Holocene Maritime Hunter-Gatherer Lithic Assemblage Variability in the Eastern Aleutians, Alaska: Planning, Provisioning and Predictability

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Abstract

This dissertation investigates toolstone provisioning and lithic production employed by the maritime hunter-gatherers of Unalaska Bay in the southern Bering Sea during the early and middle Holocene. Lithic assemblage variability in the Holocene archaeological record of the eastern Aleutian Islands has been documented for decades but little attempt has been made to understand the underlying causes affecting hunter-gatherer technological strategies and how they contribute to variability. Early and middle Holocene hunter-gatherers were faced with a great deal of uncertainty and shifting coastal landscapes as a result of post-glacial sea-level rise, isostatic rebound, retreating and advances glaciers and variable sea ice conditions affecting the spatial and temporal distribution of key prey species. As an adaptive response to environmental conditions lithic technological systems, that is lithic production and its organization in space and time, reflect future-oriented strategies employed to offset risks associated with unpredictable environments. In this study I use lithic data from three assemblages in Unalaska Bay, Unalaska Island to compare toolstone provisioning and lithic production between the early and middle Holocene. Reconstruction of technological systems at the middle Holocene Margaret Bay (UNL-048) and early Holocene Russian Spruce (UNL-115) occupations is done using Minimum Analytical Nodule Analysis providing a line of evidence with which to assess toolstone procurement and transport. As a specialized form of transported toolkit, microblade technology and variation in production techniques across time in Unalaska Bay are also documented. Finally, this study employs quantitative techniques to characterize the lithic landscape of Unalaska Bay and to systematically distinguish between the material economies of local and non-local toolstone.

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Chapter 1: Introduction

This dissertation presents the results of archaeological research pertaining to technological organization of maritime hunter-gatherers of the eastern Aleutian Islands during the early and middle Holocene. The dissertation is composed of three papers each of which is in preparation to be submitted to peer-reviewed journals for publication. Chapter 2 presents information on the availability of lithic material suitable for chipped stone tool production within Unalaska Bay derived from field survey and systematic sampling of beach gravel deposits, and identifies and compares toolstone procurement patterns in three artifact assemblages. Chapter 3 describes microblade technology in early and middle Holocene occupations in Unalaska Bay based on technological analyses of cores and production debris and an evaluation of material economies. Variability in Aleutian microblade production technique is identified and related to changes in organizational strategies of mobility and tool design. Chapter 4 presents a cumulative view of technological organization based on site-based assessment of assemblage variability and diachronic comparison of three lithic assemblages within Unalaska Bay. The results of this research program contribute to an understanding of the Aleutian archaeological record by (1) quantifying and evaluating lithic assemblage variability based on lithic production technology; (2) evaluating future-oriented strategies of lithic production from an organizational perspective; and (3) advancing a behavioral explanation of diachronic variability based in the theoretical perspective of behavioral ecology.

The organization of technology is a conceptual framework defined by Nelson (1991:57) as the "selection and integration of strategies for making, using, transporting, and discarding tools and the materials needed for their manufacture and maintenance." These integrated strategies refer to a network of interdependent decisions and outcomes of long-term planning that involve both the design of tools and toolkits as well as the spatiotemporal distribution of their production and use. As such, lithic production is structured by the anticipation of activities and tasks for which tools or toolstone are required and the configuration of these activities in time and space. As such, the degree to which activities and their locations are predictable plays a significant role in organization of lithic technology.

Because toolstone must be obtained to make tools and because lithic tools are most frequently made in advance of use, advanced planning and provisioning of toolstone and tools are critical components of technological organization (Binford 1979; Kuhn 1992, 1994; Sellet 2013; Torrence 1989). Through the analysis of lithic artifacts that are both durable and numerous, provisioning and planning are visible in the archaeological record. With a better understanding of future-oriented strategies in the Aleutian technological system, we also gain a foundation from which organizational strategies, including land use and subsistence systems, can be inferred, even when direct lines of evidence, such as faunal remains, are lacking, as is often the case in the Aleutian Islands.

Situated at the boundary of the North Pacific Ocean and the Bering Sea, Unalaska Bay (Figure 1) is among the most intensively studied areas within the remote Aleutian Island archipelago (e.g., Bank 1953; Dall 1877; Davis and Knecht 2008, 2010; Dumond and Knecht 2001; Hatfield 2011; Hrdlička 1945; Jochelson 1925; Knecht and Davis 2001, 2007; Knecht et al. 2001; McCartney 1967; Rogers et al. 2009; Veltre et al. 1984). Archaeological evidence at three sites in the eastern Aleutian Islands shows that humans have inhabited the region since ca. 9,000 years ago, with initial occupation occurring soon after the Younger Dryas climatic interval and the submergence of Beringia due to post-glacial sea level rise (Hoffecker and Elias 2007). Human groups inhabiting coastal area of the Bering Sea during the early and middle Holocene would have experienced dramatic climatic fluctuations and spatially and temporally variable environmental conditions as the relatively warm waters of the North Pacific Ocean breached the passes between islands and mixed with colder water of the Bering (Manley 2002). These maritime-adapted hunter-gatherers had to contend with the effects of deglaciation and associated landscape processes (Black 1975, 1976; Kaufman et al. 2011; Persico et al. 2018), post-glacial sea level rise (Lambeck et al. 2014), as well as an increase in the frequency of volcanic activity (Miller and Smith 1987; Okuno et al. 2017).

