater Ridge, OR	4 | 6.1	11 |5.88	0	4 | 1.73
Obsidian Cliffs, OR	1 | .33	2 | .18	31 | 10.8	8 | .29
Wolf Creek, OR	0	2 | .24	0	0
Quartz Mountain, OR	1 | .29	0	18 | 1.62	0
Newberry Volcano, OR	0	6 | 1.1	6 | .23	15 | 1.05
Glass Buttes, OR	1 | 2.34	0	1 | .09	0
Tule Spring, OR	0	1 | .05	0	0
Timber Butte, ID	3 | 1.54	0	0	0
Unknown	0	2| X[b]	3 | .049	0
Total	**51 | 98.64**	**111 | 77.96**	**58 | 13.21**	**32 | 3.51**

[a]Weight data for Beech Creek is based on a subsample of 95 artifacts, as the data on all of the artifacts was not available.
[b]Weight data not available.
Note: Critical values and p-values for Spearman's r_s and the t-distribution were obtained from Zar (1984).

After looking at artifact counts, we ran the Spearman's Rank test with artifact aggregated weight (Table 7). For each site, an incorporation of all sources present in the study failed to reject the null hypothesis. When we conducted the test on only sources present at each site, the null hypothesis was rejected for the Grissom site, but was accepted for the Sunrise Ridge Borrow Pit, Beech Creek, and Tipsoo Lake sites. As discussed previously, the Grissom site resulted in a moderate, negative correlation, meaning that source representation decreases as source-to-site distance increases. For the other three comparison sites, no correlation was present between artifact aggregated weight and source abundance.

Table 6. Spearman's Rank Analysis Artifact Results for Inter-Site Comparison (Counts)

Spearman Rank Analysis Artifact Count Results: All Sources				
Site	**45-KT-301**	**45-PI-408**	**45-LE-415**	**45-PI-406**
r_s-value	-0.26	0.19	-0.04	-0.07
t-value	-0.96	0.71	-0.15	-0.25
n	15	15	15	15
Degrees of Freedom	14	14	14	14
Critical Value[a] (*a*=.05)	2.145	2.145	2.145	2.145
Bracketing p-values	.2<p>.5	.2<p>.5	.5<p>1	.5<p>1
Null Hypothesis	Failed to Reject	Failed to Reject	Failed to Reject	Failed to Reject
Spearman Rank Analysis Results: Present Sources				
r_s-value	-0.49	-0.26	-0.08	0.60
n	10	6	7	5
Critical Value[b] (*a*=.05)	0.648	0.886	0.786	1.000
Bracketing p-values	.1<p>.2	.5<p>1	.5<p>1	.2<p>.5
Null Hypothesis	Failed to Reject	Failed to Reject	Failed to Reject	Failed to Reject

[a] Determined using the t-test for Pearson's correlation coefficient, suitable for n values greater than 10.

[b] Determined using the critical value table for Spearman's r_s, suitable for n values of 10 or less.

Table 7. Spearman's Rank Analysis Results for Inter-Site Comparison (Aggregated Weight)

Spearman Rank Analysis Artifact Weight Results: All Sources

Site	**45-KT-301**	**45-PI-408**	**45-LE-415**[c]	**45-PI-406**
r_s-value	-0.33	0.14	0.11	-0.05
t-value	-1.27	0.52	0.39	-0.19
n	15	15	15	15
Degrees of Freedom	14	14	14	14
Critical Value[a] (*a*=.05)	2.145	2.145	2.145	2.145
Bracketing p-values	.2<p>.5	.5<p>1	.5<p>1	.5<p>1
Null Hypothesis	Failed to Reject	Failed to Reject	Failed to Reject	Failed to Reject

Spearman Rank Analysis Results: Present Sources

Site	**45KT301**	**45PI408**	**45LE415**[c]	**45PI406**
r_s-value	-0.69	-0.71	-0.14	0.90
n	10	6	6	5
Critical Value[b] (*a*=.05)	0.648	0.886	0.886	1.000
Bracketing p-values	.02<p>.05	.1<p>.2	.5<p>1	p=.1
Null Hypothesis	Rejected	Failed to Reject	Failed to Reject	Failed to Reject

[a] Determined using the t-test for Pearson's correlation coefficient, suitable for n values greater than 10.

[b] Determined using the critical value table for Spearman's r_s, suitable for n values of 10 or less.

[c] Weight data for 45LE415 is based on a subsample of 95 artifacts.

Discussion

Source Diversity at 45-KT-301

As the Grissom site (45-KT-301) is a late-period site, the source diversity and the number of nonlocal sources represented there appears to be quite high (cf. Kassa and McCutcheon 2016), especially when compared to other studies where source diversity seems to decrease and become more localized through time (Mack et al. 2010; Cadena 2012). The immediate area in which the Grissom site is located was documented in the past as a major gathering and trading location for Native American groups and Europeans (Splawn 1917; Schuster 1975; Glauert and Kunze 1976; Swagerty 1988; Ruby and Brown 1995; Shea 2012). The proximity of the Grissom site relative to the location where Alexander Ross (1855) described a Native American encampment in 1814 is unknown, but such a gathering place in the Kittitas Valley could account for an elevated abundance of nonlocal obsidian sources present at the site. Like Kassa and McCutcheon's (2016) findings that sites located at or near tertiary trade centers appear to have a higher diversity of obsidian sources in addition to a greater representation of nonlocal sources, the Grissom site obsidian sample appears to be unusually diverse, which suggests that the site was near, if not at, a tertiary trade center (Swagerty 1988:Figure 1).

Observations of the macroscopic qualities associated with the Grissom site obsidian artifacts suggest that the local tachylyte material has a greater occurrence of inclusions, possibly making this material of lower quality for flint knapping when compared to many of the nonlocal sources. When comparing the relationships between source locality, technology, and source diversity to the findings of Eerkens et al. (2007), we found that the occurrence of local and nonlocal obsidian at the Grissom site is similar to that predicted by Eerkens et al. (2007), with lower source diversity (and primarily local sources) associated with cores and higher diversity (and more nonlocal sources) associated with formed tools. However, we found that a number of the nonlocal flakes were larger in size than expected. Eerkens et al. (2007) predicted that large (greater than 10 mm) flakes will generally have lower source diversity than smaller flakes, and will be primarily local, although this pattern may be altered by factors such as trade and source quality. All of the sourced initial and intermediate flakes from the Grissom site were 15 mm or greater in size, and approximately half of the sourced initial flakes and all of the intermediate flakes were from nonlocal sources. While these results are based on a small sample size, the diversity represented in these large flakes is much higher than expected. The presence of large, nonlocal obsidian flakes may indicate that people were transporting nonlocal obsidian into the Kittitas Valley not only in the form of formal tools, but also as larger pieces of raw material (e.g., Connolly et al. 2015). However, increasing the sample size of sourced obsidian flakes for the Grissom site, specifically smaller flakes, will help elucidate the relative changes in diversity between larger and smaller flake size classes; the very small obsidian flakes may exhibit much higher source diversity than the larger flakes (Eerkens et al. 2007).

Current stratigraphic and chronological evidence makes it clear that the strata at the Grissom site have undergone disturbance. Due to this evidence, we did not attempt to undertake an intensive analysis of change in source distribution through time at the Grissom site, and instead assessed the site as a singular, Late Period temporal unit based on a range of radiocarbon assays (McCombs 2003; Lubinski and Partlow 2011; Vassar 2012). However, the abundance of nonlocal sources, and the high source diversity in general, could support previous research (Galm 1994; Kassa and McCutcheon 2016), which has suggested that source diversity at archaeological sites may increase through time on the Plateau, or at least not show a significant decrease. Additional evidence for an increase in diversity through time at the Grissom site comes from preliminary research on obsidian hydration data at the site. Burris's (2015) submission of 35 obsidian artifacts for obsidian hydration analysis suggests that obsidian source diversity increases through time at the Grissom site, rather than decreasing or staying constant.

Lastly, the correlation tests between distance from source and source abundance produced variable results. For the Grissom site and the three comparison sites, all of the tests run with counts indicated that there was no correlation between distance from a site and source abundance, while the use of aggregated weight produced slightly more varied results, where the null hypothesis was rejected in one instance when the sources actually present at the individual sites were incorporated into the test. The site for which this occurred was the Grissom site, with a moderately strong, negative correlation between source abundance and source-to-site distance. In all, it is clear that distance from a source may not be the primary driver of source distribution at these sites, and that instead there are likely multiple and varied factors influencing obsidian occurrence (e.g., Galm 1994; Quinn 2006; Minor 2013). In the case of the Grissom site, where the counts and weights produce variable results, it is possible that two different mechanisms were at work. While a number of larger, nonlocal obsidian flakes were identified in the Grissom assemblage, the lack of correlation with counts could be caused by people primarily bringing in small, finished tools and subsequently creating small flakes through retouch, both of which do not accumulate very much weight (e.g., Beck et al. 2002; Eerkens et al. 2007), therefore minimizing transport costs but still resulting in a high number of nonlocal artifacts. However, when analyzing the same assemblage through aggregated weight, a correlation between abundance and site-to-source distance could be observed if the material from closer sources appears in larger, heavier chunks more commonly than the nonlocal material (e.g., Renfrew 1977), despite variable frequencies of local and nonlocal artifacts.

Conclusions

Some conclusions can be drawn based on comparing our results to the four previously outlined regional expectations and considering them in terms of selective conditions operating on the Grissom site (45-KT-301) obsidian. The high source diversity and increased nonlocal source presence in bifaces, and the low diversity and localized source presence in cores, falls in line with previous obsidian and lithic source studies' expectations. Some aspects of lithic technology and source distribution at the Grissom site may be reflective of natural selection acting on the procurement and utilization of obsidian. For example, the commonality of impurities within the local obsidian sources, the lack of local sources used in formal tools, and the fact that local sources are primarily present in the form of waste material, may represent selection against less predictable raw materials in favor of higher quality tool stone for formal tool manufacture (Andrefsky 1994; cf. Eren et al. 2014; cf. Kassa and McCutcheon 2016).

From an evolutionary archaeology theory perspective, when variation in the archaeological record does not appear to fall in line with what one would expect in terms of natural selection, horizontal cultural transmission (the movement of contemporaneous ideas) may serve to explain the occurrence of certain neutral traits (Dunnell 1978b; Lipo et al. 2006; Eerkens and Lipo 2007). The Spearmans Rank analyses at the Grissom site and three other sites showed a general lack of correlation between site-to-source distance and source abundance, indicating that distance was not the only mechanism affecting the obsidian source distributions at these sites. The lack of a monotonic decay pattern at these sites could be the result of natural selection, cultural transmission, or both. It may be a result of preferences regarding source quality (i.e., a selective pressure), or could also be the result of horizontal cultural transmission sorting the nonlocal obsidian, possibly through trade routes, relationships between different groups of people, or the movement of people from one geographical location to another. At the Grissom site, the influence of a cultural transmission mechanism is further supported by the occurrence of large, nonlocal flakes within the Grissom site obsidian assemblage, and the relatively high source diversity overall at the site. Patterns of increased source diversity near trade hubs have been observed in areas like the Northern Mid-Columbia River (Kassa and McCutcheon 2016) and The Dalles, the latter of which shows evidence of source diversity decreasing with distance away from a central location (Minor 2013).

While constrained by small sample sizes, research on obsidian source distribution at the Grissom site has resulted in interesting initial results regarding the ways in which past people were accessing and using obsidian resources on the western Plateau culture area. Continued research on the remaining excavation units at the Grissom site will likely yield additional obsidian artifacts, which should be incorporated into further study, thereby increasing the obsidian sample size available for the site. In this way, it may be possible to elucidate further information about source diversity at the Grissom site, and about the ways in which selective conditions were influencing past obsidian source utilization in the Pacific Northwest.

ACKNOWLEDGMENTS

We would like to extend our gratitude to the organizations that have funded this research, including Central Washington University's (CWU) C. Farrell Scholarship for Fine Arts and Research, the CWU College of the Sciences Undergraduate Research Grant, and the Association for Washington Archaeology Undergraduate Research Grant. We would also like to thank Craig Skinner at the Northwest Obsidian Research Laboratory for his excellent analytical work, and for lending his expertise regarding all of our obsidian-related questions. This research would not have been possible without support and assistance from Holly Shea, Rick McClure, Christopher Donnermeyer, and Patrick Lubinski. We also thank Guy Mora, The Confederated Tribes of the Colville Reservation, Jon D. Shellenberger and Kate Valdez, Confederated Tribes of the Yakama Nation, and Rex Buck and Angela Neller, Wanapum Heritage Center, for their comments on the article. While this article was improved by detailed comments from Sonja Kassa, Karissa Terry, JONA editor Darby Stapp, and two anonymous reviewers, any remaining errors are the responsibility of the authors.

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Exploratory Analysis and Significance Testing of the Nez Perce Settlement Patterns Model

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Abstract *This study revisits Schwede's (1970) ethnographic Nez Perce (Nimiipuu) settlement model data using a fresh ensemble of visualization techniques and quantitative methods: 1) The distribution of ethnographic villages and camps with respect to ordinal-scale elevation and stream size-class data is assessed using cumulative proportion plots and the Kolmogorov-Smirnov (K-S) test; and 2) The chi-square (X^2) test is used to examine village and camp settlement distribution with respect to nominal-scale food resource data. Schwede's three settlement research questions are redesigned into testable H_0 hypotheses. The measures of significance provided by the K-S and X^2 tests are used to assess the strength of settlement patterning in order to reject or accept the hypotheses. Many elements of Schwede's ethnographic Nimiipuu settlement model are corroborated by this re-analysis. The additional visualization methods and quantitative techniques reveal subtle details of ethnographic settlement patterning not easily discernible in frequency and percentage tables alone. This re-analysis presents alternative interpretations of the distribution of ethnographic villages and camps with respect to ethnographic food resource areas: village occupations tend to be associated with dual-resource fish and root areas, camps have higher than expected frequencies within single-resource game or root areas, but are most strongly associated with triple-resource (fish, roots, and game) areas, and villages and camps have similar frequency distributions within single-resource fishing areas.*

Introduction

Madge Schwede's (1970) article "The Relationship of Aboriginal Nez Perce Settlement Patterns to Physical Environment and to Generalized Distribution of Food Resources," is one of the seminal publications on ethnographic-period Nez Perce (*Nimiipuu)* settlement. The article has been cited frequently in subsequent publications that address *Nimiipuu* landscape use, to the degree that its conclusions have become nearly axiomatic. As part of Deward E. Walker Jr.'s extensive *Nimiipuu* ethnography project, Schwede's thesis (1966) and article (1970) represent some of the earliest efforts in the Pacific Northwest to apply quantitative techniques to analyze and explore ethnographic data and develop hypotheses of traditional *Nimiipuu* landscape use. All of the data utilized and published by Schwede (1966, 1970) was produced by Dr. Walker's ethnography project. Dr. Walker directly supervised Schwede's field research and thesis project, and directed all of the ethnographic interviews (Walker 2017). Working with Dr. Walker's ethnographic data, Schwede (1970) used a combination of map-based analyses and basic frequency table techniques to develop a trio of *Nimiipuu* ethnographic settlement research question "hypotheses" addressing the distributions of villages and camps and their relationships to environmental variables of elevation, stream size, and food (fish, roots, and game) resource regimes.

Schwede's analysis results consist of tables of numeric counts and derived percentages from which either positive or negative correlation was attributed based on patterning in percentage distribution. Schwede used very basic, but powerful, quantitative techniques to reveal patterns. Re-analysis of the original table data with an ensemble of only slightly more sophisticated visualization and quantitative techniques can provide the researcher with surprising new information, and establish a level of statistical significance for settlement patterning. Accordingly, this article utilizes cumulative proportion data visualization techniques and tests of significance to reanalyze Schwede's settlement pattern research.

This re-analysis of Schwede's published ethnographic data was undertaken as part of the exploratory hypothesis development phase of an ongoing pre-contact archaeological site distribution study of the Lower Snake River and northern Blue Mountains region. Thankfully, archaeological site distribution models can now be developed utilizing a diverse suite of landscape and environmental variables within a GIS environment. This article illustrates one way that additional interpretive and hypothesis-building potential can be found within the tables and appendices of published archaeological and ethnographic literature.

Ethnographic Settlement Data

The 1960s witnessed a florescence of anthropological research within the traditional territory of the *Nimiipuu* people which coincided with significant developments of infrastructure and the eventual damming of the Snake River. During this time, Dr. Deward Walker Jr., of Washington State University, was leading an intensive *Nimiipuu* ethnography project. Dr. Walker directly supervised Schwede's Washington State University Master's thesis research as a part of his large-scale *Nimiipuu* ethnography project. Schwede utilized the research of Chalfant (n.d.), Ray (1962), and Walker (n.d.), as well as information from *Nimiipuu* informant interviews with Elizabeth Wilson, Sam Watters, Sam Slickpoo, and James Miles; individuals who were part of Dr. Walker's ethnography project. Schwede created a data table and assembled a location map of traditional ethnographic *Nimiipuu* villages, camps, and food resource procurement areas. Schwede's ethnographically derived settlement locations should not be confused with archaeological sites, though many ethnographically derived settlement locations do correspond to actual locations of archaeological sites. The settlement location data and associated resource information used in Schwede's study come from early ethnographic accounts and the cultural knowledge of *Nimiipuu* elders.

Schwede (1966, 1970) was able to assemble a list of 295 individual *Nimiipuu* ethnographic settlements. Forty-seven (16%) of the 295 reported *Nimiipuu* settlements could not be mapped and could not be classified as either a village or camp; perhaps only partial details of the localities were preserved in the ethnographic record. Schwede excluded these 47 settlements from analysis. Two hundred and forty-eight (84%) of the 295 settlements were classified into one of two distinct types (village or camp) based on ethnographic *Nimiipuu* concepts of ascribed landscape ownership versus temporary use-ownership (usufruct). Villages (*tewʔyeni·kes*) are geographic places that are considered to be owned by a group even when absent from that place (Walker n.d.; Schwede 1970). Camps (*wi·se·s*) are geographic places that are only controlled by a group that is geographically present and has temporary use-ownership through usufruct (Schwede 1970). This dichotomy of site type is an oversimplification of what must truly be a spectrum of procurement and occupation adaptations to the landscape that has changed over time. Of the 248 classifiable settlements, Schwede (1970) classified 114 as villages and 134 as camps. This ethnographic *Nimiipuu* settlement data is summarized in Table 1.

Table 1. Summary of Ethnographic Nez Perce Settlements from Schwede (1970).