The recently established cultural-historical framework of the region (Table 1), as defined by Knecht and Davis (2001) and Davis and Knecht (2010), reflects broad shifts in lithic and bone tool types and technological repertoires within a generally continuous cultural sequence (Hatfield 2011; Knecht et al. 2001). Unifying similarities in Aleutian technology through time have been argued by some scholars to be a consequence of the maritime orientation that is required to inhabit these islands (McCartney 1984), rather than linear developments within a single cultural system (e.g. Laughlin 1980). The degree of insularity versus outside influences or population migrations is a recurring theme in efforts to make sense of the technological variability in the Aleutian archaeological record. Recent research has demonstrated through multiple lines of evidence that substantial human contact with the Kodiak area occurred approximately1000 years ago (Misarti and Maschner 2015; West et al. 2018), correlating with both a shift in genetic composition (Coltrain et al. 2006; West et al. 2007) and material culture (Davis et al. 2016; Holland 2001). Substantial questions remain regarding the early and middle Holocene records, including the origins and cultural affiliations of microblade producers in the Aleutian Islands and their relationship to producers elsewhere in Alaska and the Pacific Northwest, the impact of seasonal variability in resource distribution on subsistence-settlement systems and lithic production, and the factors driving middle-Holocene expansion westward across the island chain.

The origin of the maritime-adapted hunter-gatherers of the Aleutian Islands is a subject of debate that is based, unfortunately, on scant direct evidence. Two predominate models are at the center of the issue and are reduced to their basic premises here. According to the first model, the islands were populated by a generalized coastal-oriented variant of the Paleoarctic Tradition (Dumond 1987, 2001) with its closest cultural affinities on the Alaska Peninsula or the Pacific Northwest Coast. The second model posits that the seemingly unique maritime adaptation represented by the earliest inhabitants of the Aleutian Islands developed on the southern shores of Beringia (Aigner 1976; Laughlin 1975, 1980), to which the eastern Aleutian Islands were connected prior to inundation of the Bering platform. Modern *Unangan* are genetically most closely related to the Chukchi and Siberian Eskimos (Rubicz et al. 2003) and are estimated to have diverged from these populations, thereby forming a distinct genetic group by the middle Holocene (Zlojutro et al. 2006; Rubicz and Crawford 2016). This chronology coincides with region-wide archaeological evidence for development of a centralized settlement pattern.

The centralization may have developed over time as re-use of locations became more common, possibly driven by increased population density in the east, leading to westward expansion, possibly by groups carrying specialized bifacial projectiles in their toolkit. Because of the small number of sites excavated from which to draw inferences, it is also possible that the extant record simply reflects differential site types, perhaps seasonally occupied, within an otherwise static settlement system. Alternatively, the apparent pattern may be a factor of archaeological visibility in the context of landscape evolution. The preservation of evidence for repeated use of key locations as residential bases near the shoreline after 6,000 cal BP may be a function of post-glacial sea level stabilization unrelated to changes in settlement or subsistence organization. There is a very real need for detailed investigations of technological variability within this timeframe to better understand the relationship of the early and middle Holocene occupations in terms of subsistence and land use.

Paleoenvironmental Context

Following the Last Glacial Maximum (LGM), Unalaska Island remained joined to neighboring islands to the west and the Alaskan mainland in the east by a combination of lowered sea level and the extensive Alaska Peninsula Glacier Complex (APGC) (Kaufman et al. 2011). Glacial ice extended from mountain peaks to the exposed continental shelf (Drewes et al. 1961; Thorson and Hamilton 1986), leaving little habitable land. Deglaciation of the APGC began as early as 17,000 cal. BP (Misarti et al. 2012) and was complete by 12,000 cal BP (Mann and Peteet 1994). Geomorphological evidence in the eastern Aleutian Islands place glacial retreat of the area by 11,000 cal BP (Thorson and Hamilton 1986). Basal radiocarbon ages on two peat deposits on Unalaska Island demonstrate that vegetation cover had developed by ca.10,000 cal BP (McConnell et al. 1997; Okuno, personal communication, 2017). Dry land may have been available to terminal Pleistocene foragers in the eastern Aleutian Islands, but the extant record of occupation does not begin until nearly a millennium later. Rising sea levels during the postglacial inundated shallow island passes separating Unalaska from the Alaska Peninsula (Manley 2002). Because the earliest Aleutian sites are situated in maritime settings that lack evidence for terrestrial fauna, and because watercraft would have been required to reach Unalaska, it is likely that the people who arrived in Unalaska Bay were already adapted to the marine environment, including the use of watercraft.

Post-glacial global sea-level rise stabilized about 7,000 years ago with a continued, much slower rate of rise until 4,000 years ago (Lambeck et al. 2014; Smith et al. 2011). Case studies of paleoshorelines and relative sea-level rise in the North Pacific generally agree with global models for stabilization by 7,000 years ago, but underscore the dynamic and locally variable processes influencing this tectonically active region (Crowel and Mann1996). In the Aleutian Islands, episodic effects of tectonic or volcanic processes may have spatially discontinuous impacts on relative sea level. In conjunction with the effects of isostatic rebound (Carlson and Baichtal 2015; Jordan 2001; Jordan and Maschner 2000), there is a complex and highly localized history of landscape evolution and relative sea-level rise for the eastern Aleutian Islands. Holocene variation in relative sea level is marked on northwest Unalaska Island by hanging, glacially-carved valleys as well as strandline beaches and bay-mouth bars. However, no comprehensive studies of marine transgressions or regressions have been completed in this area.

The timing and impacts of the Holocene Thermal Maximum (HTM) in the southern Bering Sea are not yet well understood (Cassie et al. 2010), but bounding dates of 11,000 to 7,000 cal BP derived from pollen records on the Alaska Peninsula (Kaufman et al. 2016) place the initial peopling of the Aleutian Islands during this climatic interval. Colder than modern conditions at ca. 7,000 cal BP in the central Aleutians (Savinetsky et al. 2012) corroborates a late ending for the HTM in the region. Wide-scale evidence across southwest Alaska documents a period of glacial advance ca. 4,500 – 2,700 cal BP, referred to as the Neoglacial (e.g., Badding et al. 2013; Barclay et al. 2009; Calkin et al. 2001; Heusser et al. 1985; Mann et al. 1998). On Unalaska Island, ice-obligate species, most notably ringed seal pups, are present in archaeological contexts between 5,000 and 3,000 years ago (Crockford and Frederick 2007;

Davis 2001) and suggests that seasonal sea ice was within the foraging range of Aleutian hunters-gatherers.

Spatial and temporal fluctuations in sea surface temperatures and salinity through the Holocene in the Bering Sea and North Pacific (Hunt and Stabeno 2005; Savinetsky et al. 2012) have altered the structure and productivity of marine ecosystems (Causey et al. 2005; Crockford and Frederick 2011; Finney 2002; Ladd et al. 2005; Logerwell et al. 2005; Misarti et al. 2009; Savinetsky et al. 2012). Evidence for temporally variable distributions and productivity counters the often implicit assumption that maritime ecosystems in the Aleutians have been stable and predictable through the Holocene, particularly as the topic bears on models of colonization and cultural evolution (e.g., Black 1976; Laughlin 1975, 1980; Yesner and Aigner 1976).

Research Objectives

Changes in material culture and lithic technology have long been recognized in Aleutian prehistory. It is the objective of the studies comprising this dissertation to initiate development of an integrated theory of Aleutian lithic technology through which the behavioral significance of assemblage variability can be more widely understood. I use a site-level analysis and diachronic approach to reconstruct lithic production technologies at three occupations in Unalaska Bay. Timing and spatial variation in resource distribution is a critical component in hunter-gatherer organizations. Lithic resources are relatively stable, and therefore evidence for toolstone procurement and provisioning at sites with close proximity of one another serves to hold distance to lithic source areas constant, thus allowing investigation of variability in use of procurement areas and artifact transport.

This dissertation builds on previous research related to Aleutian lithic production technology. Data collection protocols were designed to allow for future comparisons to the extensive technological reconstructions of the Anangula site (Aigner 1978, Del Bene 1981). The focus on technological sequences of production rather than "end product" typologies allows for a dynamic view of hunter-gatherer adaptive behaviors related to toolstone selection, tool production, and discard.

Sites and Assemblages

Lithic data from two sites positioned near the modern shoreline of Unalaska Bay (Figure 1) are used to compare procurement patterns between middle and early Holocene occupations. I analyzed lithic assemblages from the Margaret Bay site, Level 4 and Level 5 (hereafter, MB-4 and MB-5), dating to the middle Holocene, and from the early-Holocene single-component Russian Spruce site (hereafter, RS) (Table 2). In the course of excavations conducted through the Museum of the Aleutians, Richard Knecht and his colleagues recovered the materials included in this analysis. Lithic assemblages from both sites have been described previously (Dumond and Knecht 2001; Knecht et al. 2001) and were instrumental in establishing the culture-historical framework and chronology for the eastern Aleutian Islands (Davis et al. 2016; Davis and Knecht 2010, Knecht and Davis 2001). Table 2 provides a summary of reported site chronologies based on radiocarbon determinations derived from wood charcoal. The calibrated radiocarbon ages of occupation are corroborated by their stratigraphic positions in relation to the Makushin Pyroclastic Flow (MPF), a well-dated and prominent chronostratigraphic marker in the region deposited during the crater-forming eruption of Mt. Makushin ca. 9,000 years ago (Bean 1999; Beget et al. 2000; McConnell et al. 1997; Miller and Smith 1987).

Analysis includes all cores, tools, and blade/microblades recovered from each of the three assemblages (Table 2). All debitage from RS was analyzed, and complete debitage assemblages from MB-4 and MB-5 were sampled from two excavation units (4 m^2). For all three assemblages, debitage < 2 cm in maximum dimension were excluded from technological analysis, but are included as bulk weights by material type. The analyzed material was coded for lithic material type, cortical attributes, and metric data. Dorsal cortex quantity was classified using five ordinal categories (none, <10 %, 10-50%, 51-90%, >90 %). Lithic material type was determined by macroscopic examination of color, texture, luster, and grain-size (after Leudtke 1992). Lithic material groups were further distinguished using up to 60x magnification as needed. Detailed monitoring of toolstone type as well as minimum analytical nodule analysis were employed with each assemblage to aid in reconstruction of on-site reduction strategies and toolstone procurement and transport patterns exhibited at each site.

The Margaret Bay site is located on Amaknak Island and within the town of Unalaska (Figure 1). The site is situated on a bedrock knoll approximately 18 m above sea level (absl) overlooking Illiuluk Harbor to the east. Varied degrees of land development, including land-filling of the surrounding low lying marshy areas during the construction of Fort Mears in 1940, have impacted the immediate vicinity of the site. The Margaret Bay site is stratified, with four cultural layers (Figure 2) spanning from approximately 6,000 to 2,500 cal BP, of which the two lower levels, Level 5 and Level 4, are included in this analysis. The artifacts analyzed in this study comprise the complete assemblages recovered during the 1999 and 2000 excavations of a contiguous 76m^2 block. Level 5 was recorded across the entire excavated area of the site, but Level 4 was restricted to a 27m^2 area of the excavation block.

The basal cultural layer of Margaret Bay, MB-5, occurs within a matrix of predominately air-fall tephra and is buried 1.5 to 2 m below the modern ground surface. This component contained a dense lithic scatter with few post-molds, charcoal stains, and concentrations of ochre. A single conventional radiocarbon age of 5250±70 dates the occupation of MB-5 to about 6,000 cal BP. Level 5 is situated 10-20 cm above the MPF, which in this location lies conformably on bedrock. MB-5 is overlain by approximately 1.5 m of stratified tephra and anthropogenic deposits.