Total Settlements	295
Classified Settlements	248
Village Settlements	114
Camp Settlements	134

Schwede mapped the locations of 248 camp and village settlements and then classified each into an ordinal scale elevation class (500-foot increments). The settlement elevation data was originally derived by averaging the elevation values of contour lines immediately above and below the mapped ethnographic settlement locations (Schwede 1966). While Schwede's published elevation classes are not explicitly mutually exclusive (overlapping by a single digit at each end), they will be considered to be mutually exclusive here for re-analysis. The arbitrary 500-foot increments may have been chosen by Schwede to aid in data processing efficiency, rather than to accurately sample the patterns of occupation distribution. This study is a re-analysis of the original "etic" published data and did not re-sample or re-classify the original *raw* ethnographic data.

Schwede used hand-based "analog" map techniques to establish associations between settlement locations and ordinal size-classes of streams; geographic information system (GIS) and personal computer technology was not yet widely available to anthropologists. All streams within traditional *Nimiipuu* territory were assigned an ordinal size-class ranging from 1 (smallest) to 9 (largest) based on a modified version of Horton's (1945) stream classification (Schwede 1970). Villages and camps were assigned an ordered ordinal stream size-class if they were within one linear mile of the mouth of a stream of that size-class. While not explicitly explained, it is assumed that a larger stream class would be assigned over a smaller stream class when settlements were within the one-mile radius of multiple stream size-class mouths. A total of 184 *Nimiipuu* ethnographic settlements were within one mile of a stream mouth and could be classified into an ordinal stream size-class.

Map procedures were also utilized to develop nominal-scale measures of food resource availability based on ethnographic data. Schwede (1966, 1970) divided the entire traditional *Nimiipuu* territory into a grid of 590 six-mile square units (one map unit roughly equivalent to the size of a 7.5 minute topographic map). Five hundred of the map units (those outside of Washington and Oregon) were assessed for known ethnographic procurement of fish, roots, and game food resources. Forty-six of the 500 map units were identified as ethnographic food resource procurement areas. Schwede classified each of the 46 map units into one of seven mutually exclusive food resource diversity regimes based on ethnographic data. Each of the 46 map units were classified as either a fish procurement area, roots procurement area, game procurement area, fish and roots procurement area, fish and game procurement area, roots and game procurement area, or fish and game and roots procurement area. The fact that different combinations of the same three food resources (fish, roots, and game) define the seven classes can cause confusion with respect to mutual exclusivity. Each six-mile square map unit, and all the ethnographic occupations mapped within it, can only be associated with one of the seven food resource regimes. The seven different mutually exclusive food resource regime classes can be viewed as distinct environmental zones with different combinations of fish, roots, and game available to procure.

Schwede (1970) identified 165 mapped *Nimiipuu* ethnographic settlements within the entire 500 map unit study area. A total of 141 ethnographic settlements (74 villages and 67 camps) were located within the 46 map units with records of ethnographic food procurement data. Each of the 141 ethnographic settlements (74 villages and 67 camps) were classified into one of the seven mutually exclusive food resource regimes based on their positions within the 46 map units.

Hypothesis Testing

Schwede (1970) produced three research question "hypotheses" to address relationships between ethnographic *Nimiipuu* village and camp settlements, environmental variables, and food resource procurement. The research question "hypotheses" are:

1. Village settlements tend to be established at lower elevations, whereas camp settlements may be established at higher elevations.

2. Villages tend to be established near large tributaries, whereas camps tend to be more evenly distributed among the spectrum of stream sizes.

3. The frequency of village and camp settlements in a given region is positively correlated with the number and type of food resources in that region.

Schwede tested these research question "hypotheses" by interpreting patterning within raw data tables of frequencies and percentages. The data visualizations and tests of significance presented in this article represent a fresh analysis of Schwede's (1970) original published data. Schwede's three exploratory hypotheses have been re-developed into testable H_0 hypotheses. Each table provided by Schwede (1970) has been re-worked to efficiently convey data patterns to the reader, and to provide statements of significance with respect to patterning of ethnographic *Nimiipuu* villages and camps.

Schwede's (1970) map-derived elevation zone data and stream size-class data are ordinal scale. Schwede's seven food resource regime classes are nominal-scale and do not have any inherent internal ranking or order. Two different types of significance tests are utilized to examine these differently scaled datasets. In this re-analysis, ordinal scale data (stream size class and elevation zones) is compared using the Kolmogorov-Smirnov (K-S) test (Shennan 1997). The chi-square (X^2) test (Drennan 1996; Shennan 1997) will be used in accordance with its strengths to examine settlement distribution with respect to food resources data that is non-ordered and nominal in scale. The K-S test (ordinal) and X^2 test (nominal) are each used separately to address different questions. The K-S and X^2 tests will provide measures of significance that will be used to assess the strength of settlement patterning and allow us to either reject or accept the redesigned H_0 hypotheses.

The "two-sample" K-S test is a nonparametric test that can compare two empirical continuous distribution samples. The map-derived elevation class and stream-size class associations of camps and villages are empirical continuous distribution samples. The K-S test requires ordinal scale (or higher) data. The K-S test takes advantage of the ordered nature of the ordinal scale by summing cumulative differences in proportion between the continuous distribution samples. The largest difference between the cumulative frequencies ($D_{max_{obs}}$) of the samples is compared to a formula-derived minimum frequency corresponding to the desired level of statistical significance. The K-S test is also appropriate for continuous distribution samples that exhibit bimodal distribution, such as Schwede's ethnographic camp elevation and village and camp stream size distribution data.

The X^2 test is a nonparametric hypothesis testing technique for categorical (nominal) data that utilizes the sum of the squared differences between the observed data and an expected model distribution to assess "goodness of fit." This study utilizes the familiar contingency table format to explore the observed distributions of ethnographic camps and villages within Schwede's nominal scale mutually exclusive food resource areas.

A caveat with respect to the data and variables utilized in this re-analysis should be discussed. This article utilizes only the data that was published by Schwede in 1966 and 1970, and does not use reclassified data from the original raw ethnographic data and maps. The qualities of the original data were not changed by this study; the original variables were not scaled to higher levels of observation. Schwede's utilization of 500-foot elevation intervals and 7.5 minute map analysis units likely did not capture the subtleties of camp and village distribution, and the errors embedded within the original level of observation have been passed into this re-analysis.

An archaeological site distribution study should utilize GIS technology to evaluate a suite of landscape and environmental variables that were not available to the ethnographic project in the 1960s and 1970s. Additionally, the scale of observation for the variables should be developed based on early data exploration, and should integrate ratio and interval data in addition to more detailed ordinal and nominal datasets.

This study is clearly oriented within a quantitative paradigm, and the variables utilized are distinctly "etic" in nature. An ethnographic landscape distribution model based on *Nimiipuu* "emic" variables would be exceptionally interesting. The stream-size classes used by Schwede and this re-analysis are clearly not size classes that were ever used by the *Nimiipuu.* The ordinal variables used in this study are clearly "etic" in nature. "Camps vs. villages" is an "etic" ordinal dichotomous variable. Dichotomous variables are quite flexible, and can be used as nominal variables, ordinal variables, or sometimes even interval variables (there is one interval between them). The camp and village ethnographic occupation localities were differentiated by their respective levels of tribal exclusivity (usufruct); each locality was ranked by the Nez Perce informants with respect to the level of "use-right." Villages are highly exclusive to affiliation, while camps are minimally exclusive to affiliation; the scale between the levels is not clearly defined.

Elevation

Schwede classified 248 settlements into 13 ordinal elevation zones. Revisualization of Schwede's (1970) elevation data as a bar chart allows visual interpretation of the distribution. Figure 1 is a bar chart illustrating the distribution of villages and camps within the 13 ordinal elevation zones. Figure 1 clearly illustrates a distinct peak in village frequency between 500 and 1000 ft. in elevation, and a nearly equal frequency distribution of villages and camps between 1000 and 1500 ft. Additionally, Figure 1 shows a bimodal distribution of ethnographic camps; there are two peaks in camp frequency within the 1000–1500 ft. and 3000–3500 ft. elevation zones. The bar chart (Figure 1) illustrates the fact that there are no ethnographic villages located above 4000 ft. in elevation.

Schwede interprets the elevation data using cumulative percentages of villages and camps below and within elevation thresholds. The 1970 analysis consists of several direct observations of sample proportion, highlighting the facts that 98% of villages are located below 2500 ft. in elevation, and that the majority (54%) of camps are located higher in elevation between 2500 and 6500 ft.

A redesign of Schwede's elevation "hypothesis" allows us to use the K-S test to compare the cumulative frequency distributions of villages and camps classified into ordered ordinal elevation classes. Specifically, by making the H_0 hypothesis assumption that villages and camps represent samples from identical populations, we can determine if the differences in their distribution within elevation zones may be the result of chance variation in sampling. Accordingly, Schwede's first hypothesis has been modified into a testable null hypothesis:

> H_0: There is no difference in the distribution of villages and camps across elevation zones.

Table 2 is the cumulative frequency table of Schwede's (1970) elevation data that was constructed to perform the K-S test. Figure 2 is a cumulative proportion plot derived from Table 2 that graphically illustrates the most pronounced differences between villages and camps with respect to elevation zones. In Figure 2, elevation "1" corresponds to the lowest 0–500 ft. elevation zone, and elevation "13" corresponds to the highest 6000–6500 ft. elevation zone.

The cumulative proportion plot (Figure 2) succinctly illustrates the differences between village and camp elevation distributions that Schwede (1970) had presented solely in table form. Figure 2 allows us to directly observe how the proportions of villages and camps differ within the elevation zones. The peak in the frequency of camps between 2500 and 3500 ft. illustrated so distinctly in Figure 1 appears almost insignificant in Figure 2, where the differences in village proportion above and below 2500 ft. (#5 in the Figure 2 elevation scale) are the most visually striking plot feature. Figure 2 suggests that there is a relatively even distribution of camps across elevation

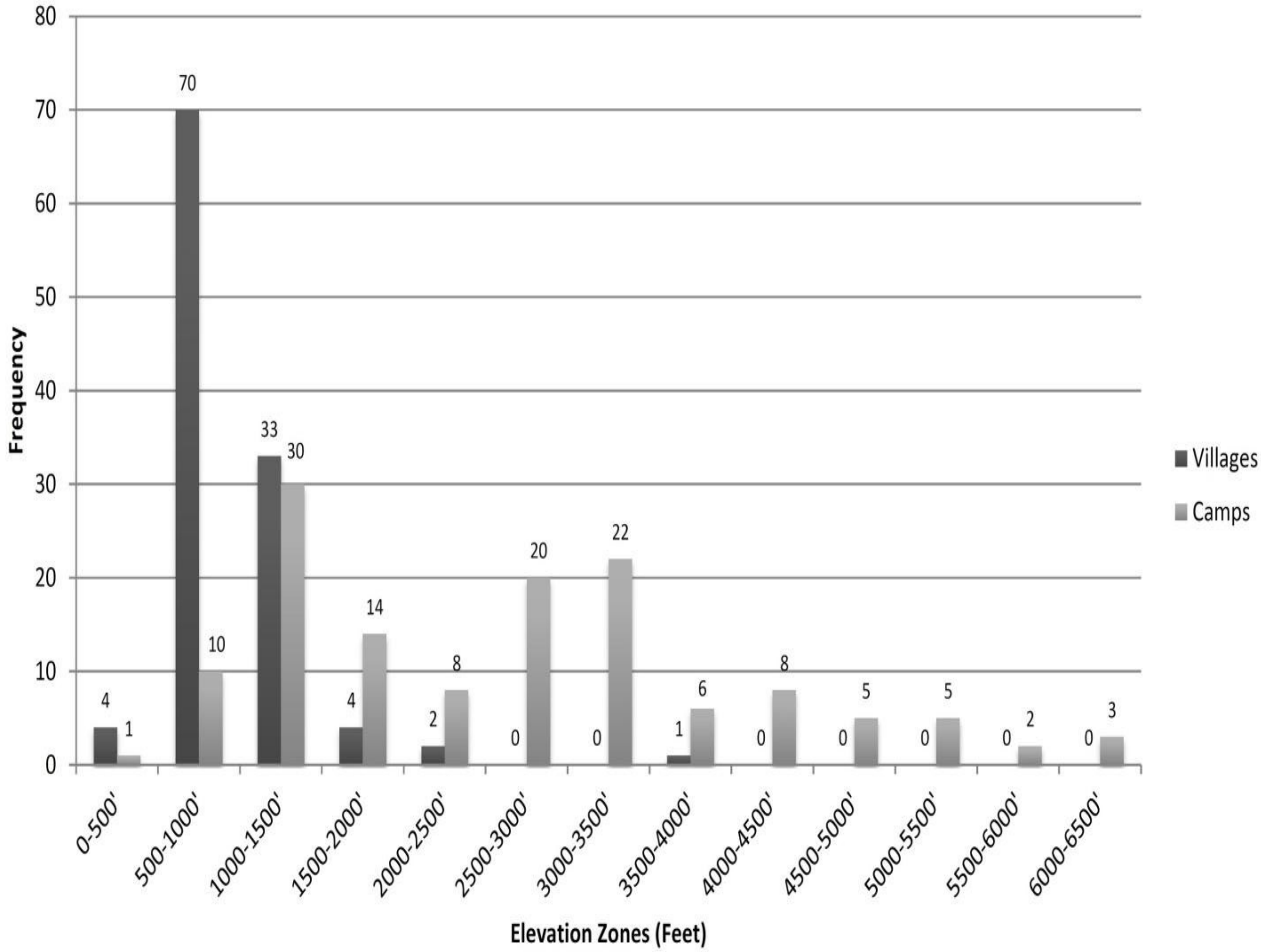

Figure 1. Bar chart of villages and camps within ordinal elevation zones.

zones and a very pronounced skew towards low-elevation villages. The differences illustrated by the cumulative proportion plot suggest that there probably is a significant difference between the distribution of villages and camps within ordinal elevation zones.

The cumulative frequency table of villages (N = 114) and camps (N = 134) within ranked ordinal elevation zones (Table 2) produced by this study was used to derive the observed maximum difference ($D_{max_{obs}}$) of 0.632626. The K-S test was used to determine that the minimum required difference for H_0 to be rejected at the .001 Level of significance ($D_{max_{0.001}}$) is 0.248459511. The observed maximum difference is larger than the minimum required, indicating that we can reject H_0 at a .001 level of significance. There is a difference between the distribution of villages and camps within elevation zones. The result of this significance test supports Schwede's assertion that there is a difference between village and camp settlement with respect to elevation. The difference appears to be primarily related to the tendency for villages to

Table 2. Cumulative Frequency Table of Villages and Camps Within Ranked Ordinal Elevation Zones.

Elevation Zone (ft)	Villages	Villages %	Villages Cumulative %	Camps	Camps %	Camp Cumulative %	Cumulative Difference
0-500	4	0.035088	0.035088	1	0.007463	0.007463	0.027625
500-1000	70	0.614035	0.649123	10	0.074627	0.08209	0.567033
1000-1500	33	0.289474	0.938597	30	0.223881	0.30597	**0.632626**
1500-2000	4	0.035088	0.973684	14	0.104478	0.410448	0.563236
2000-2500	2	0.017544	0.991228	8	0.059701	0.47015	0.521079
2500-3000	0	0	0.991228	20	0.149254	0.619403	0.371825
3000-3500	0	0	0.991228	22	0.164179	0.783582	0.207646
3500-4000	1	0.008772	1	6	0.044776	0.828358	0.171642
4000-4500	0	0	1	8	0.059701	0.888059	0.111941
4500-5000	0	0	1	5	0.037313	0.925372	0.074628
5000-5500	0	0	1	5	0.037313	0.962685	0.037315
5500-6000	0	0	1	2	0.014925	0.97761	0.02239
6000-6500	0	0	1	3	0.022388	1	
Total	114			134			

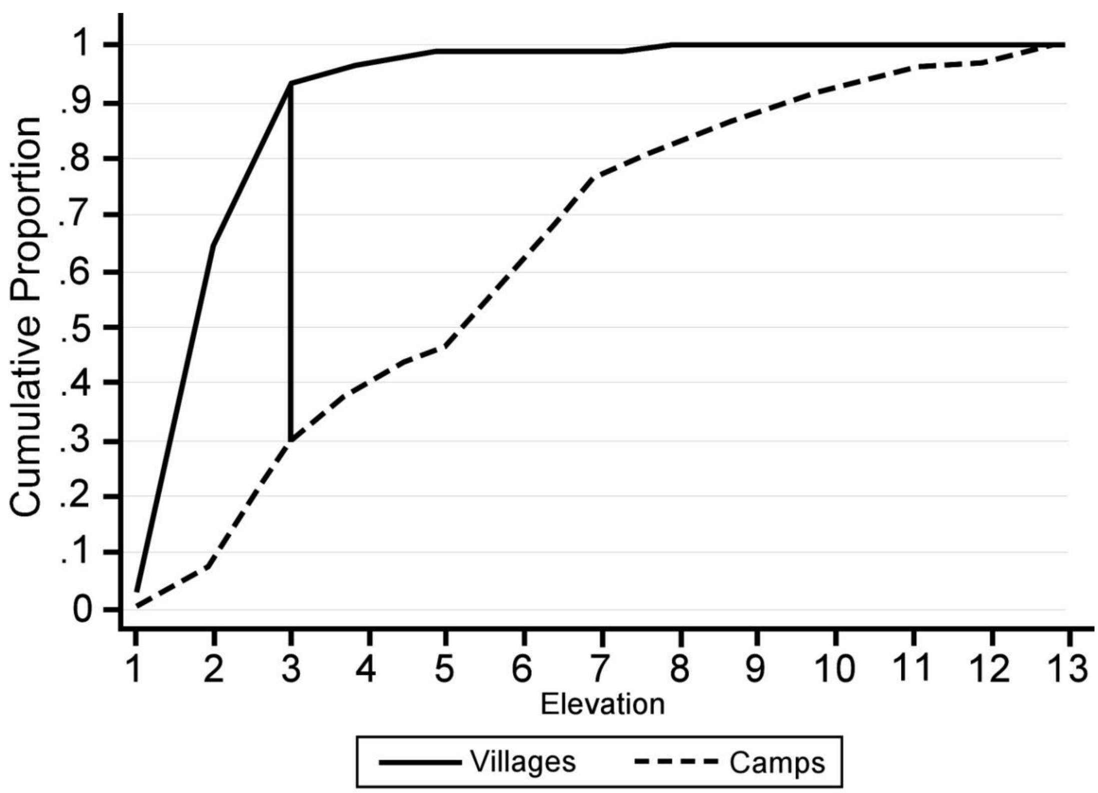

Figure 2. Cumulative proportion plot of villages and camps within elevation zones.

be located in lower elevations. This analysis does not confirm Schwede's "hypothesis" that camps are preferentially established at higher elevations. This analysis shows that camps are fairly evenly distributed across elevation zones. In contrast to Schwede's data interpretation, a slight skew in proportion (Figure 2) may actually suggest that camps tend to be established more frequently in lower elevations than in higher elevations.