Directly overlying MB-5 in a portion of the excavation block is a dense accumulation of vertebrate and invertebrate faunal remains that comprise MB-4. Four conventional radiocarbon ages (Knecht et al. 2001:42) place the accumulation of this midden deposit in the range of 4,600 to 5,500 years ago. The preservation of fauna at this location is notable; organic remains of this age are not common in the region due to the acidity of the volcanic soils and sediments, except where shells of bivalves are also present to neutralize the matrix. Along with the midden deposits at the Tutiakoff site (ADK-171) on Adak Island that accumulated between 6,000 and 7,000 cal BP (Crockford 2012; Savinetsky et al. 2012), and at the Agnes Beach site (UNL-046) in Unalaska Bay with a calibrated radiocarbon age of 5,880±142 cal BP (Knecht and Davis 2001), the MB-4 midden is among the oldest fauna-bearing sites in the Aleutians. Even more remarkable is the inclusion of multiple ice-obligate mammalian species (Crockford and Frederick 2007; Davis 2001), in addition to the typical Aleutian inventory of Stellar's Sea Lion (*Eumetropias jubata*), Harbor Seal (*Phoca vitulina*), and Northern Fur Seal (*Callorhinus ursinus*) (Crockford 2012).

For Chapter 3, lithic artifacts related to microblade and blade technology from Margaret Bay Level 2 (MB-2) and Level 3 (MB-3) are analyzed to investigate changes in these production technologies into the latter part of the middle Holocene (Table 2). Consideration of these materials is restricted to the analyses presented in Chapter 3 of this dissertation and details of those artifacts are available therein.

The Russian Spruce site is located on Hog Island, a relatively low-lying islet within Unalaska Bay (Figure 1). The site is situated 100 m from the modern coastline on a slightly sloping landform approximately 19 m above sea level. Wind action eroded as much as two meters of bedded soil and tephra layers, exposing the MPF deposit on the deflated surface (Figure 4). Excavations exposed a lithic artifact scatter from a single cultural zone 2-5 cm thick and stratigraphically situated directly beneath the MPF (Figure 3). Beneath the cultural zone, a sequence of bedded tephras 30-50 cm thick overlies bedrock. In addition to abundant chipped stone, a shallow depression ringed by post molds and a hearth were recorded in the 28 m^2 of area excavated. Charcoal from the hearth feature yielded an AMS age of 7,950±90 uncalibrated years BP, while a bulk sample of scattered charcoal in the cultural layer returned a conventional radiocarbon age of 8,050 ±80 (Dumond and Knecht 2001:12). These dates are congruent with the age for deposition of the MPF (Bean 1999; Beget et al. 2000; McConnell et al. 1997) placing both the occupation of the site and the crater-forming eruption of Makushin Volcano at ca. 9,000 years ago.

Analytical Methods

All artifacts utilized in this study are housed at the Museum of the Aleutians, Unalaska, Alaska. Attribute and metric data pertaining to technological or typo-technological traits were collected for all chipped stone artifacts. Metric data for all artifacts used in the study were collected using an Ohaus Scout Pro digital scale and Control Company Traceable digital calipers, and for core platform angles, a Flexion goniometer was used.

Lithic material identification was done macroscopically, often with the aid of a loop with 10x magnification. For very fine-grained volcanic materials identification and toolstone type groupings required the use of greater magnification to examine groundmass and phenocryst traits. A stereo optic microscope providing magnification up to 100x was utilized as needed in such cases.

During field survey of local beach gravels and geologic outcrops, geologic samples were weighed using a PESOLA MS1000 digital scale. Size measurements were taken using a standard tape measurer and rounded up to the nearest 0.5 cm. Form was recorded based on visual examination using procedures outlined by Powers (1935). The distance between sample locations (50 m) was determined by pacing, and the location of all samples was recorded using a Garmin 64s hand-held GPS device.

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Table 1. Characteristic traits of the five phases of the eastern Aleutian Cultural Sequence.

	EARLY ANANGULA 9000 – 7000 cal. BP	**LATE ANANGULA 7000-4000 cal. BP**	**MARGARET BAY 4000-3000 cal. BP**	**AMAKNAK 3000-1000 cal. BP**	**LATE ALEUTIAN 1000 – 200 cal. BP**
Dwellings	Small depressions, tent-like structures	Undefined/ Post Molds	Semi-subterranean, rock-lined, oval	Semi-subterranean, rectangular	Semi-subterranean, longhouses and multi-room
Lamps	Present	Present	Present	Present	Present
Net Sinkers	End-notched	?	Grooved	Elongated, grooved	End-notched
Harpoons	?	Bilateral barbed, with line guards	Unilateral barbed, toggles	Elaborate barbed	Bilateral
Needles	?	Eyed	?	Eyed	Knobbed
Labrets	None	None	Present	Present	Present
Bifaces	None	Projectile Points, Adze, Wedge	Projectile Points, Adze, Wedge	Projectile Points, Adze, Wedge	Projectile Points, Adze, Wedge
Microblades	Abundant	Abundant	Present	None	None
Blade	Abundant, prismatic	Present, Prismatic	Present	None	None
Burins	Transverse, common	Rare	Rare	None	None
Art	?	?	Present	Present	Present

Table 2. Assemblages analyzed**.**

Context	**Lithics Analyzed**	**Radiocarbon Years BP**	**Calendar Years BP* (2sigma)**	**Cultural Phase**
Margaret Bay Level 2	Total = 229	3270 +/-70 3110 +/-60 3280 +/-70	3430 – 3588 3259 – 3390 3442 – 3600	Margaret Bay
Margaret Bay Level 3	Total = 171	3630 +/-70	3866 – 4062	Margaret Bay
Margaret Bay Level 4	Tools = 553 Cores = 20 Debitage = 660 Total = 1233	4130 +/-40 4520 +/-60 4660 +/-80 4700 +/-40	4591 – 4783 5070 – 5279 5311 – 5519 5352 – 5546	Late Anangula
Margaret Bay Level 5	Tools = 663 Debitage = 642 Cores = 66 Total = 1371	5250 +/-70	5954 – 6153	Late Anangula
Russian Spruce	Tools = 365 Debitage = 774 Cores = 14 Total = 1153	7950 +/-90 8050 +/-80	8672 – 8951 8783 – 9057	Early Anangula

*Calibrated with CalPal2007_HULU curve; no corrections applied.

Figure 1. Location of Unalaska Island and site locations within Unalaska Bay.

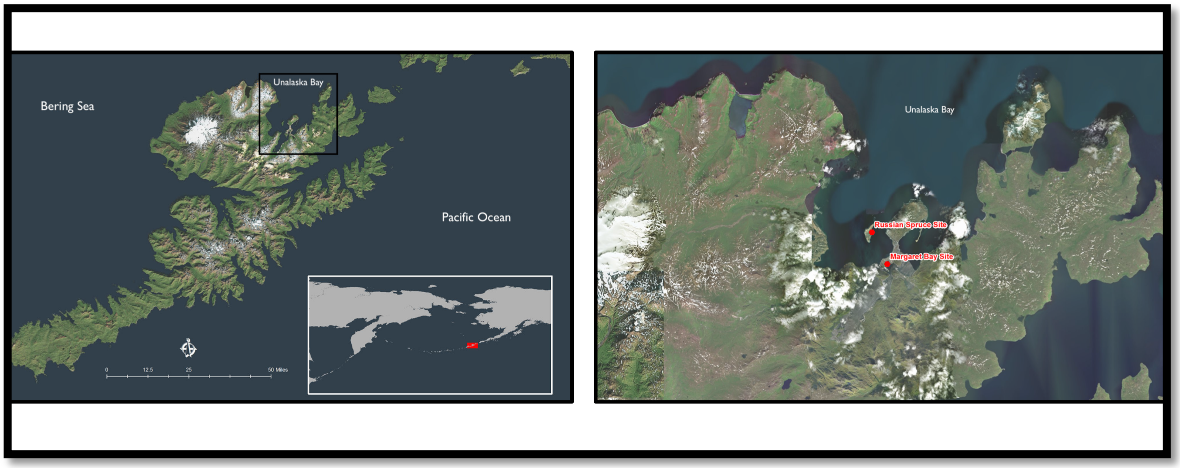


Figure 2. Stratigraphic profile at Margaret Bay (adapted from Knecht et al. 2001).

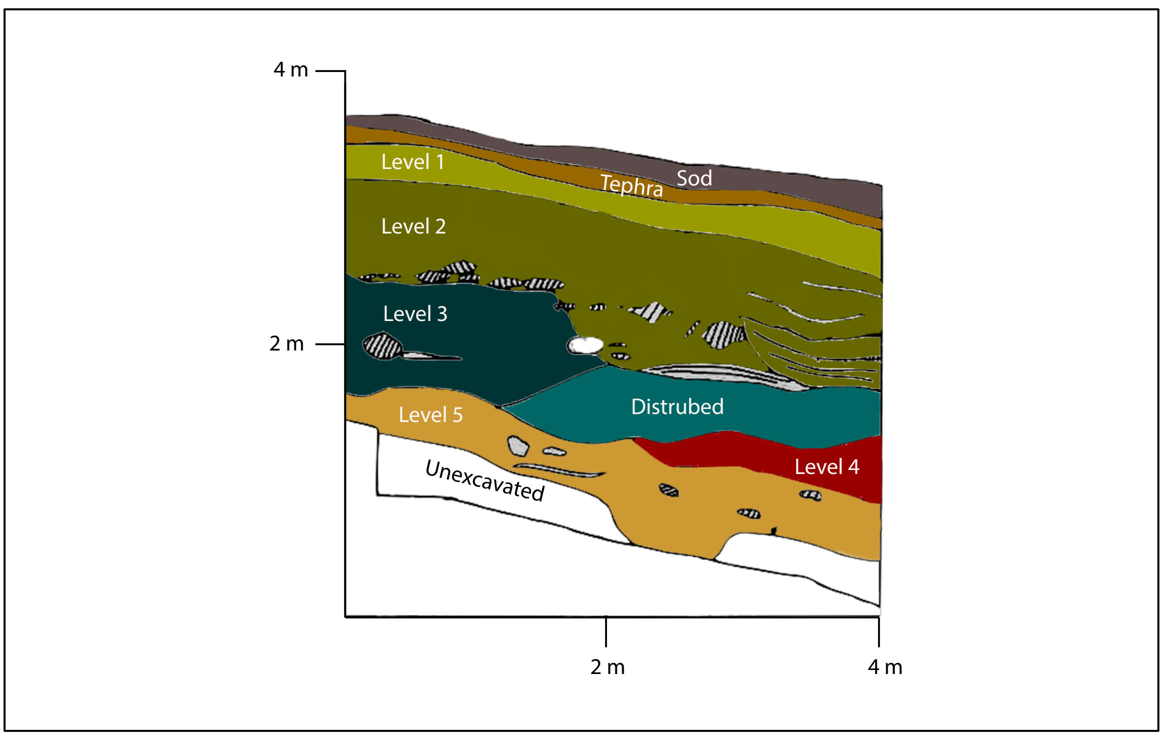
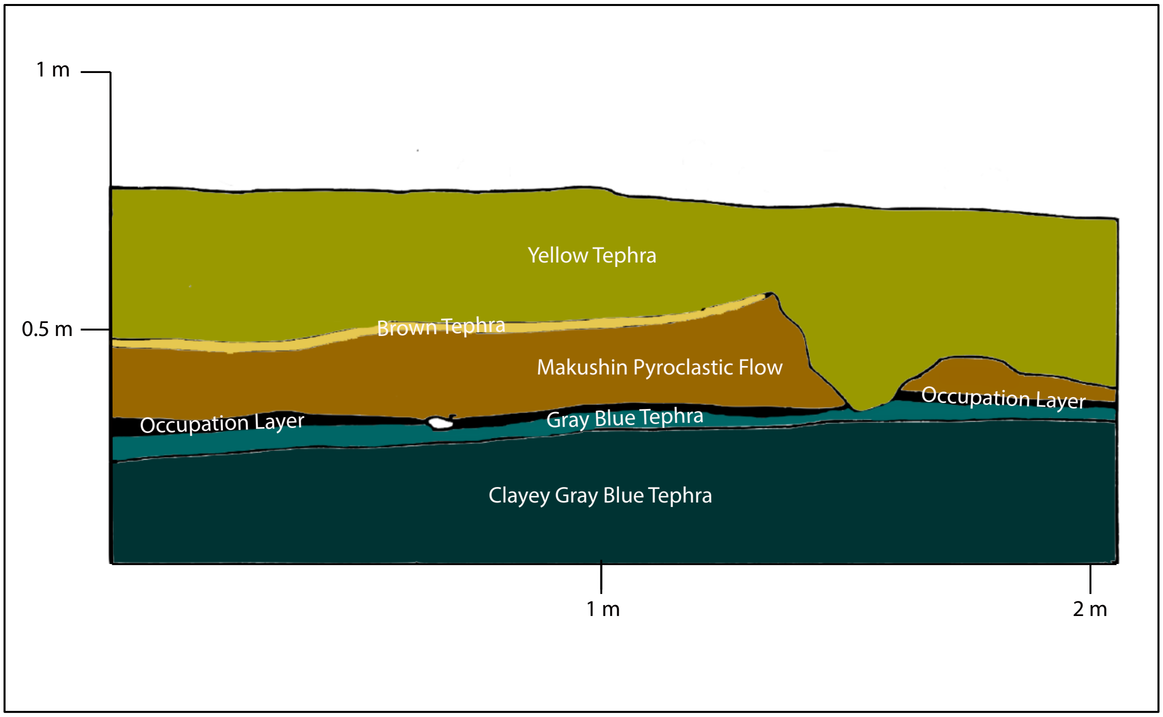