Stream Size

The 184 village and camp settlements located within one linear mile of a stream mouth were classified into ranked ordinal stream size-classes with 1 as the smallest and 9 as the largest. The analysis of frequencies and percentages led Schwede (1970) to conclude that camps are more widely dispersed throughout the different stream classes than villages, and that villages are associated with larger tributaries. We can again develop a H_0 hypothesis based on Schwede's work that can be evaluated with a K-S test. The reworked stream size null hypothesis is:

> H_0: There is no difference in the distribution of villages and camps across stream size-classes.

We may then construct a cumulative frequency table, create a cumulative proportion plot, and generate the observed maximum difference to compare with a K-S test.

Table 3 is the cumulative frequency table of Schwede's (1970) stream size-class data. Table 3 shows a potential bimodal distribution of camps within the stream size classes. Figure 3 is a cumulative proportion plot derived from Table 3 that graphically illustrates the most pronounced differences in proportion between villages and camps with respect to stream size-class. The cumulative proportion plot of villages and camps within stream size-classes (Figure 3) illustrates the fact that the greatest differences between the proportions of villages and camps exist in the middle range of stream size-classes. This trend was not observed in the results of the original study. Schwede (1970) hypothesized an even distribution of camps through the stream classes with a preference for villages to be associated with large stream classes. Figure 3 illustrates the fact that the maximum observed distance ($D_{max_{obs}}$) between camps and villages exists within the middle stream size-classes rather than towards the large size-class.

The cumulative frequency table of villages (N = 97) and camps (N = 87) within ranked ordinal stream size-classes (Table 3) was used to derive the observed maximum difference ($D_{max_{obs}}$) of 0.3075009. The K-S test was used to determine that the minimum required difference for H_0 to be rejected at the .001 level of significance ($D_{max0.001}$) is 0.28793737. The observed maximum difference is larger than the minimum required indicating that we can reject H_0 at a .001 level of significance. The test results indicate there is a difference between the distribution of villages and camps within stream size-classes. This test supports Schwede's assertion that there is a difference between village and camp settlement with respect to stream size-class. The re-analysis also generally supports Schwede's "hypothesis" that camps are evenly distributed or associated with medium and large stream size-classes (6–8) while villages are primarily associated with large stream classes. This re-analysis showed that the greatest cumulative difference in proportions between villages and camps exists between the midsized stream classes rather than the large or small stream classes. Smaller stream size-classes had higher cumulative proportions of camps than villages.

It is critical to note that there are significant differences between Schwede's 1966 and 1970 stream size-class analyses. The thesis document (Schwede 1966) used a sample of only 89 settlements (49 villages and 40 camps), while the article (Schwede 1970) used a sample of 184 settlements (97 villages and 87 camps). The preceding K-S test utilized the larger 1970 data sample. While no explanation for this difference is provided by Schwede (1970), communication with Dr. Deward Walker, Jr., (Personal Communication 2011) revealed that the most likely explanation was that only a fraction of the stream size classifications had been completed in 1966, and that far more settlements had been hand-classified using analog map techniques by 1970. The ordinal stream class variable was derived using hand/ruler map techniques that were likely even more tedious and time-consuming to use than our millennial-era GIS data processing toolboxes. Additionally, another difference deserving of note is the subtle difference in the river size-classes between 1966 and 1970. The 1966 analysis utilized eight stream class sizes, while the 1970 analysis used nine. This procedure does not appear to have altered the results of the analysis, as ultimately only one camp was added to the 1970 sample associated with the newly added largest stream class.

The differences between the Schwede 1966 and 1970 hydrology datasets become more important when one learns that the two samples exhibit very different village and camp distributions with respect to stream size-class. In fact, the results of the 1966 (thesis) sample K-S test do not allow H_0 to be rejected. This is the *opposite*

Table 3. Cumulative Frequency Table of Villages and Camps within Ranked Ordinal Stream Size Classes.

Stream Size	Villages	Villages %	Villages Cumulative %	Camps	Camps %	Camp Cumulative %	Cumulative Difference
2	0	0	0	3	0.0344828	0.03448276	-0.0344828
3	4	0.04123711	0.041237	6	0.0689655	0.10344828	-0.0622112
4	4	0.04123711	0.082474	9	0.1034483	0.20689655	-0.1244223
5	8	0.08247423	0.164948	21	0.2413793	0.44827586	-0.2833274
6	1	0.01030928	0.175258	3	0.0344828	0.48275862	**-0.3075009**
7	38	0.39175258	0.56701	33	0.3793103	0.86206897	-0.2950587
8	42	0.43298969	1	11	0.1264368	0.98850575	-0.0114943
9	0	0	1	1	0.0114943	1	
Total	97			87			

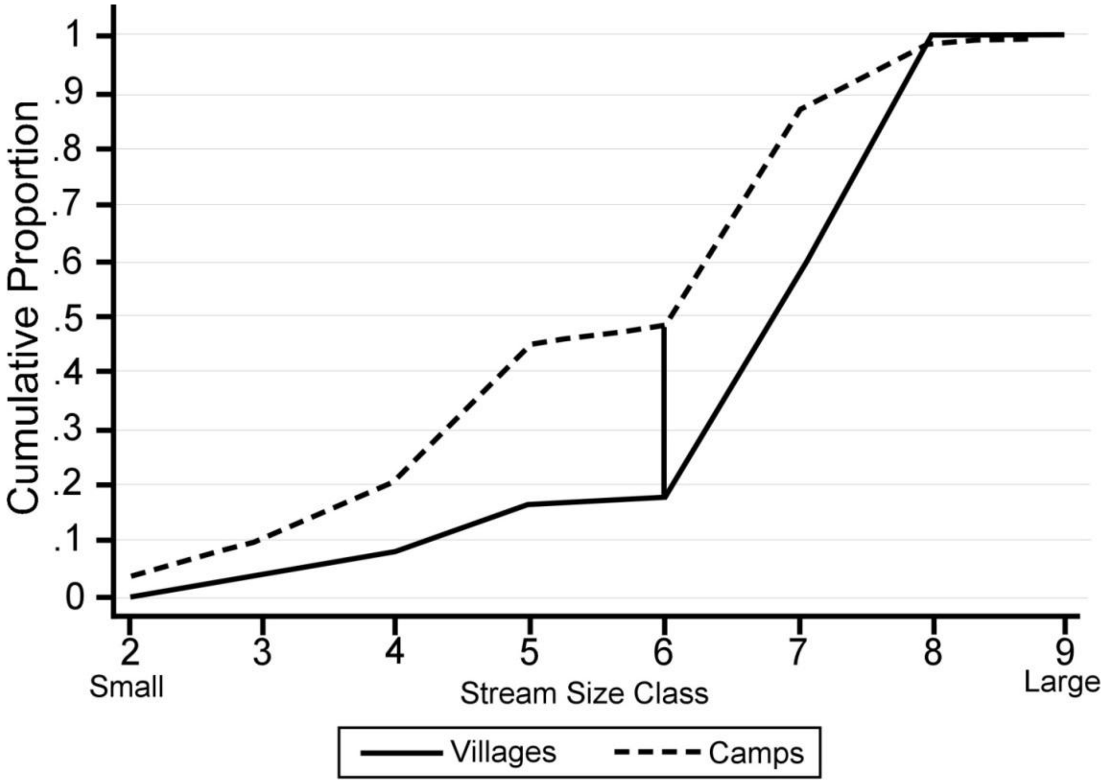

Figure 3. Cumulative proportion plot of villages and camps within stream—size classes.

result of the 1970 (article) sample test (Table 3). The 1966 (thesis) sample's observed maximum difference ($D_{max_{obs}}$) of 0.081633 is smaller than the minimum required ($D_{max_{0.05}}$) 0.289805 at a .05 level of significance. There is no difference in the distribution of villages (N = 49) and camps (N = 40) with respect to stream size if the smaller 1966 (thesis) sample is tested. Table 4 is the cumulative frequency table of Schwede's 1966 (thesis) stream size-class data. Figure 4 is a cumulative proportion plot derived from Table 4 that graphically illustrates the striking similarities of village and camp distributions within the smaller 1966 (thesis) sample. Nearly doubling the size of the sample between 1966 and 1970 changed the results.

Food Resources

A comparison of the distribution of settlements within Schwede's (1970) six-mile square area that have ethnographic reports of food exploitation (141), and those within six-mile square areas that do not have ethnographic reports of food exploitation (24), reveals a very strong association between settlements and food resource availability. Indeed, people stayed where there was food. A null hypothesis for this basic trend is:

> H_0: There is no difference in the distribution of villages and camps between areas that had ethnographic food procurement, and areas that did not have ethnographic food procurement.

Table 4. 1966 Sample Cumulative Frequency Table of Villages and Camps within Ordinal Stream Size Classes.

River Size	Villages	Villages %	Village Cumulative %	Camps	Camps %	Camp Cumulative %	Cumulative Difference
2	0	0	0	1	0.025	0.025	-0.025
3	3	0.0612245	0.0612245	3	0.075	0.1	-0.038776
4	4	0.0816327	0.1428571	2	0.05	0.15	-0.007143
5	8	0.1632653	0.3061224	8	0.2	0.35	-0.043878
6	0	0	0.3061224	1	0.025	0.375	-0.068878
7	30	0.6122449	0.9183673	25	0.625	1	**-0.081633**
8	4	0.0816327	1	0	0	1	0
Total	49			40			

Table 5 is this study's contingency table with associated X^2 test results. The X^2 test results show that the null hypothesis cannot be rejected. There is no difference in the distribution of villages and camps with respect to ethnographically reported food procurement (Pearson X^2 (1) = 0.3630, Pr = 0.547). There is little doubt that this positive correlation between settlement and food resources availability would be corroborated through analysis of archaeological site distribution and food resource density.

Having established a definitive relationship between food availability and settlement using simple percentage comparison, Schwede (1970) cautions that the actual relationships between food resource availability and settlement locations are likely far from simple. Resorting again to interpretation of data tables with frequency and percentage information, Schwede addresses the third "hypothesis" regarding the distribution of villages and camps with respect to seven mutually exclusive fish, roots, and game food resource regimes. Schwede (1970) created three tables within one, comparing the frequencies of villages and camps within six-mile square areas with seven different combinations of ethnographically reported harvestable food resources. The settlement frequencies associated with the seven mutually exclusive food resource regimes (six square mile ethnographic zones with combinations of fish, roots, and game resources) are presented in Schwede's (1970) Table 4 (not illustrated

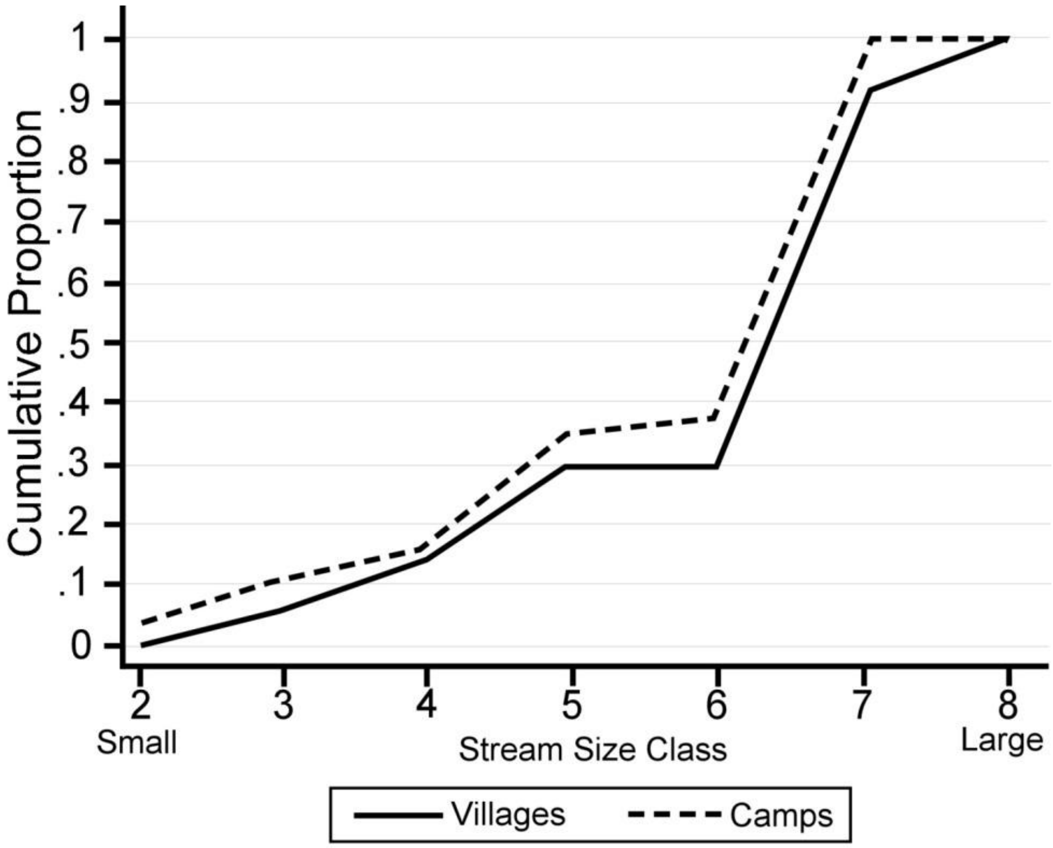

Figure 4. 1966 sample cumulative proportion plot of villages and camps within stream size classes.

here). The frequency percentages associated with Schwede's table had been used to interpret basic patterns in the raw data. Schwede's (1970) analysis asserts that villages tend to be found most often associated with fishing areas rather than root gathering areas, and least with game resource areas. In the 1970 study, camps are reported to be strongly associated with fishing, but are interpreted to be more frequently found in association with root gathering or hunting areas (Schwede 1970). Schwede's ultimate conclusion in regard to the third "hypothesis" is that fishing is the most determinative factor in respect to settlement because the highest frequencies of villages and camps are associated with ethnographic fishing areas. Root areas and game areas follow behind as the second and third strongest determinative factors in the 1970 analysis.

This article uses the exact same data, but approaches the third "hypothesis" in a different way using 2 x 7 and 2 x 6 contingency tables and X^2. Table 6 compares the distribution of villages and camps within the seven mutual exclusive nominal-scale classes of food resource procurement areas (regimes). The Table 6 nominal-scale food resource procurement regime classes represent the seven possible combinations of fish, roots, and game resources. Each ethnographic village or camp had been grouped by Schwede into only one food resource regime class based on their positions within the map grid. The fact that Table 6 shows no ethnographic villages within "game-only" resource areas and 12 villages within "fish and game" resource areas illustrates the principle of mutual exclusion between the distinct areas. "Fish and game" and "game" areas are distinct localities that never overlap.

Table 5. Contingency Table and X^2 Test Results of Settlement and Food Resource Exploitation

	Villages	Camps	*Total*
Ethnographic record of Food Exploitation	74	67	141
expected	72.6	68.4	141
X^2 *contribution*	0	0	0.1
No Ethnographic record of Food Exploitation	11	13	24
expected	12.4	11.6	24
X^2 *contribution*	0.2	0.2	0.3
Total	85	80	165

Pearson X^2 (1) = 0.3630 Pr = **0.547**

likelihood-ratio X^2 (1) = 0.3630 Pr = 0.547

Cramér's V = 0.0469

gamma = 0.1324 ASE = 0.218

Kendall's tau-b = 0.0469 ASE = 0.078

Fisher's exact = 0.660

1-sided Fisher's exact = 0.351

This study developed a new null hypothesis to test:

H_0: There is no difference in the distribution of villages and camps with respect to food resource areas.

A X^2 test of the 2 x 7 contingency table (Table 6) resulted in a Pearson X^2 value of 37.5138 with 6 degrees of freedom and Pr = 0.000. The null hypothesis is rejected. There is a difference in the distribution of villages and camps with respect to resource procurement areas. A closer examination of the differences between the observed and expected frequencies and X^2 contributions in Table 6 reveals that there are more camps than expected in procurement areas with all three (fish, root, and game) resources available. This is not at all surprising given the fact that the raw contingency table indicates no (0) observed villages and 16 observed camps in the triple-resource (fish, root, and game) food resource regime areas (Table 6). There are far more villages than expected in food resource areas with both fish and root resources available, and far fewer camps than expected in these areas. It should not be surprising that there would be high numbers of "owned" villages in such potentially productive food resource areas. Map units with the single available food resource of game have more observed camps than expected, and fewer villages than expected. Single-resource procurement areas with either fish or roots had nearly equal distributions of villages and camps, as did double-resource areas with both fish and game, or roots and game. The double-resource combination of fish and roots appears to be the most predictive resource condition for the presence of villages, rather than fishing alone as suggested by Schwede (1970). Single-resource fish areas have very similar distributions of ethnographic villages and camps.

Table 6. 2 x 7 Contingency Table and χ^2 Test Results of Settlement and Food Resources Diversity.

	Villages	Camps	*Total*
Fish	25	19	44
expected	23.1	20.9	44
χ^2 *contribution*	0.2	0.2	0.3
Roots	8	13	21
expected	11	10	21
χ^2 *contribution*	0.8	0.9	1.7
Game	**0**	**4**	4
expected	**2.1**	**1.9**	4
χ^2 *contribution*	2.1	2.3	4.4
Fish and Roots	**29**	**7**	36
expected	**18.9**	**17.1**	36
χ^2 *contribution*	5.4	6	11.4
Fish and Game	12	7	19
expected	10	9	19
χ^2 *contribution*	0.4	0.5	0.9
Roots and Game	0	1	1
expected	0.5	0.5	1
χ^2 *contribution*	0.5	0.6	1.1
F, R, & G	**0**	**16**	16
expected	**8.4**	**7.6**	16
χ^2 *contribution*	8.4	9.3	17.7
TOTAL	74	67	141

Pearson χ^2 (6) = 37.5138 Pr = **0.000**

likelihood-ratio χ^2 (6) = 46.5578 Pr = 0.000

Cramér's V = 0.5158

gamma = -0.0860 ASE = 0.116

Kendall's tau-b = -0.0567 ASE = 0.076

The χ^2 test was performed a second time on a 2 x 6 contingency table with the triple resource map units (fish, roots, and game) removed from consideration (Table 7). Triple resource areas have an obvious and significant difference in village (0) and camp (16) frequency distribution. It is possible that the triple resource χ^2 contribution may be obscuring subtle differences in settlement distribution within the other six food resource regime classes. A χ^2 test of the 2 x 6 contingency table (Table 7) resulted in a Pearson χ^2 value of 18.1514 with 5 degrees of freedom and Pr = 0.003. Indeed, Table 7 illustrates the same distributional trends as Table 6, but the observed distribution of camps in single-resource root areas is noticeably higher than the expected frequency. This is reflected in the cell's χ^2 contribution. Table 7 shows that villages were preferentially established within double-resource fish and roots procurement areas, while camps were preferentially created within single-resource

Table 7. 2 x 6 Contingency Table and χ^2 Test Results of Settlement and Trimmed Food Resources Diversity.

	Villages	Camps	*TOTAL*
Fish	25	19	44
expected	26	18	44
χ^2 *contribution*	0	0.1	0.1
Roots	8	**13**	21
expected	12.4	**8.6**	21
χ^2 *contribution*	1.6	2.3	3.9
Game	**0**	**4**	4
expected	**2.4**	**1.6**	4
χ^2 *contribution*	2.4	3.4	5.8
Fish and Roots	**29**	**7**	36
expected	**21.3**	**14.7**	36
χ^2 *contribution*	2.8	4	6.8
Fish and Game	12	7	19
expected	11.2	7.8	19
χ^2 *contribution*	0.1	0.1	0.1
Roots and Game	0	1	1
expected	0.6	0.4	1
χ^2 *contribution*	0.6	0.9	1.5
TOTAL	74	51	125

Pearson χ^2 (5) = 18.1514 Pr = **0.003**
likelihood-ratio χ^2 (5) = 20.4685 Pr = 0.001

Cramér's V = 0.3811

gamma = -0.1210 ASE = 0.137

Kendall's tau-b = -0.0753 ASE = 0.086

procurement areas with either roots or game. Camps are most strongly associated with triple resource (fish, roots, game) procurement areas (Table 6) that are not included within the Table 7 contingency table.

Conclusions

Cumulative frequency tables and cumulative proportion plots were used to explore the distributions of ethnographic *Nimiipuu* villages and camps within ordered ordinal scale classes of elevation and stream size. Schwede's first two core settlement model research question "hypotheses" were re-formed into testable null hypotheses, and evaluated utilizing K-S significance testing. Schwede's third core settlement model "hypothesis" was also reworked into a null hypothesis and tested by creating 2 x 7 and 2 x 6 contingency tables of nominal-scale food resource classes. This allowed us to explore and evaluate the significance of village and camp distributions using χ^2.

This re-analysis supports Schwede's (1970) assertion that there is a difference between village and camp settlement patterns with respect to elevation. Villages have a strong tendency to be located in lower elevations. Schwede's (1970) "hypothesis" that camps are preferentially established at higher elevations was not corroborated by this study. Camps are fairly evenly distributed across elevation zones and may actually tend to be established more frequently in lower elevations than in higher elevations.

This re-analysis supports Schwede's (1970) assertion that there is a difference between village and camp settlement with respect to stream size. Camps are distributed throughout the stream class sizes and exhibit a slight preference to medium and large streams. Villages are primarily associated with large stream classes. The greatest cumulative difference in proportions between villages and camps exists between the midsized stream classes, rather than the large or small stream classes. Smaller stream size-classes have higher cumulative proportions of camps than villages.

This re-analysis provides a set of alternative conclusions to the third "hypothesis," which addresses the distribution of villages and camps in relation to seven different food resource procurement regimes within the *Nimiipuu* landscape. This study's analysis highlighted the significant tendency for villages to be associated with double-resource fish and roots procurement areas. This significant and interesting trend was not revealed by Schwede's table-based analysis. Camps are most strongly associated with triple-resource (fish, roots, and game) food resource areas, and also tend to have higher than expected frequencies within single-resource game or roots areas. Villages and camps have similar frequency distributions within single-resource fish areas. Similar distributions of villages and camps also occur within double-resource procurement areas that have fish with game, or roots with game. While containing the highest frequencies of settlements, single-resource fish procurement areas exhibit an even distribution of villages and camps.

This re-analysis required very little modification of the data tables provided in Schwede's (1970) publication. In one case, even the published table structure was maintained and incorporated into a contingency table for purposes of significance testing. Simple bar charts and cumulative proportion charts allowed Schwede's data to be displayed in ways that highlighted obvious patterns and revealed less obvious trends that were difficult to detect within frequency and percentage tables.

Schwede's article represents one of the first applications of quantitative methods to *Nimiipuu* region settlement modeling. This re-analysis utilized statistical procedures and data visualizations that were only rarely seen in Plateau anthropological literature prior to the infusion of social and biological scientific techniques introduced by ecological and processualist anthropologists in the 1970s and 1980s. The number of archaeological sites identified in the Snake River watershed landscape has grown significantly since 1970 thanks in-part to ongoing archaeological surveys of federal lands mandated by Section 106 of the National Historic Preservation Act of 1966. There is now a large sample of pre-contact and ethnographic period archaeological sites in the Snake River region. The fundamental trends in *Nimiipuu* ethnographic settlement patterning have been quantitatively explored and a set of hypotheses have been tested. This same set of hypotheses, as well as fresh hypotheses, can be further explored and tested with multivariate techniques and GIS software using a diversity of ethnographic, archaeological, and environmental data.

ACKNOWLEDGMENTS

Thank you to Dr. Deward E. Walker, Jr., Bob and Lillian Ackerman, Colin Grier, and Galen Leonhardy for reading and commenting on early drafts of this paper. *Qe 'ci 'yéw 'yew* to the *Nimiipuu* elders and families who shared the traditional cultural knowledge this re-analysis is based on.

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Ancient Artifact or New Age Totem: Analysis of a Carved Sacrum from the Oregon Coast

Dennis G. Griffin

Abstract *In 2009, a large animal bone was found floating in a tidal pool on the central Oregon coast. The bone appeared quite old and had been modified to look like the head of an animal, with garnets inset as "eyes." The antiquity of the object was in question, whether it represented an archaeological artifact that had eroded from a nearby shell midden, or a New Age totem-like carving more recently deposited. Several lines of scientific enquiry were sought to determine the origin and antiquity of the object including: comparative faunal analysis to determine the species of the bone, ^{14}C radiocarbon dating, X-ray fluorescence analysis (XRF) to source the origin of the garnet used as an eye, microspectroscopy to source the composition of the glue used to adhere the garnet to the bone, and an electron microscope and stereoscopic microscope to identify the tool used to create the "eye sockets."*

Introduction

Following a storm in February 2009, a couple from Florence, Oregon, Mary and Chris Nichols, discovered a large bone floating in a tidal pool along the central Oregon coastline. Turning the bone over they noted that the bone had been carved in the shape of an animal head with a gem forming what appeared to be one of the animal's eyes (Figure 1). Seeking information on its antiquity and use, they contacted the Oregon State Historical Preservation Office (SHPO) to see if it belonged to a local native tribe. This article outlines the more than four-year-long investigation to discover if this bone carving represented a unique Native American artifact that eroded from a nearby shell midden or something more like a New Age carving.

Bone Provenance

The bone, measuring approximately 15 cm x 9 cm x 8.5 cm in size, was discovered along a stretch of coastline having two prehistoric sites located within one quarter mile. Site 35-LA-1271, located 15 meters above the beach and less than 100 meters from the tidal pool where the artifact was discovered, consists of an approximately 30-cm-thick shell midden comprised of California mussel, barnacles, and charcoal (Tasa and Bland 2003). The site has never been archaeologically tested and its age remains unknown. If the bone had eroded from this site and fallen to the beach, it could have easily been transported by the tide to the site of the discovery.

A quarter mile to the north of the tide pool site, 35-LA-8, a very large midden site with an over one-meter-thick exposure comprised primarily of California mussel and charcoal with an age of 1180 ± 410 RYBP, is eroding from the cliff (Tasa and Bland 2003). If the bone eroded from this shell midden it would likely have ended up on a large earthen slump area, located directly below the midden. It is difficult to account for the bone ending up on the beach where it was discovered without it being transported by a carnivore, which would likely have left marks from such transportation. Site 35-LA-1271 represents a more likely prospect as its place of origin if the bone arrived on the beach from natural erosion. Upon examination of the exposed midden using binoculars, no bones of any kind were visible within the midden or have ever been noted from this site.

Figure 1. Photograph of the sacrum bone discovered on central Oregon coast.

Initial Identification and Consultation with Tribes

The discovered bone was recognized as being that of a large sacrum from an animal of unknown age or species. While the bone appeared to be very old and weathered, little evidence of human modification could be seen on the bone except for some definite minor carving around two of the sacral foramina; these had been enlarged and a large naturally faceted garnet had been glued within at least one of the foramen. The other foramen showed evidence of being carved as well, along with small fragments of some type of glue attached to the edges of the foramen, but whatever had been inset into this "socket" was missing when discovered. To date, the author could find no information of any other bone being found in an archaeological context in North America that had a gem inset within it. If this sacrum bone represented an artifact from a nearby archaeological site, it could be the first apparent bone effigy discovered in North America that had an inset gem.

With the discovery of the modified bone, SHPO contacted the state's four coastal tribes to determine which tribe considered this area to be their primarily ancestral lands, and if this bone was similar to anything they were familiar with. Representatives from the Confederated Tribes of the Siletz Reservation, Confederated Tribes of the Grand Ronde Community, Confederated Tribes of the Coos, Lower Umpqua and Siuslaw, and the Coquille Tribe examined the artifact and none had ever seen or heard of anything similar. The Tribes agreed that the area of the discovery was within the ancestral territory of the Confederated Tribes of the Siletz Reservation, therefore consultation regarding the bone was coordinated with Robert Kentta, the Siletz Tribe's Cultural Heritage Director. While the bone looked quite old in appearance, the unique nature of the artifact suggested that it may be modern. With the permission of the Siletz Tribe, the SHPO began to consult with scientists from throughout the region in order to determine the nature of the discovered bone.

History of the Sacrum Bone

The sacrum bone is a large, triangular bone located at the base of the spine at the back of the pelvic cavity where it is located between the two hip bones connecting to the last lumbar vertebra and the coccyx (tailbone). In English the word *sacrum* dates to the eighteenth century and is derived from the Latin *os sacrum*, which is a translation of the Greek *hieron osteon* meaning 'sacred bone' from the belief that the soul resides in it, and as such, it was frequently used in animal sacrifice (Stross 2007).

In searching for similar discoveries of carved sacrum bones in North America, only one example was identified and that was of a carved camel sacrum found in 1870 by Mariano Barcena, approximately 67.5 km (42 miles) north of Mexico City (Figure 2). The discovery was made at a depth of 12 meters below surface in Pleistocene deposits. A similarity of geological deposits in the area of the discovery has later been used to suggest an age of 11,000 to 12,000 years BP for the bone (De Anda 1965:271).

Figure 2. Head of animal carved from extinct camelid found in 1870 in Mexico. (Photograph by Jorge Perez de Lara)

Methods

In examining the bone five main areas of research were identified that would help clarify the bone's origin and human alteration. These included identifying 1) the species of the animal to which the sacrum belonged; 2) the age of the bone; 3) the source of the garnet used as the "eye" of the figure; 4) the tool used to enlarge the sacral foramina; and 5) the type of glue used to adhere the garnet to the bone. Each of these lines of evidence are presented below.

Species Identification

In order to identify the animal species to which the sacrum belonged, comparative examples were sought from major faunal collections at Pacific Northwest universities and museums, in addition to reaching out for assistance from zooarchaeologists from across the United States. A 3-D model and video (Figure 3) of the sacrum was created to assist zooarchaeologists who were not able to examine the bone itself in identifying the possible species.

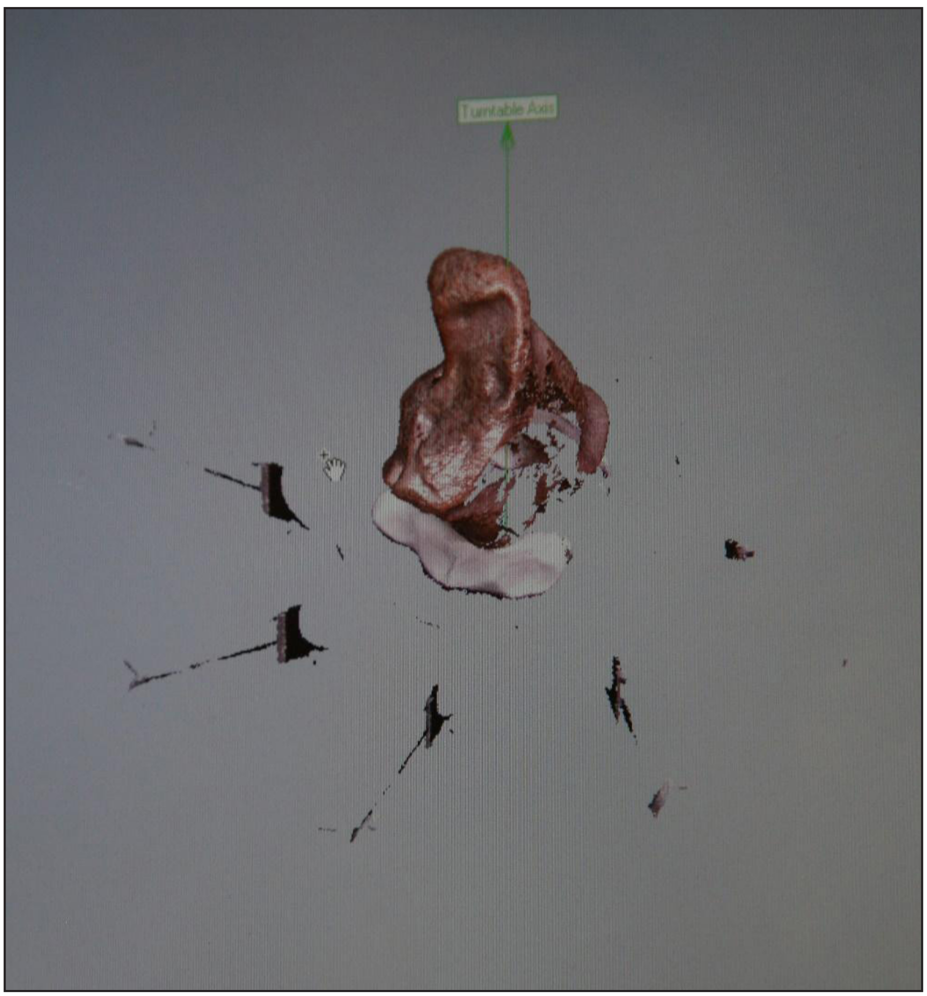

Figure 3. Creation of 3-D image of bone sacrum. (Courtesy Dr. Stephen Frost)

Large comparative faunal collections from the University of Oregon (UO), Oregon State University (OSU), and the Burke Museum of Natural History and Culture at the University of Washington (UW) were visited. In addition, photographs, the video, and scans were sent to zooarchaeologists from many universities outside of the region. Comparisons of the sacrum were made with that of bison, polar bear, black bear, grizzly bear, mastodon, African elephant, giraffe, sloth, tiger, moose, gorilla, zebra, bearded seal, sea lion, northern elephant seal, Stellar sea lion, elk, and walrus. Initial comparisons determined that the sacrum was much larger than an adult *Bison bison*, twice the size of a rhino and grizzly bear but with less mobility, and half the size of an adult mastodon. In spite of its large size, the sacrum was determined to be the first sacral vertebra from an immature animal (i.e., two areas of epiphyseal bone not fused). No barnacles were found attached to the bone, suggesting that its period in the ocean may have been short.

Age of Bone

From a visual inspection, paleontologists from the UO thought that the bone was greater than 8,000 yrs. BP; however, no signs of mineralization were found so it was not yet considered a fossil. Initially, no funding was available to obtain a ^{14}C date of the bone to discover its age. With knowledge that such a determination would yield the age of the bone but not necessarily when it was modified into the animal-like face, this process was postponed until other lines of enquiry could be followed. Initial identification efforts failed to yield a comparative sample so DNA analysis was considered as a means of sourcing the bone. The U.S. Fish &Wildlife Forensic Lab in Ashland, Oregon was consulted but success was not deemed likely due to the probable age of the bone, based on a visual inspection.

Upon closer examination, a small piece of root was found lodged in the vertebra bone on one end suggesting that the bone had been buried for at least a short time prior to its discovery in the Pacific Ocean. Analysis of the root as to species was determined not possible. The use of a high-powered micro-vacuum could be used to obtain soil from the bone for analysis, for soil scientists at OSU specialize in beach sand, but the process was estimated to be both time consuming and expensive, and so was not prioritized.

Source of Garnet

There are four main ways of sourcing garnets: 1) optical (refractive index), 2) chemical, 3) density, and 4) specific density. In order to attempt to source the origin of the garnet that was inset into the discovered sacrum bone, I chose to conduct a chemical analysis of the garnet using X-Ray fluorescence (XRF) analysis. XRF analysis has become a common non-destructive analytical technique to measure the geochemical signature of an object by measuring its major and trace element components. To assist in identifying like-garnets, samples of garnets from throughout the Pacific Northwest and Alaska were sought. A sample group of 44 garnets, largely purchased from rock shops, was obtained from eight sources in Oregon, Washington, Idaho, and Alaska, in addition to two samples from China and India, the two major sources of garnets available through the internet.

Tool Used to Modify Bone

A close examination of the sacrum bone found that all modifications to the bone were due to natural weathering except for the areas where the garnet(s) had been placed. These "eye" sockets showed signs of intentional cut marks. In order to determine the type of tool used to modify these areas, the cut marks were examined under extreme magnification. A FEI Quanta 600F Scanner electronmicroscope as well as a stereoscopic microscope was used to attempt to measure microscopic striations per inch to ascertain the "grit or grain" the item was sharpened with. Use of a Zeiss Zen (CZI) modeling program was then used to compare the cut marks to those left from a range of tool types (metal, stone, bone, shell).

Glue Used to Adhere Garnet

In an effort to determine the type of glue used to adhere the garnet, samples of various natural sources that could be used to create an adherent (tree pitch and animal), as well as commonly available modern chemical glues, were obtained for comparative purposes. Comparative samples included tree pitch from four northwest tree species (Lodge Pole Pine, Douglas Fir, Hemlock, and Engelmann Spruce), four natural animal bi-products known to be used historically as a glue (fish nerve glue, surgeon bladder, rabbit skin, and hide glue), and four chemical glues (Gorilla Glue™, epoxy, Titebond™, and Super Glue™). Dr. Karlis Muehlenbachs, a geochemistry professor from the University of Alberta, was contacted to conduct a chemical analysis of the adherent used in the modified sacrum and each of the obtained comparative samples.

Results of Analyses

Species Identification

Comparative analysis of the discovered sacrum with specimens from many west coast collections discovered that the bone was from a Pacific Walrus (*Odobenus rosmarus*). Initial attempts to compare the discovered sacrum with walrus specimens in collections in the Pacific Northwest were unsuccessful due to only a small infant walrus specimen available for comparison. The large size of the discovered sacrum was not recognized as that of a walrus until specimens from the University of Alaska Anchorage and the University of California Davis were available for more accurate comparisons. Pacific Walruses generally range over the relatively shallow waters of the northern Bering and Chukchi Seas, extending as far south as Bristol Bay in Alaska and the Kamchatka Peninsula in Siberia (Krupnick and Ray 2007). Walruses have never been indigenous to Oregon and the bone would have had to have been brought by humans to the area some time in the past.