Figure 3. Stratigraphic profile at Russian Spruce (adapted from Dumond and Knecht 2001).



Chapter 2: Toolstone Procurement Patterns and Gravel Deposit Source Areas in Unalaska Bay, Alaska

In preparation for: Journal of Field Archaeology

Abstract

Gravel deposits were systematically sampled in Unalaska Bay, Alaska, to (1) identify variability in local secondary toolstone sources, and (2) investigate *Unangax* procurement patterns and toolstone selection through time. Technological variability and typological changes through the Holocene are documented in the eastern Aleutian archaeological record; however, the underlying causes of shifts at ca. 7,000 and 5,000 cal BP, a time of substantial environmental variability, have not been evaluated from a perspective of technological organization and long-term planning. The high-quality toolstones most often selected for lithic production are not abundant within the local foraging range of Unalaska Bay sites. This finding suggests that procurement and transport costs were important in Aleutian hunter-gatherer decisions, ultimately structuring lithic technological systems and contributing to assemblage variability. Comparisons of Unalaska Bay lithic assemblages spanning the early to middle Holocene reveal not only variability in toolstone selection and use of locally available toolstone, but also a pattern of toolstone procurement from unknown distances outside of Unalaska Bay.

Introduction

Gravel deposits were important source areas exploited for lithic material needed for stone tool production throughout prehistory. These secondary deposits, whether fluvial, residual, or glacially formed, provide access to tool-quality lithic materials (hereafter, toolstone) at locations dispersed over a wider geographic range than are most primary *in situ* outcrops, thereby extending the spatial distribution of toolstone across the landscape (Backhouse et al. 2009; Shackley 1990, 1992; Shelley 1993; Wyckoff 1993). Because lithic materials in secondary deposits have been subjected to mechanical and chemical weathering, archaeologists often consider them to be of lesser quality and technological utility than material obtained from primary outcrops. Nevertheless, their persistent utilization as toolstone sources beginning with the earliest evidence of lithic technology in human evolution (Potts 1991; Schick and Toth 1993) attests to the significant role gravel deposits have played in supplying hunter-gatherer tool kits. In many areas of the world, secondary deposits are among the most productive sources of lithic material exploited (Kelly 1985; Shackley 1990; Thacker 1996).

Recognizing exploitation of secondary deposits (Haury 1994) versus primary outcrops in the archaeological record has significant implications for understanding patterns of land use, material economies of local and non-local toolstones, as well as economizing and curation practices in the organization of lithic technological systems. More to the point of this study, identification of toolstone procurement patterns and selection in lithic assemblages of hunter-gatherers is a method by which future-oriented technological strategies are visible in the archaeological record (Nelson 1991). The natural distribution, abundance, quality (i.e. availability), and accessibility of toolstone on the landscape underpins the ability for mobile hunter-gatherers to plan ahead for lithic material needs, and contributes to assemblage variability through decisions regarding lithic production (Andrefsky 1994; Bamforth 1986; Ingbar 1994) and organizational strategies (Hofman 1991, 1999; Thacker 1996). Therefore, at least a working knowledge of regional toolstone sources is fundamental to an investigation of anticipatory behaviors manifested within lithic technological systems.

Many toolstone types were utilized for chipped stone tool (hereafter, lithic) production by the people of Unalaska Bay on the northeast of Unalaska Island (Figure 1), including obsidian, a range of fine-grained to microcrystalline volcanic rocks, and a diverse variety of siliceous rocks with cryptocrystalline structure. Preferential use of some of these materials for specific tool classes has been observed by previous researchers (e.g., Del Bene 1992; Dumond and Knecht 2001; Hatfield 2011; Knecht et al. 2001). Also, some researchers have posited that changes in toolstone availability may underlie technological variation, specifically the shift away from blade and microblade production in favor of biface production ca. 7,000 cal BP (e.g., Aigner 1978; Gomez Coutouly 2015; Mason and Aigner 1987). Such observations are often predicated on an incomplete understanding of regional toolstone distribution and the circulation of toolstone within the technological system. As a relatively stable and predictable, though spatially discontinuous, resource necessary for lithic production, the exploitation of toolstone source areas was a component of technological organizational integrated into decisions concerning mobility and technological provisioning.