Age of Bone

Given the difficulty in identifying the age of the sacrum bone by other means, donations were sought to pay for a ^{14}C date of the specimen. Money was donated by Dr. Loren Davis (OSU) to obtain an AMS date of the bone from Beta Analytic. The sample yielded an AMS date of 880 ± 30yrs BP Conventional Radiocarbon Age; $^{13}C/^{12}C$ Ratio - 12.6 o/oo (Beta-341172). Not knowing the area of origin for the walrus, the Marine Reservoir Effect is not known, but probably ranges from 450–750 years (Dumond and Griffin 2002), making the age of the bone from 130–430 ± 30yrs BP. In spite of the bone's appearance of being very old, it was discovered to be quite young.

Garnet Analysis

A multivariate scatterplot of basic elements found in garnets (i.e., calcium, cadmium, iron, manganese, antimony, and tin) was obtained from all 46 collected garnet samples. Using XRF analysis, a bivariate scatterplot (Figure 4) of the first two principal components, and a trivariate scatterplot of the first three principal components (Figure 5), each yielding a 95% confidence interval, revealed three distinct comparative groups and three outliers. Geochemical similarities were noted between the sacrum's garnet and four regional samples, including: 1) a northeast Oregon garnet (exact location unknown [ELU]; 2) an Idaho garnet (ELU); 3) Emerald Creek garnet near Coeur d'Alene, Idaho; and 4) Wrangell, Alaska. The outliers were from China, India, and a sample from St. Marie, Idaho. The diversity of comparative samples from this analysis highlights the usefulness of this technique but the need for a much larger sample size and better provenience data of samples for it to be useful in the future.

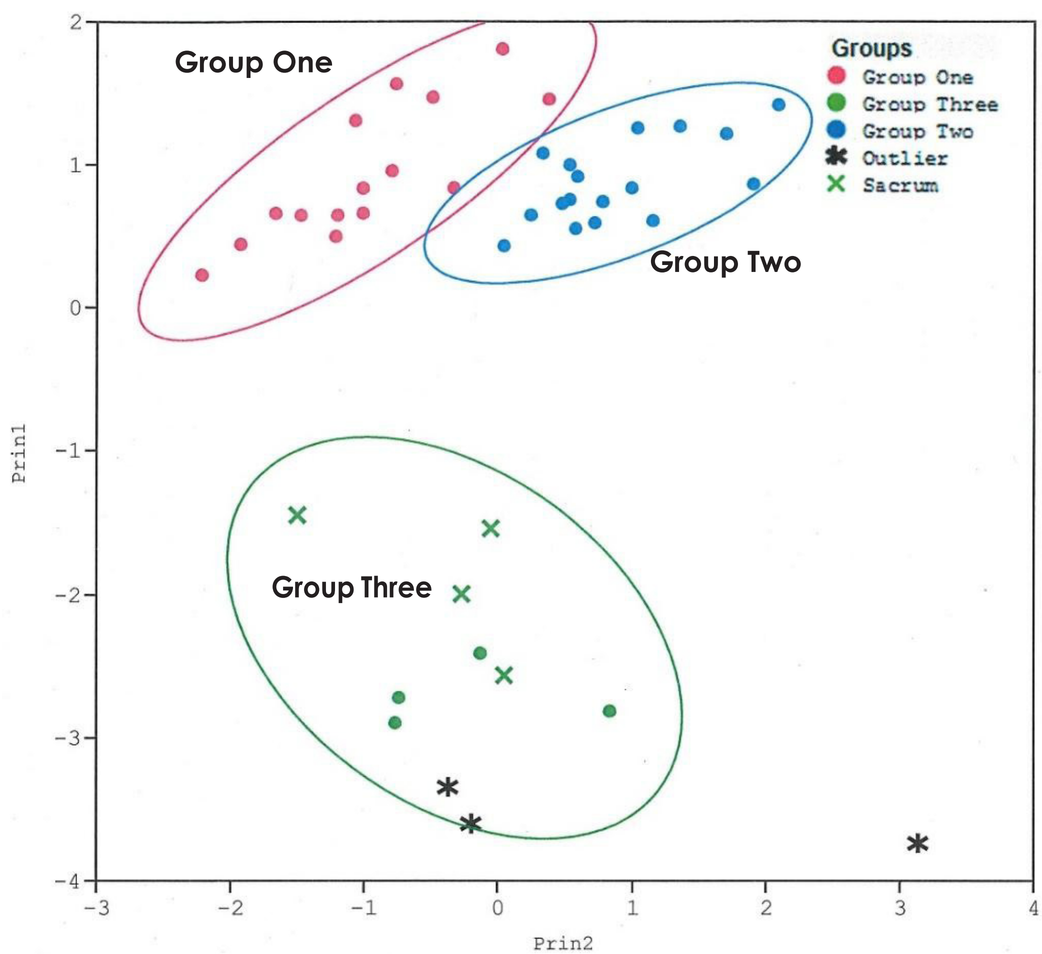

Figure 4. Bivariate scatterplot of first two principal components. (Courtesy Dr. Loren Davis and Alex Nyers)

Cut Mark Analysis

An analysis of microscopic striations in four distinct areas exhibiting cut marks revealed no distinct anomalies, with all areas appearing perfectly regular, which would not likely occur if they were created with stone tools. Cuts in the bone were made by a very sharp tool with the surface of the bone flaked off in some areas (Figure 6). The high degree of regularity found suggests uniform sharpening. Due to the regularity seen in the striations, the cut marks are believed likely to have been made with a machined (metal) object (e.g., knife). Weathering (including a crack) extends through the socket suggesting the modification occurred a long time ago and may have only recently been left in the beach environment.

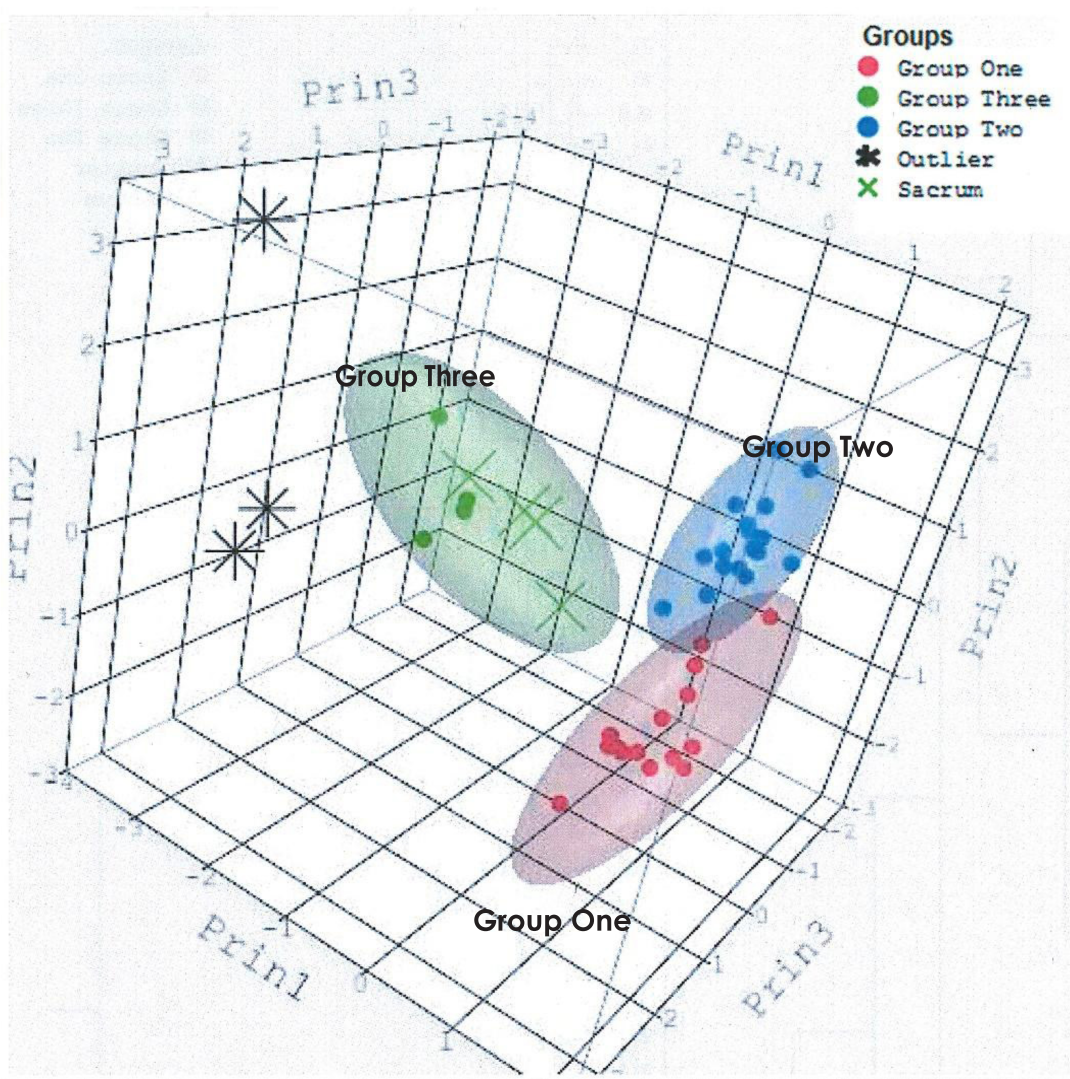

Figure 5. Trivariate scatterplot of first three principal components. (Courtesy Dr. Loren Davis and Alex Nyers)

Glue Analysis Results

Prior to paying to have the eight natural and four chemical comparative glue samples analyzed, a fragment of the glue used on the discovered bone was submitted to Dr. Karlis Muehlenbachs from the University of Alberta for analysis. His analysis detected the presence of Super Glue™ within the sample. In consulting with the couple who originally discovered the sacrum, they stated that they had applied no glue to the bone before turning it over to our office for analysis. Given the presence of Super Glue on the sacrum, the bone had to have been handled and modified by humans before ending up on the Oregon beach. Given this discovery, no further analysis of the alternative glue samples was undertaken.

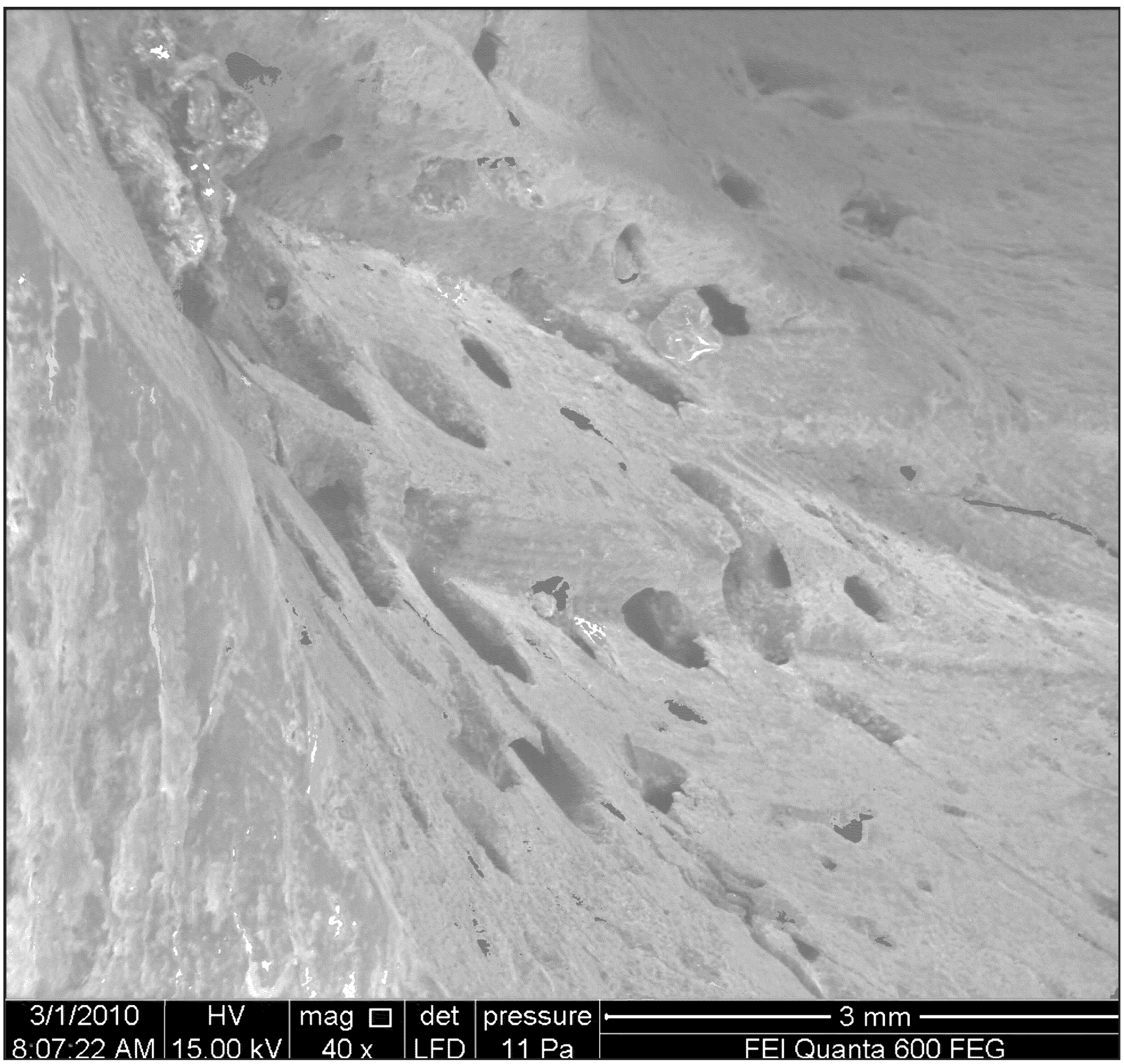

Figure 6. Close-up of cut marks using electronmicroscope. (Courtesy Dr. Theresa Sawyer)

Conclusion

The sacrum bone discovered on the Oregon coast was that of a Pacific Walrus (*Odobenus rosmarus*), an animal not native to Oregon. The bone was less than 500 years of age and exhibited cut marks likely made with a metal tool. Garnets from an unidentified location, likely from the Pacific Northwest, were attached to the bone as "eyes" forming an animal-like face. Super Glue™ and sand was used to adhere the garnet to the bone or at least to repair an earlier adherent before the artifact found its way to the Oregon coast. The artifact is more likely a modern creation than an ancient artifact.

The analysis of the discovered sacrum utilized several techniques including: XRF analysis for geochemical comparisons; use of an electronmicroscope (good for close photography but size limitation for larger objects due to scanner parameters); stereomicroscope (provides good close details); 3-D imagery and models; and DNA analysis. While the discovered artifact was found to lack antiquity and is probably modern in origin, the analysis efforts highlighted the usefulness of a variety of available scientific techniques in sourcing materials and establishing the antiquity of an artifact.

ACKNOWLEDGMENTS

Special thanks to the following individuals for their contribution in the above research:
Bone Identification: Drs. Loren Davis, David Brauner (OSU); Drs. Madonna Moss, Jon Erlandson, Edward Davis (UO); Drs. Mike Etnier, Laura Phillips, Jeff Bradley, Ron Eng, Don Grayson (UW); Dr. Lyle Hubbard (Chemeketa Community College); Dr. Diane Gifford-Gonzales (UC Santa Cruz); Dr. R. Le Lyman (University of Missouri); Dr. Diane Hanson (UA Anchorage); Dr. Michael C. Wilson (Douglas College, BC); Dr. Christyann Darwent (UC Davis); Dr. Daryl Domning (Howard University). Creation 3-D Image: Dr. Stephen Frost (UO); Dr. Loren Davis, Alex Nyers (OSU). Cut Mark Analysis: Dr. Theresa Sawyer (OSU); Drs. John Lukacs, Jeanne McLaughlin, Pat O'Grady (UO). ^{14}C Dating: Dr. Loren Davis (OSU); Beta Analytic. Glue Samples: David Gusset, Dr. Le Gilsen. Glue Analysis: Dr. Karlis Muehlenbachs (University of Alberta). XRF Sourcing of Garnet: Dr. Loren Davis, Alex Nyers (OSU). Discovery: Mary and Chris Nichols, Florence, OR. Permission to conduct research: Robert Kentta, Confederated Tribes of the Siletz Reservation. Article review: Thanks also to the two anonymous readers who provided editorial comments.

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Dr. Dennis Griffin, PhD., RPA, has served as the State Archaeologist with the Oregon State Historic Preservation Office since 2002. He received his PhD from the University of Oregon in 1999. He has worked extensively throughout the Pacific Northwest and Alaska for over 37 years specializing in oral history and community-based archaeology.

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Changes in Middle Holocene Shellfish Harvesting Practices: Evidence From Labouchere Bay (49-PET-476), Southeast Alaska[1]

Mark R. Williams

Abstract *This article uses zooarchaeology and community paleoecology to interpret the invertebrate assemblage from a middle Holocene shell midden in Southeast Alaska. The composition of midden 13.3 at Labouchere Bay (AHRS# 49-PET-746), which was occupied between roughly 6,500 and 2,500 calendar years before present, reflects changes in how the human inhabitants of the site interacted with intertidal shellfish communities. The amount of shellfish from soft substrate habitats (mudflats) did not change significantly over time, while the amount of shellfish from hard substrate habitats (rocky tide pools) declined. This trend in the relative abundance of these shellfish in the midden may have been influenced by environmental factors, but may be better explained by changes in human behavior. These behavioral changes could represent foraging adaptations in response to resource depression at different tidal ranges or increasingly-organized household economic systems.*

Introduction

For as long as humans have lived in coastal regions, shellfish have been an important source of food (Price 1989; Mayer 2002; Nadel 2002; Stiner et al. 2003; Mannino et al. 2007; van der Schriek et al. 2007; Colonese et al. 2009; Dupont et al. 2009; Habu et al. 2011; Gutiérrez-Zugasti et al. 2013). As early as 164,000 years ago, the inhabitants of South Africa collected and ate oysters (Jerardino and Marean 2010). On the Northwest Coast, evidence for opportunistic shellfish consumption dates back to 12,000 calendar years ago (Erlandson 1988; Ames 1994; Ames and Maschner 2000; Porcasi 2011). Widespread evidence for intensive shellfish harvesting first appeared during the middle Holocene, around 7,000–4,000 calendar years ago (Ames 1994; Ames and Maschner 2000). This period was marked by a shift in both settlement and subsistence patterns on the Northwest Coast of North America, as highly mobile hunter-gatherer groups transitioned to a more sedentary lifestyle (Ames 2006). The coincident appearance of both shell middens and permanent settlements throughout the Northwest Coast suggests that shellfish harvesting may have played a role in the development of sedentism (Yesner 1980).

Among ethnographically-documented foragers living on the Northwest Coast, shellfish are generally considered low-ranked, low-status foods (De Laguna 1990; Suttles 1990; Moss 1993). Individual shellfish can accumulate deadly levels of undetectable toxins, which means that although shellfish are easily acquired and processed, their consumption entails an element of personal risk (Acres and Gray 1978; Trainer et al. 2003; Moore et al. 2010). For this reason, elite members of society tended to avoid consuming shellfish when possible (Moss 1993). Although ancient ancestral communities likely had similar dietary rules discouraging the frequent consumption of shellfish, shellfish remains represent a large portion of the archaeological assemblage at Northwest Coast sites. However, the specific shellfish harvesting practices employed during the middle Holocene are not well-understood (Moss 1993; Daniels 2014).

Fladmark's (1985) initial model for the development of sedentism and cultural complexity on the Northwest Coast proposed that sedentary lifeways and social stratification were the direct consequence of the re-establishment of salmon migration routes that had been disrupted by Pleistocene glaciation. Under this model, once sea level stabilized and salmon began migrating up the rivers of the Pacific coast, the inhabitants of the region were provided with an inexhaustible bounty of food (Fladmark 1985).

However, further analyses of early Northwest Coast sites have demonstrated not only that seasonal spawning migration and human harvesting of salmon predate sea-level stabilization (Finney 1998; Campbell and Butler 2010), but also that salmon were not the most prevalent food source at every site (Moss and Cannon 2011). The superabundance of resources reported by early European settlers is best explained as the response of prey populations to the removal of the top-tier predator: humans. When the native human population was reduced by introduced diseases, the predatory pressure they exerted on the environment lessened, and prey populations rebounded (Butler 2000; Moss and Cannon 2011; McKechnie et al. 2014).

The inhabitants of the Northwest Coast were not passive recipients of an endless bounty of nature. The long-term success of a village depended on carefully managing the environment to ensure that harvests remained within sustainable levels. Although the timing and location of annual salmon runs are highly predictable, traditional ecological knowledge must also take into account the expected yield, since the size of salmon runs can vary greatly from year to year. Abrupt, multi-decade reversals in the oceanic and atmospheric conditions of the North Pacific have profound impacts on coastal salmon fisheries (Hare et al. 1996; Mantua et al. 1997; West 2009). These climactically-driven cycles of high and low productivity among salmon stocks predate European contact. Long-term fisheries management must take into account patterns of change that play out over multiple generations (Rogers et al. 2013).

Harvesting and storing migratory salmon were undeniably important activities for the ancient inhabitants of the Northwest Coast, but the annual and decadal variation in salmon productivity would have necessitated a dynamic subsistence system that also included terrestrial, intertidal, and marine resources. The systematic incorporation of shellfish into a logistical foraging system (cf. Binford 1980) may have helped the inhabitants of early sedentary settlements overcome periodic resource shortfalls in the absence of agriculture (Yesner 1980).

Shellfish are available year-round, can be found in dense concentrations in predictable locations, are sessile, and require minimal technological investment to harvest. They can easily be collected by all demographics within a segmented society, including children and elders (Yesner 1980; Bird and Bliege Bird 2000; Thomas 2007). Shellfish have high reproductive rates, so carefully-managed harvests can produce high yields of mature individuals without causing significant population decline (Daniels 2014). Habitat modification through the construction of walled clam gardens can further improve the long-term yield of shellfish beds (Groesbeck et al. 2014; Lepofsky et al. 2015).

Examining how these natural and cultural processes may have affected the relationship between humans and shellfish can be accomplished by documenting patterns of change in the material remains at shellfish-harvesting sites. The Labouchere Bay sites present excellent examples of seasonally-occupied coastal foraging camps from the middle Holocene. The exceptional preservation conditions at these undisturbed middens have yielded a high-quality invertebrate fauna assemblage suitable for this type of analysis (Williams and Dixon 2014, 2016).

Archaeological Setting

The Labouchere Bay sites (49-PET-746) are located on the northern tip of Prince of Wales Island, Alaska (Figure 1). The sites lie within the traditional territory of the Takjik´aan Tlingit *Kwáan*, and are currently administered by the U.S. Forest Service Craig Ranger District. In 2012, a pedestrian survey first identified cultural material at these sites (Williams et al. 2013). Additional testing and excavation in 2013 and 2014 expanded the boundaries of the study area to encompass eight separate sites, five of which contained undisturbed shell midden deposits (Williams and Dixon 2014, 2016).

The shell midden sites are located along a wave-cut terrace roughly 9–12 m above modern sea level overlooking a sheltered inlet of Labouchere Bay. Midden 13.3, which is the focus of this article, is a shallow rockshelter located at the base of a bedrock bluff where the wave-cut limestone forms a slight overhang (Figure 2). Based on the volume of fallen boulders and cobbles overlying the midden, the overhang would have been even larger during the site's occupation. From the bottom of the fallen cobbles and boulders, the midden extends down another meter to meet bedrock. Two radiocarbon dates from wood twig charcoal provide lower and upper bounding dates for the midden of 6,568 ± 73 and 2,604 ± 115 cal BP (Table 1).

Sea Level History

Prince of Wales Island was subject to significant loading from glacial ice during the last ice age, and isostatic rebound from this glaciation greatly affected Holocene sea level changes along the Pacific coast. The relative sea level at Prince of Wales Island reached a maximum extent of 14 m above modern sea level around 9,800 to 9,100 years ago, and then slowly receded to modern level around 5,300 to 4,900 years ago (Carrara et al. 2007; Shugar et al. 2014; Carlson and Baichtal 2015).

Moss (2011) has proposed that the location of coastal foraging camps tracked with changing sea levels, with foragers relocating their seasonal base camps to keep pace with both rising and falling shorelines. Recent work by Carlson and Baichtal (2015) verified this pattern for early Holocene (ca. 10,500–7,500 cal BP) sites on Prince of Wales Island using a predictive model for site location based on elevation.

Based on the topography and elevation of the surrounding area, Labouchere Bay would have remained a highly productive environment throughout the entire Holocene, despite the changing sea level. Labouchere Bay itself was overridden by glacial ice only briefly during the peak of the last glacial maximum and the surrounding mountains served as a refugium (a locally ice-free biome that could support large-bodied land mammals) during much of the last ice age (Heaton et al. 1996; Dixon 1999; Heaton

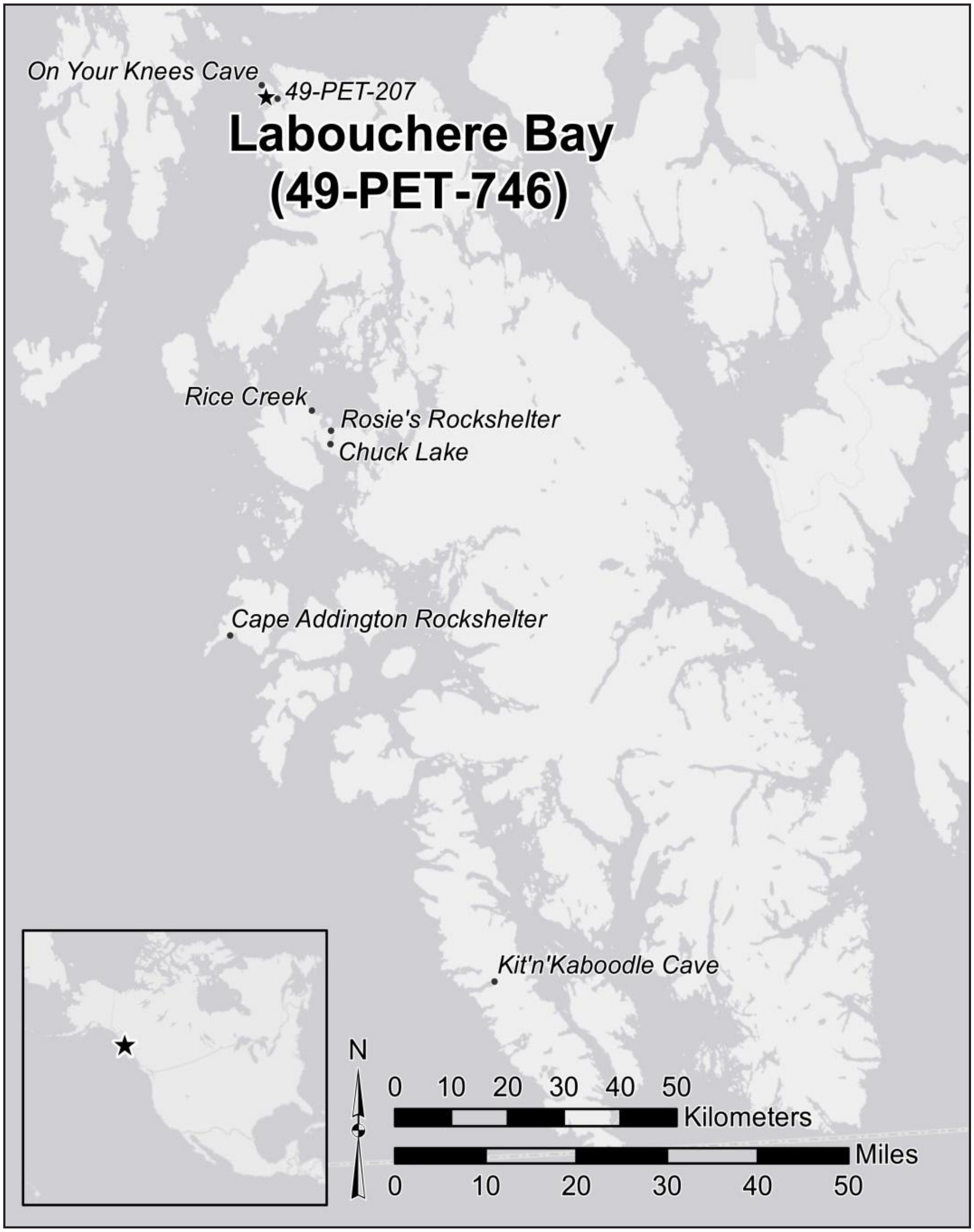

Figure 1. The Labouchere Bay sites (AHRS# 49-PET-746) are located on Prince of Wales Island, AK (indicated by the star on the inset map). They comprise eight discrete cultural deposits encompassing rockshelters, shell middens, and a raised marine beach deposit containing lithic artifacts (indicated by the star on the primary map). This article specifically examines the shell midden at Labouchere Bay midden 13.3. Other early to middle Holocene sites in the region are included for context.

and Grady 2003). During the middle Holocene, the combined factors of global sea level rise, local isostatic rebound, and tectonism resulted in the stabilization of the coastline at modern sea level (Baichtal et al. 1997; Carrara et al. 2007).

The sheltered inlet would have provided relatively easy access to multiple ecological communities and afforded strategic control of important surrounding waterways throughout these changes, making it an ideal location for a seasonal foraging camp.

Regional Archaeological Context

The middle Holocene marked the widespread appearance of an economic and settlement pattern in which foraging activity at seasonal gathering camps supported the permanent reoccupation of strategically-located winter villages (Ames and Maschner 2000; Moss 2011). Only a small number of sites on the northern Northwest Coast with middle Holocene components have been systematically tested. These include Kit'n'Kaboodle (49-DIX-46), On Your Knees Cave (49-PET-408), an unnamed lithic scatter on a raised marine beach (49-PET-207), Rosie's Rockshelter (49-CRG-236),

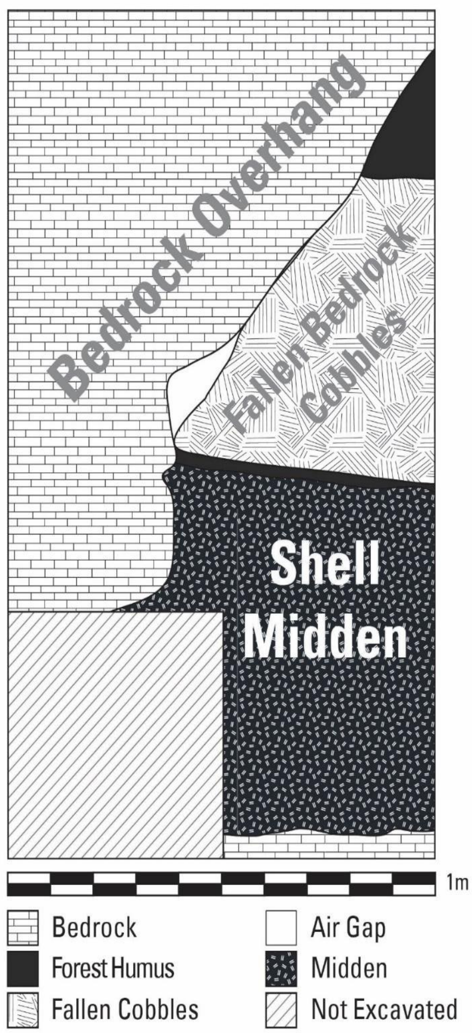

Figure 2. Labouchere Bay shell midden 13.3 is located under a shallow overhang in the karstic limestone bedrock, as indicated in this profile drawing. The midden extends down to bedrock and is overlain by a layer of fallen limestone cobbles. Bounding dates of 6,568 ±73 and 2,604 ± 115 cal BP were obtained from the lowermost and uppermost levels of the midden.

Table 1. Two-Sigma Bounding Radiocarbon Date Ranges for Labouchere Bay Midden 13.3, Calibrated Using Intcal 13.

Sample	Depth (cm)	2σ Calibrated Age (BP)	Uncalibrated Age (BP)	Material	Lab Reference #
Midden Upper Extent	110	2,604 ± 115	2,492 ± 24	Wood Twig Charcoal	D-AMS 010116
Midden Lower Extent	175	6,568 ± 73	5,770 ± 25	Wood Twig Charcoal	NOSAMS 118293

Rice Creek (49-CRG-234 and 49-CRG-235), Chuck Lake (49-CRG-237), and Cape Addington Rockshelter (49-CRG-188), as described below.

The closest analog to the Labouchere Bay sites is the North Rockshelter at Kit'n'Kaboodle Cave (49-DIX-46), located 157 km to the southwest on Dall Island. The Kit'n'Kaboodle site comprises three distinct site locales spaced roughly 20 m apart, along and within the base of a karst bluff 10 m above sea level. The site was occupied over a period from ca. 5,590 to ca. 1,700 calendar years ago (Moss and Erlandson 2010:3365). The species occurrence in the Kit'n'Kaboodle middens is similar to that of Labouchere Bay, although Kit'n'Kaboodle contains a larger amount of barnacles (*Semibalanus cariosus*) and mussels (*Mytilus spp*). While barnacles are generally considered an incidental inclusion in Northwest Coast middens, there is clear evidence for their consumption at Kit'n'Kaboodle (Moss and Erlandson 2010). Midden accumulation at the Kit'n'Kaboodle North Rockshelter was low (1.87 cm/100 years), with indications of recurring animal activity, reflecting a long-term pattern of seasonal abandonment and reoccupation (Moss 2015).

On Your Knees Cave (49-PET-408) is an early Holocene cave site located in steep karst 1.6 km north of Labouchere Bay. Analysis of the artifacts and human remains from nearby On Your Knees Cave demonstrate that people inhabited the vicinity of Labouchere Bay as early as 12,097 ± 136 cal BP (Dixon et al. 2014). Isotopic analysis of human remains from the individual known as Shuká Kaa, ^{14}C dated to 10,342 ± 144 calendar years BP, indicate heavy consumption of high tropic level marine resources during the early Holocene (Dixon et al. 2014). The site was revisited during the middle Holocene, as indicated by a bone implement dated to 6,577 ± 95 calendar years BP (Dixon 1999).

49-PET-207 is an early Holocene (9,831 ± 278 to 9,435 ± 244 cal BP) raised marine beach deposit in a stream estuary 1.2 km west of Labouchere Bay (Greiser et al. 1993). Although originally identified as a shell midden, subsequent re-analysis of the site's shell component indicated that it is non-cultural in origin (T. Marshall and R. Carlson, personal communication, 2013). The stratigraphic sequence of raised marine gravel, fossil shell bed, and glacial till is comparable to that at 49-PET-746-12.1 and the depositional sequence suggests a similar geological history of uplift and subsidence. The few lithic artifacts recovered from 49-PET-207 resemble those from the lithic scatter at Labouchere Bay site 12.1.

Rosie's Rockshelter (49-CRG-236) is a middle Holocene (4,682 ± 169 to 3,518 ± 639 cal BP) site on Heceta Island located 27.92 m above sea level at the base of a limestone cliff. It contains two thin (5–10 cm) lenses of culturally deposited shell separated by 5–10 cm of sterile rockfall (Ackerman et al. 1985:97). *Saxidomus gigantea*, *Protothaca staminea*, and *Mytilus edulis* comprise the majority of the midden (Ackerman et al. 1985).

The Rice Creek sites (49-CRG-234 and 49-CRG-235) are lithic workshops on Heceta Island that tentatively date to the early Holocene (10,234 ± 347 cal BP) (Ackerman et al. 1985:89). The sites comprise lithic artifacts in raised marine beach sediments overlying glacial till exposed by a small creek at 7 m and 13–17 m above sea level. On a nearby terrace overlooking the creek, *Saxidomus gigantea* and firecracked rocks visible in the upturned roots of a fallen tree indicate the presence of a shell midden. The presence of this site was noted in the report but it was not sampled. A stone tidal fish weir (49-GCR-238) is present at the mouth of the creek (Ackerman et al. 1985).

The Chuck Lake (49-CRG-237) is an early Holocene site located 13–15 m above sea level on Heceta Island. The site comprises six distinct localities across 1 km^2, three of which contain thin (ca. 20 cm) lenses of shell midden. Within the middens, *Saxidomus gigantea* were the most abundant shellfish species, followed by *Protothaca staminea* and *Mytilus edulis*. Fish dominated the vertebrate fauna assemblage, although there were few salmon remains (1% – 3% of the total). A small number of marine and terrestrial animal bones were also present (Ackerman et al. 1985). The patchy deposition of artifacts and shell lenses suggest low-intensity periodic occupation from 9,220 ± 270 to 5,484 ± 191 cal BP (Okada et al. 1989, 1992).

Cape Addington Rockshelter (49-CRG-188) is a late Holocene (1,900 ± 90 to 430 ± 120 cal BP) site on Noyes Island located 2–4 m above sea level at the base of a wave-cut karst outcrop. The site contains a shell midden characterized by the rapid accumulation of mussels (*Mytilus sp*). The small quantity of periwinkles and limpets did not represent a substantial contribution to the midden assemblage (Moss 2004:229). Cod and halibut are the most abundant vertebrate species, and a small number of salmon bones are also present (Moss 2004:159–171). The midden directly overlies beach deposits, suggesting that the rockshelter was inhabited as soon as they were above the reach of storm surf (Moss 2004:40–41).