Yet, the lithic landscape of Unalaska Bay, and the region more generally, is virtually unknown. No toolstone source areas or sites of lithic material exploitation are documented on Unalaska Island. Gravel deposits are common on the shoreline of Unalaska Bay and could have served as toolstone source areas (e.g. Knecht et al. 2001:43; Veltre et al. 1984:64) when and if they contain suitable lithic material types. However, lithological characterization of beach gravel contents, including the types and relative abundance of potential toolstone types within them, thus far is lacking. This study takes an initial step in assessing toolstone availability in Unalaska Bay through systematic sampling of gravel deposits on five Unalaska Bay beaches, providing important contextual information for analysis of assemblage variability and toolstone procurement patterns utilized by Holocene hunter-gatherers.

Background and Research Objective

Lithic assemblages of Unalaska Bay contain a range of lithic material types. Cryptocrystalline silicates (CCS) and obsidian are well represented in lithic production at sites spanning the Holocene. Volcanic rocks are more numerous, with aphyric or porphrytic varieties exhibiting moderately fine to fine-grained groundmass being particularly common. Though volcanic rocks used for tool production are by convention often referred to as “basalt” by regional archaeologists, such a grouping comprises a range of igneous lithologies and is here divided into three categories based on visual examination of texture and phenocryst abundance. The most inclusive and numerically abundant category is comprised of fine-grained and porphrytic materials that are termed here fine-grained non-glassy lava (NGL-fg). Other non glassy lava rocks, generally porphrytic varieties of andesite or basaltic andesite (NGL-mg), constitute a minor proportion of lithic assemblages in Unalaska Bay. For the purposes of this study and its focus on toolstone selection and procurement decisions, the primary distinction between the more coarse textured non-glassy lavas and those that are with finer-grained texture lies in their differential knapping properties and the duration of tool use lives. Coarse varieties of non-glassy lava (NGL-mg) exhibit poor conchoidal fracture but are sufficiently knappable to have been utilized for a limited range of expediently produced chipped stone tool types. More often NGl-mg cobbles were selected for ground or pecked stone items such as net-sinkers, ochre grinders, or even lamps, and also were used as hammerstones. In contrast, NGL-fg rocks exhibit good to excellent conchoidal fracture, and were regularly used to produce a wide range of chipped stone tool types. For this analysis I distinguish a third variety of volcanic rock termed here fine-grained volcanic (FGV), with very fine to microcrystalline texture that in some specimens are glassy. FGV rocks are notably elastic and exhibit excellent conchoidal fracture.

They are common components of Aleutian artifact assemblages, although previous technological analyses have not systematically isolated FGV within Aleutian assemblages.

As the above discussion highlights, technical identification of toolstone types utilized in Aleutian prehistory is lagging. This is a consequence in large part to the diverse lithologies that exist across the island chain as a consequence of the complexity of volcanic and tectonic formation processes and variation in the chemical composition of source material generated by more than 50 Aleutian volcanoes active during the Quaternary. Few lithic sourcing studies have been conducted within the remote and insular Aleutian Islands (but see Laughlin and Marsh 1954 and Mason and Aigner 1987), leading to a situation where, with the exception of much of the archaeological obsidian (Cook 1995; Reuther et al. 2011; Nicolaysen et al. 2012), source areas for toolstone remain largely unknown. The results presented here regarding the character of the lithic landscape local to Unalaska Bay reflect an early stage of research aimed to locate and identify toolstone source areas on Unalaska Island.

This paper has four objectives: (1) characterize and quantify the lithic material types and abundance in beach gravel deposits of Unalaska Bay; (2) to create a toolstone material classification scheme based on macroscopically visible properties of lithic artifacts; (3) document and compare toolstone selection and procurement strategies represented in three excavated assemblages from Unalaska Bay sites; and (4) assess the role of toolstone selection in creating assemblage variability. I employ field survey and lithic assemblage analysis to determine if local toolstone availability impacts material provisioning strategies of area hunter-gatherers and how these strategies may have changed between the early and middle Holocene.

Study Area

Geologic Setting

Located in the Fox Island group of the eastern Aleutian Islands, Unalaska Island (Figure 1) is the second largest in the Aleutian chain with a landmass of 2,720 km^2. The coastline on the northern portion of Unalaska Island is complex, with rugged and rocky headlands and many fjord-like bays and inlets. Unalaska Bay is a large, deep-water embayment on the northeast of Unalaska Island opening to the Bering Sea. The bay has a surface area of 168 km^2 and a coastline perimeter of nearly 76 km. Where not impacted by modern development, the shoreline is dominated by rocky headlands and steep cliffs, with many pocket and bay-head beaches composed of clasts ranging from boulders to fine sand. The island's terrain is rugged and mountainous, with several peaks exceeding 1000 m. An active, glacier-capped stratovolcano, Mt. Makushin (2,036 m absl), is located on the northern portion of the island. Till interbedded with volcanic tephra and pyroclastic flows forms a $\geq$1 m-thick mantle above bedrock (Bean 1999; Beget et al. 2000; Miller and Smith 1987). The mantle of sediment has been modified by soil development.