These sites indicate that around the same time that permanent winter villages were becoming widespread on the Northwest Coast (6,000–5,000 calendar years ago), archaeological shell deposits shifted from thin and discontinuous lenses to thick, well-defined middens. This may indicate that during the middle Holocene, human foraging behavior became less opportunistic, and increasing emphasis was placed on organized harvesting and habitat management. The Labouchere Bay shellfish assemblage provides the test to examine this hypothesis.

Methods

Sampling

The recovery of faunal materials at Labouchere Bay followed the methods developed at the Qʷuʔgʷes and Sunken Village sites (Croes et al. 2004, 2009). Excavation of 1 m x 1 m test units was conducted using 5 cm arbitrary levels and 3.2

mm (⅛ in.) mesh. All vertebrate fauna elements within the unit were collected, and shellfish were collected from a designated quadrant within each unit. Bivalve shells were collected only if the umbo (the joint where the two halves of the shell meet) was greater than 50% intact. Univalve shells and chiton plates were collected if they were greater than 50% intact. Barnacle fragments were collected if they were at least ¼ in. long on one side.

This sampling strategy provided the best balance between efficient field sorting and manageable transportation of samples. Cumulative species richness (NTAXA) was assessed across the excavated assemblage (after Lyman and Ames 2004) to confirm that midden was sampled to redundancy. This collection method ensured that the number of identified specimens (NISP) in the sample assemblage was representative of the actual midden contents without being prohibitively heavy to transport from the remote field camp.

Identification

Each element in the invertebrate fauna assemblage was identified to the most specific possible taxonomic level. Fragments that lacked diagnostic features could not be conclusively assigned a taxonomic group. Identification was conducted using printed field guides (Morris 1966; Rehder et al. 1981; Foster 1991) and the author's personal comparative collection. With the exception of whelks and limpets, all elements were identified to species. Quantification of the assemblage was conducted using NISP instead of mass in order to compensate for the heavily-fragmented state of the shells.

Statistical Model

Data from individual species were aggregated according to ecological community for analysis. Ecological communities are two or more species that simultaneously occupy the same habitat (Krebs 1972). Communities are not static taxonomic categories, but rather reflect dynamic interactions between multiple coexisting species. Paleoecological reconstructions according to community type can help identify consistent trends in these species-level interactions, and can reveal whether such changes are induced by environmental vs. biological factors and whether the trend reflects gradual change vs. punctuated equilibrium (Hoffman 1979:360).

Shellfish can be broadly categorized into two communities depending on their preferred habitat type: soft substrate (characterized by mudflats and sandy beaches) vs. hard substrate (characterized by rocky shores and tide pools) (Morris 1966; Rehder et al. 1981; Foster 1991). These two habitats (Figure 3) represent opposite ends on the coastal erosion-lithification cycle, in which bedrock is broken down and redeposited in sedimentary layers (Taylor and Wilson 2003:7). Soft substrate habitat is comprised of sediments that are moved by regular tidal action. Particles in these sediments include clay, silt, and sand ranging in size from 0.001 to 2 mm in diameter (Cosentino-Manning et al. 2010). Species in the soft substrate community included *Saxidomus gigantea*, *Protothaca staminea*, *Clinocardium nuttallii*, *Macoma nasuta*, *Tresus capax*, and *Cryptomya californica* (Table 2).

Hard substrate habitat is comprised of rocks greater than 256 mm in diameter that are not moved by regular tidal action (Cosentino-Manning et al. 2010). Species in the hard substrate community included *Littorina sitkana, Katharina tunicata, Balanus* *glandula*, *Mytilus californianus*, *Cryptochiton stelleri*, *Tonicella lineata*, and *Balanus nubilus* (Table 2).

Although these habitat types are occupied by different shellfish communities, they can be accessed interchangeably by human foragers. On a given stretch of coastline, both habitats can be found adjacent to each other and may also contain microhabitats supporting small pockets of the other community. Gravel and cobble substrates represent intermediate stages of the coastal erosion-lithification cycle and contain particles ranging from 2 to 256 mm in diameter (Taylor and Wilson 2003; Cosentino-Manning et al. 2010). These intermediate substrates may be populated by either hard or soft substrate species, depending on the specific local conditions.

Additional abiotic habitat constraints for each species obtained from the Encyclopedia of Life geodatabase (Encyclopedia of Life 2015a, 2015b, 2015c, 2015d,

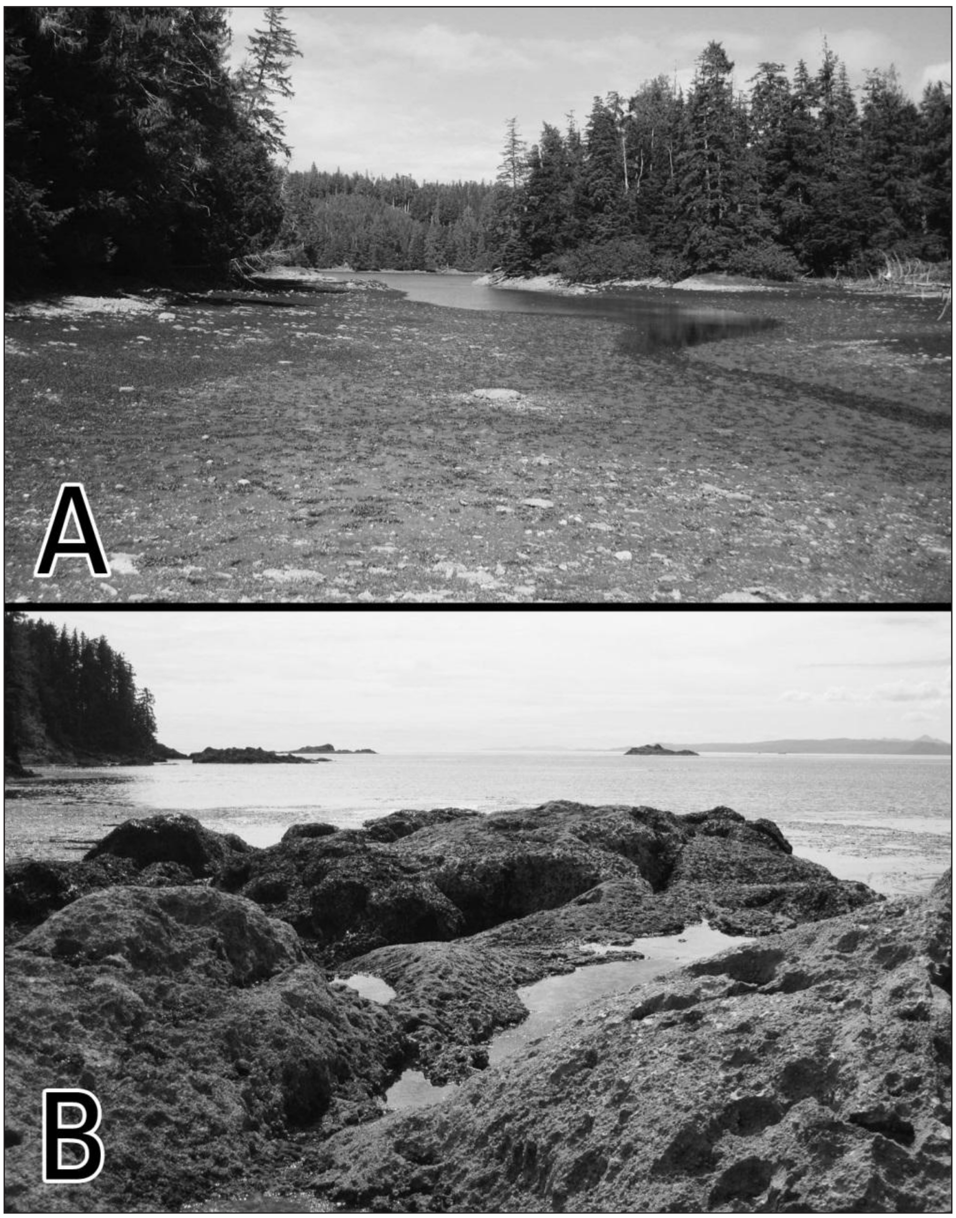

Figure 3. The shellfish in the midden were categorized according to habitat preference: soft substrate mudflats (A) vs. hard substrate tide pools (B). Photos by Mark Williams and Melyssa Huston.

2015e, 2015f, 2015g, 2015h, 2015i, 2015j, 2015k, 2015l). These variables included the minimum and maximum: latitudinal range (°), longitudinal range (°), water depth (m), water temperature (°C), water nitrate concentration (μmol/l), water silicate concentration (μmol/l), water phosphate concentration (μmol/l), water dissolved O^2 concentration (ml/l), water O^2 saturation (%), and water salinity (psu). An analysis of variance (ANOVA) test was conducted to determine if any of these factors varied significantly between the hard and soft substrate communities.

Table 2. Shellfish count by taxon. Species that prefer hard substrate habitat (rocky tide pools) are listed in the upper portion. Species that prefer soft substrate habitat (mudflats) are listed in the lower portion.

Hard Substrate Community

NISP	Common Name	Scientific Name
5,966	Sitka Periwinkle	*Littorina sitkana*
3,287	Black Katy Chiton	*Katharina tunicata*
224	Limpets	Lottia sp.
157	Acorn Barnacle	*Balanus glandula*
76	Whelks	Gastropoda sp.
54	California Mussel	*Mytilus californianus*
25	Gumboot Chiton	*Cryptochiton stelleri*
3	Lined Chiton	*Tonicella lineata*
2	Giant Acorn Barnacle	*Balanus nubilus*

Soft Substrate Community

NISP	Common Name	Scientific Name
1,250	Butter Clam	*Saxidomus gigantea*
547	Littleneck Clam	*Protothaca staminea*
48	Cockle	*Clinocardium nuttallii*
14	Bent-nosed Clam	*Macoma nasuta*
13	Horse Clam	*Tresus capax*
1	California Softshell Clam	*Cryptomya californica*

To quantify changes in the overall representation of different ecological communities within the midden assemblages, the individual taxonomic abundances were used to calculate a community relative abundance index (RAI_c) that reflects the overall representation of each community (rocky tide pools vs. soft mudflats) within the midden assemblage sample. RAI_c is determined by dividing the total number of identified specimens (NISP) of species from soft substrate habitats (*Saxidomus gigantea*, *Protothaca staminea*, *Mya arenaria*, *Tresus capax*, *Macoma nasuta*, and *Clinocardium nuttallii*) by the total NISP of all species:

$$RAI_c = \frac{NISP_{soft\text{–}substrate\ taxa}}{NISP_{soft\text{–}substrate\ taxa} + NISP_{hard\text{–}substrate\ taxa}}$$

The higher the community index, the higher the proportion of soft substrate species in the assemblage: a community index of 1 reflects an assemblage comprised entirely of clams and cockles, while a community index of 0 reflects their complete absence.

Results

The assemblage of 11,773 individual shells recovered from Labouchere Bay midden 13.3 comprised fifteen different taxonomic groupings (Table 2). The complete breakdown of shellfish counts by taxon and excavation level is available for download through the University of New Mexico's digital data repository (Williams 2017). Of all the abiotic habitat constraints examined, only minimum water depth differed significantly between hard and soft substrate communities (p = .032), with hard substrate species tolerating longer exposure to air and thus surviving closer to the maximum high-tide mark.

In the oldest portion of the midden, just above bedrock (ca. 6,568 ± 73 cal BP), shellfish from the soft substrate community composed only 6% of the total assemblage. In the youngest portion of the midden (ca. 2,604 ± 115 cal BP), shellfish from the soft substrate community composed 73% of the total assemblage (Figure 4).

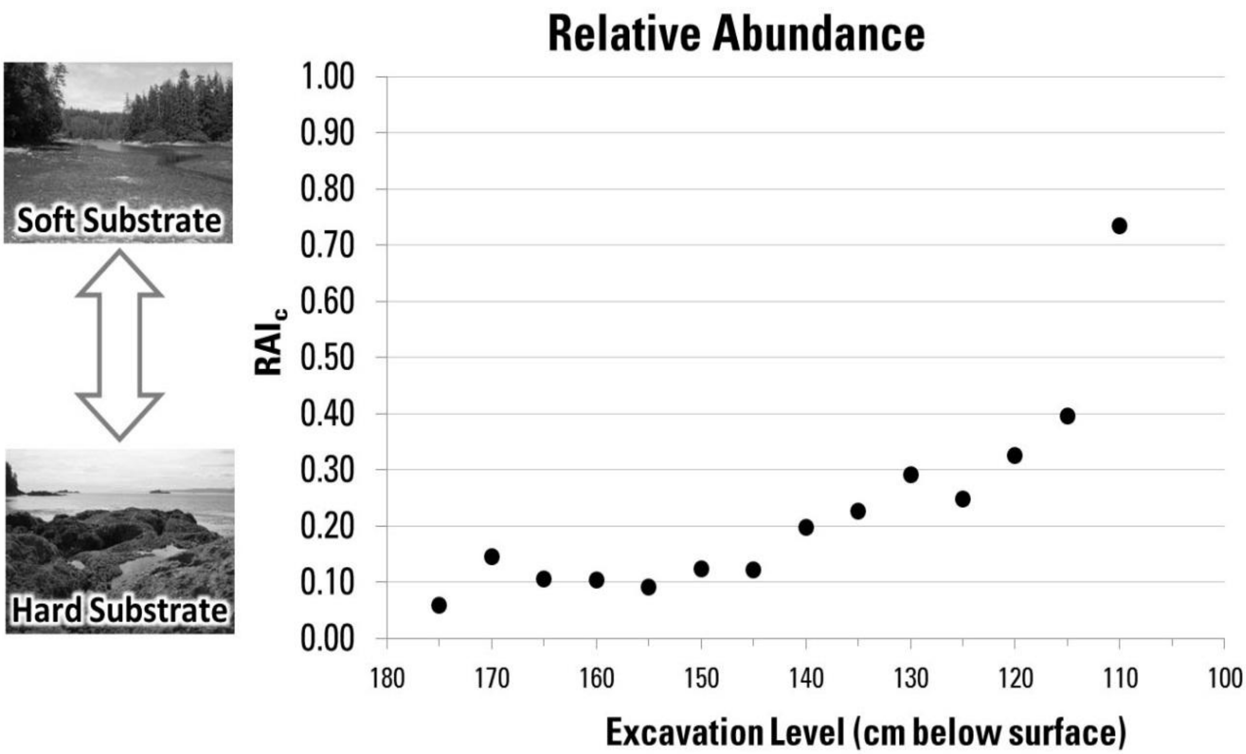

Figure 4. The relative abundance of species from soft substrate communities increased over time in the midden assemblage.

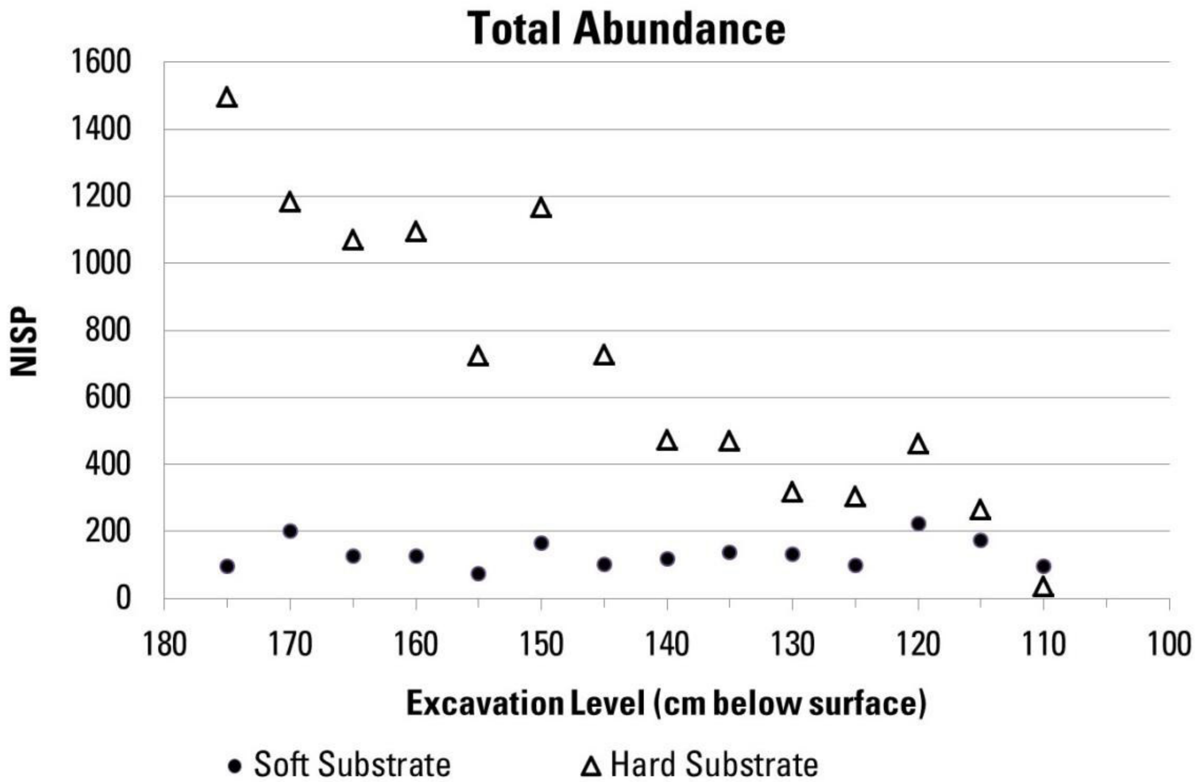

Figure 5. The total amount (NISP) of hard substrate shellfish in the sample assemblage decreased over time, while the total amount of soft substrate shellfish remained relatively constant.

This gradual change in the community abundance index was driven primarily by a decline in the total number of individuals from the hard substrate community. The total number of individuals from the soft substrate community did not vary significantly (Figure 5).

The assemblage was dominated by the two most abundant species within each community. *Littorina sitkana* (Sitka periwinkle) and *Katharina tunicate* (black Katy chiton) together comprised 94% of the hard substrate assemblage and both similarly declined in abundance over time. *Saxidomus gigantea* (butter clam) and *Protothaca staminea* (littleneck clam) together comprised 96% of the hard substrate assemblage, and their abundance did not vary significantly over time (Figure 6). The extremely low occurrence of all other species suggests that they were either incidental inclusions, or in the cases of *Cryptochiton stelleri* (gumboot chiton) and *Tresus Capax* (horse clam), preferred deeper water habitats that were difficult to access regularly.

Discussion

These preliminary data suggest there may be consistent trends in how humans at Labouchere Bay interacted with shellfish communities in the past. Over the period spanning 6,568 ±73 through 2,604 ± 115 calendar year ago, people harvested and consumed increasingly fewer shellfish from hard substrate communities. At the same time, the yield from soft substrate communities did not change significantly. In other

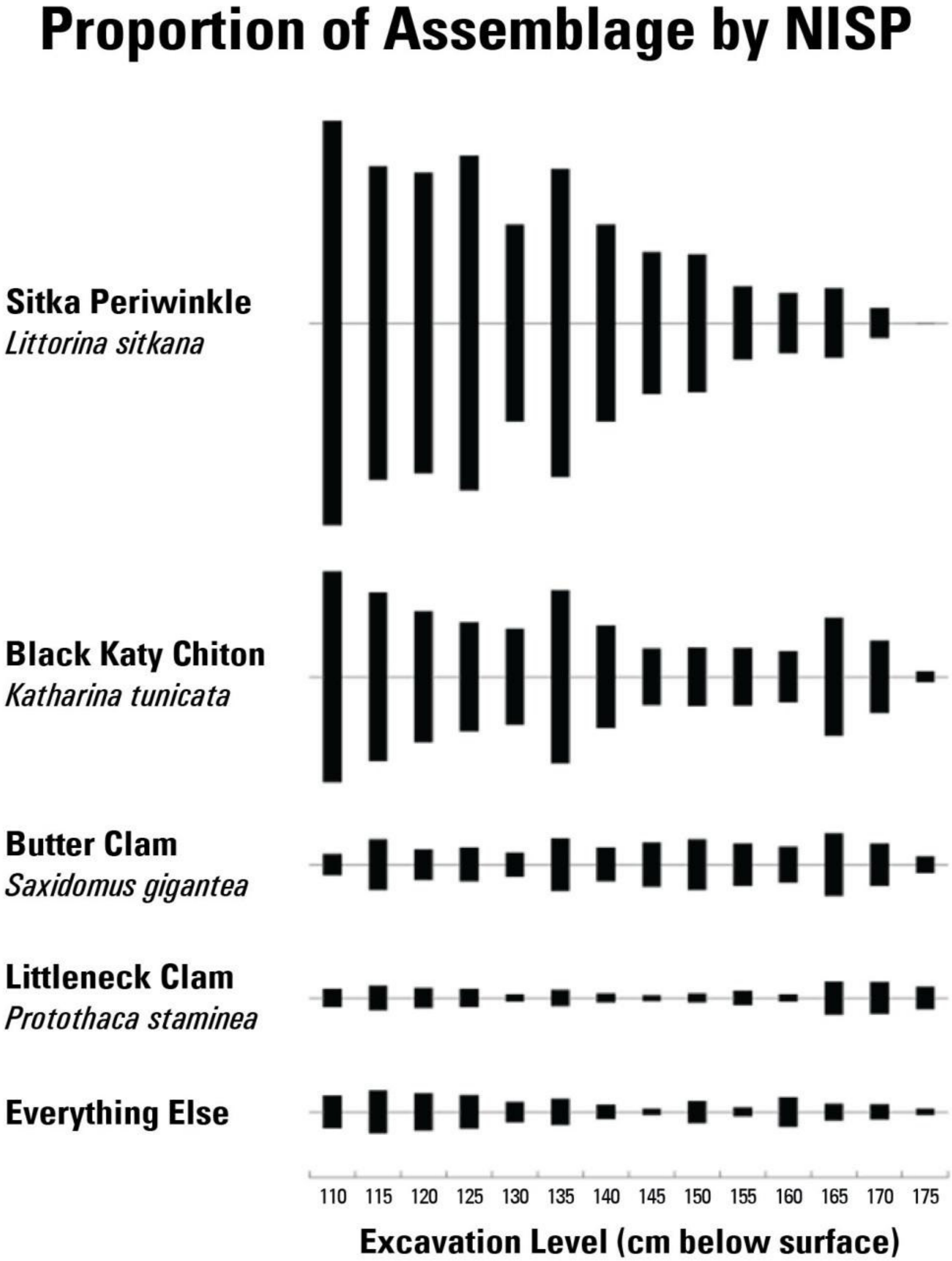

Figure 6. Patterns of change were consistent among the two most abundant species in each community (hard substrate: *Littorina sitkana* and *Katharina tunicate*; soft substrate: *Saxidomus gigantea* and *Protothaca staminea*), which together composed the majority of the midden assemblage.

words, this sample suggests that as the centuries passed people were collecting fewer and fewer periwinkles and chitons from the tide pools, but they were still digging up the same number of clams from the mudflats. This pattern of gradual change is evident not just in a single species but across entire ecological communities.

These changes are unlikely to have been induced by abiotic environmental factors alone. Since all the species in this study exist in close proximity and have similar tolerances for water temperature, ocean acidification, salinity, and dissolved trace elements, it is unlikely that changing water conditions could completely explain the differential patterns of abundance in the midden assemblage. Changes in sea level, temperature, silting, or salinity likely did affect the baseline abundance of various shellfish populations at different points in time, but it would have done so across all species. Although relative sea level had stabilized by the time the midden was first deposited, erosion and/or sedimentation may have affected the distribution and accessibility of shellfish communities in the local area. Mollusk populations in the intertidal zone are particularly susceptible to local sea level changes, but repopulate rapidly by recruiting from reserve populations in deeper waters. However, erosional processes that would decrease the amount of hard substrate habitat through silting would simultaneously increase the amount of soft substrate habitat. Thus, if erosional processes were driving the changes in the Labouchere Bay midden assemblage, one would expect to see an inverse relationship between the total count of hard and soft substrate shellfish: as periwinkles and chitons from tide pools became more scarce, clams from mudflats would become more common. This is not supported by the data, in which the total yields of the two communities change through time independently of each other.

A more likely explanation is that the decline in the abundance of hard substrate shellfish is the result of interaction with human predators. This predator/prey relationship would have been strongly mediated by tidal cycles, since shellfish in cold high latitude waters can only be practically harvested when they are exposed at low tide. Hard substrate shellfish congregate in tide pools and on seaweed fronds during low tide, so they can be gathered by the thousands using mass-harvest techniques such as scraping (Figure 7). Hard substrate shellfish have a higher minimum water requirement and can be accessed even when the tide is not fully out.

Although soft-substrate shellfish tend to be larger in size, they must be dug up individually. This activity requires greater effort, more specialized tools, and must be coordinated to coincide with extremely low tides. As the inhabitants of Labouchere Bay built up their traditional ecological knowledge, they would have learned how to take advantage of the tides to exploit these resources more efficiently.

As a result, the more easily-accessible hard substrate communities may have undergone more pronounced resource depression, with humans consuming individuals faster than they could reproduce. Furthermore, the yield of soft substrate communities could have been improved through the construction of clam gardens or by using canoes to transport clams from other nearby bays. As long as harvests did not heavily exploit immature individuals, shellfish populations could have remained stable despite human predation. Hard substrate habitats, which tend to experience much stronger wave action, would have been more difficult to modify and would have been harder to access via canoe.

Alternatively, changing cultural preferences and/or social organization may have influenced the priorities of individual foragers. The Labouchere Bay sites most

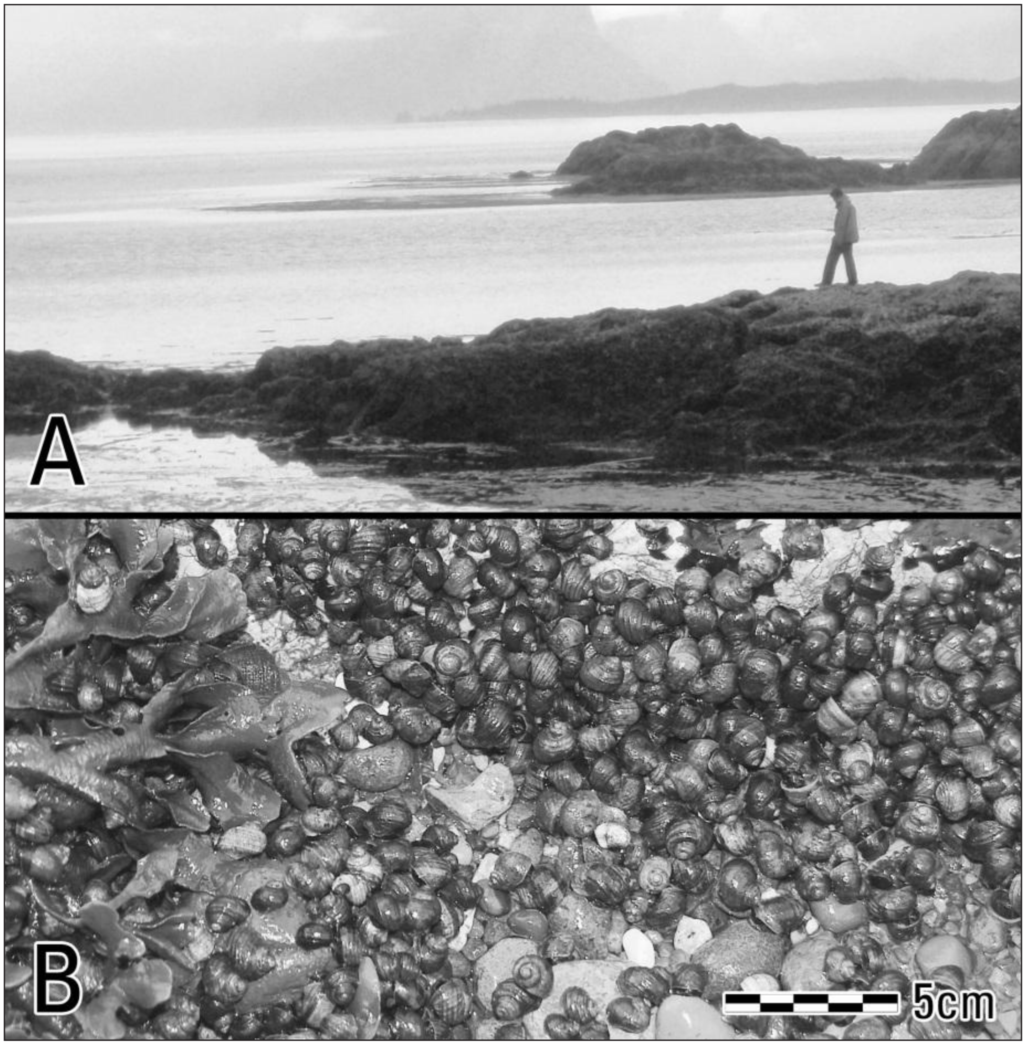

Figure 7. Field volunteer Carlos Michelen inspects Labouchere Bay's rocky shoreline at high tide (A). As the tide recedes, periwinkles, chitons, and other hard substrate shellfish cluster together in the pools of water that remain, facilitating mass harvest (B). Photos by Mark Williams.

likely served as seasonal satellite camps associated with a central winter village. During the summer, a few individuals, possibly organized into family groups, harvested and processed shellfish here, perhaps setting aside a surplus for winter storage.

The widespread emergence of formal hierarchical social structures throughout the northern Northwest Coast around 7,000–4,000 calendar years ago may also have played an important role in shaping shellfish gathering practices. These changes may have enabled households to exert control over access to strategic shellfish-gathering locations (Ames 2006). In the potlatch-driven economies typical of the Northwest Coast during the late Holocene, there was an obligation to give away resources according to collectively-understood quotas determined by one's social rank (Mauss 1954; Kan 1989). This gift economy governed not just the collection and distribution of high-prestige items such as banquets, but also more mundane resources such as winter food stores. Although elites strived to give away as much as possible, exceeding the expected quotas for food resources carried diminishing returns, since such surplus must be shared equally after harvesting but consequential gains in social capital would not be realized immediately (Trosper 2009). A shift toward site specialization due to increasing emphasis on quota-driven clam harvesting (as opposed to other, more general foraging activities) could also explain the decline in the amount of hard substrate shellfish in the midden assemblage coupled with an unchanging amount of the soft substrate shellfish.

Conclusion

Over time, the use of this site on the shore of Labouchere Bay became increasingly focused on harvesting shellfish from soft substrate habitats. This change was characterized by a decline in the amount of hard substrate shellfish in the midden assemblage. Over the four thousand years between the first and last cultural deposition at Labouchere Bay midden 13.3, the contribution of soft substrate communities did not change significantly, while the contribution of hard substrate communities experienced a decline. Although abiotic factors may have played a role in determining the baseline productivity of the local environment, this analysis suggests that the primary driving factor behind the changing representation of shellfish in the midden were most likely due to human behavior. These changes may have been the result of tidally-influenced foraging strategies, or they may reflect an increasing social hierarchy of household economic units. Ethnographic analogies suggest that shellfish harvesting, while affording little prestige, may have served as a reliable, low-investment subsistence activity that complemented more seasonally-restricted events such as salmon migrations. This research suggests that a dynamic system in which people of different social ranks performed increasingly specialized tasks at different times of the year may have been developing in and around northern Prince of Wales Island between 6,500–2,500 years ago. The data from Labouchere Bay midden 13.3 help document the emergence and long-term sustainability of sedentary subsistence systems on the northern Northwest Coast.

ENDNOTE

[1]This article developed from a paper presented at the 69th Annual Northwest Anthropological Conference held in Tacoma, Washington, March 23–26, 2016. The paper was awarded 1st place among papers submitted to the best graduate student paper competition. The *Journal of Northwest Anthropology* regularly agrees to publish the winning paper as submitted. At the author's request, the winning paper was revised and submitted to the journal for publication as a regular article. The manuscript was subjected to peer review and revised by the author to address review comments.

ACKNOWLEDGMENTS

This research was made possible through material and financial support from the National Science Foundation (OPP# 1108367), Jean and Ray Auel, Akira Matsui, and Pacific Northwest Archaeological Services. I would also like to thank the U.S. Forest Service archaeologists Timothy Marshall, Risa Carlson, and Shona Pierce, the native communities of Craig and Klawock, and all the volunteers who helped with excavations at Labouchere Bay.

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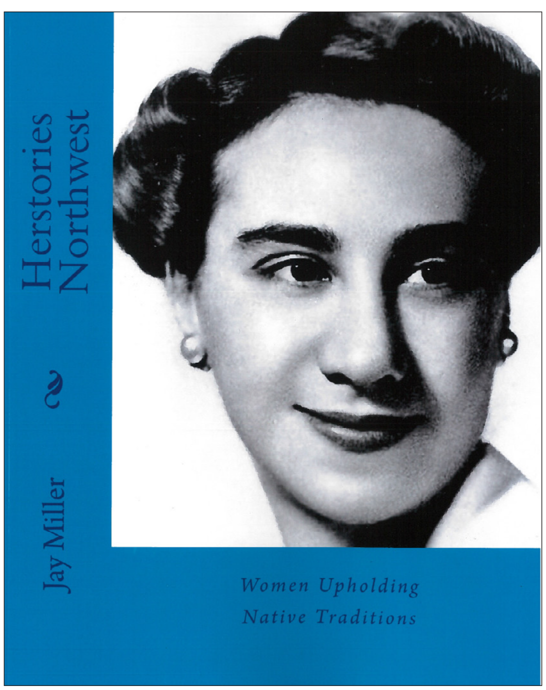

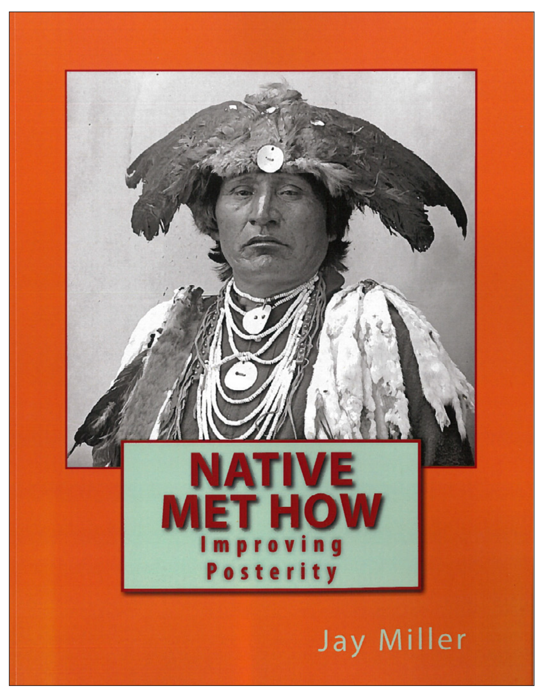

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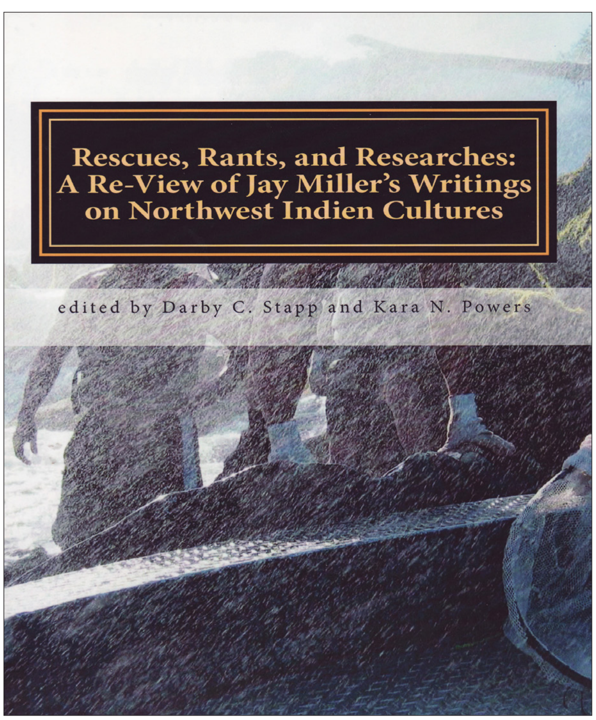

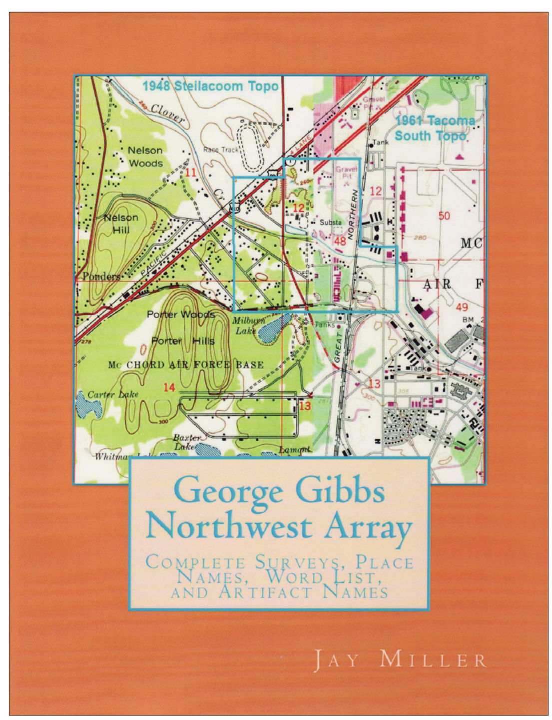

Journal Of Northwest Anthropology

Spring 2017

ISBN 9781544054407

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