As are all islands in the Aleutian chain, Unalaska Island is volcanic in origin, formed during the Neogene through processes driven by subduction of the Pacific Plate beneath the North American Plate. The Unalaska Formation covers the majority of the island, with little internal variation currently mapped (Drewes et al. 1961; Lankford and Hill 1979; Reeder 1982) (Figure 2). Drewes and others (1961:590) described the Unalaska Formation as "a thick sequence of coarse and fine sedimentary and pyroclastic rocks intercalated with dacitic, andesitic, and basaltic flows and sills.". The Dutch Harbor Member of the Unalaska Formation consists of uplifted sub-marine deposits, mostly fine to very fine-grained sandstone and pebble conglomerate dated by the presence of *desmytoid* fossils to the early Miocene (Lankford and Hill

1979). Plutons of the Shaler Range in the central portion of the island and the Captains Bay Pluton at the head of Unalaska Bay were formed by the intrusion of magma into the Unalaska Formation after emplacement of the former (Drewes et al. 1961). This process likely also associated resulted in the formation of numerous dikes and sills that are particularly abundant in and around Unalaska Bay. More detailed geologic mapping of the island has focused on the Makushin Volcanic Field (MVF) (McConnell et al. 1997), where Quaternary activity by Makushin volcano and several satellite vents has deposited numerous lava flows and array of volcanogenic deposits (Bean 1999; Beget et al. 2000; Lerner et al. 2018; McConnell et al. 1997; Nye et al. 1986). The MVF overlies the Unalaska Formation on much of the northwestern portion of the island (Figure 2).

Unalaska Bay forms a catchment for material eroding from the Unalaska Formation and the MVF and transported by three major drainages, the Iliuluik, Nateekin and Makushin rivers, as well as by several lower order drainages. Unalaska Formation and MVF lavas are intermediate, with the majority of mapped lava rocks having compositions ranging from basaltic andesite to andesite (Drewes et al. 1961; McConnell et al. 1997; Nye et al. 1986), and are commonly porphrytic. Holocene tephras and ejecta from Makushin tend to contain higher proportions of silica, ranging from trachyodacite to dacite in composition (Lerner et al. 2018).

The Dutch Harbor Member consists of fine to very fine-grained sandstone in the southeast portion of Unalaska Bay and in the adjacent inland valley of the Iliuliuk River. Mapped exposures of metamorphosed igneous rock are restricted to the southern and northern coastlines adjacent to the Shaler Mountains, and are not documented within the Unalaska Bay catchment.

Toolstone Types Utilized by Aleutian Hunter-Gatherers and their Distribution

Multiple lines of evidence point to potential toolstone sources in the region, and, in combination with the geological maps, demonstrate considerable lithological variability and uneven natural distributions of archaeologically significant lithic materials. The indigenous inhabitants of the Aleutian Islands (*Unangan*) during the early nineteenth century distinguished between several varieties of stone, each favored for their particular working properties and selected for specific tool types (Jochelson 1925:57-59). Unalaska Bay lithic artifact assemblages are comprised of obsidian, a range of extrusive igneous rock generally termed *basalt* by previous researchers, and a diverse variety of siliceous rock with cryptocrystalline structure. Quarries or other toolstone exploitation sites are rare in the Aleutian Islands and no such sites are documented on Unalaska Island. Ethnohistoric accounts of the eighteenth and early nineteenth centuries note that toolstone was at times obtained from considerable distances, whether procured directly or through trade, and inter-island transport of toolstone was common (Jochelson 1925; Dall 1877; Hrdlicka 1945, Venianimov 1984).

According to an early nineteenth century ethnographer, the native inhabitants of Unalaska Bay acquired “basalt….found in many mountains, on Unalaska, as well as on various islands” near the Alaska Peninsula (Venianimov 1984:22). Much of the FGV or NGL-fg materials found in Unalaska Bay assemblages may be from lava extruded in rapid cooling environments such as dikes and sills, many of which have been noted by geologists working in the area (e.g., Drewes et al. 1961; Reeder 1981). On Sedanka Island, located off northernmost portion of Unalaska Island, the reported occurrence of a “green rock resembling obsidian” (Venianimov 1984:96) may be an example of such an outcrop.

Deposits of chemical precipitant sedimentary siliceous rock (i.e., chert) form when lava flows come in contact with water or ice, and occur throughout the Aleutian Islands, but in discontinuous spatial distribution. These colorful siliceous rocks can form as nodules, in veins, or in pockets surrounding pillow lavas. Chert pebbles and cobbles likely derived from such formations occur on Unalaska Bay beaches and are more common in the gravels of Beaver Inlet, the next major embayment east of Unalaska Bay. Cherty nodule deposits in uplifted marine sediments were mapped on the Pacific Coast side of Unalaska Island (Drewes et al. 1961); however, no further description of these materials is provided, and their suitability for toolstone is unknown. Given the high silica content of Makushin tephras (Lerner et al. 2018), silicified tuff deposits may occur on the island, particularly on the western and northern portions of the volcano.

Obsidian has a much better defined range in the Aleutian Islands than do other toolstone types., Two geographic sources possessing unique geochemical signatures are located in the eastern Aleutians (Nicolaysen et al. 2012; Reuther et al. 2011). On Umnak Island 125 km southwest of Unalaska Bay, obsidian outcrops on the northern and eastern portions of the Okmok caldera (Byers 1959:312). Exposures have also been reported on the northern flanks of Okmok, and in beach gravels along the northwestern coastline (Mason and Aigner 1987). On the southeast side of Akutan Island, 60 km from Unalaska Bay, obsidian cobbles and small boulders occur on beaches and within a debris flow exposed in nearby cliff faces (Richter et al. 1998). Artifacts produced from obsidian are well represented in Unalaska Bay assemblages spanning the Holocene. Many obsidian artifacts from Unalaska Bay sites have trace element signatures consistent with Okmok and Akutan outcrops (Cook 1995), including several artifacts analyzed in this study (Rasic personal communication, 2017). Even in the nineteenth century, it is evident from the observations of Venianimov (1984: 22,78, 285) that obsidian from both sources was used in the production of spear points by the inhabitants of Unalaska Bay.

Archaeological Background

The margins of Unalaska Bay contain a record of indigenous occupation from 9,000 years ago to the present. Five broadly continuous techno-cultural phases are recognized in eastern Aleutian prehistory: Early Anangula (9,000 -7,000 cal BP), Late Anangula (7,000 – 4,000 cal BP), Margaret Bay (4,000 – 3,000 cal BP), Amaknak (3,000 – 1,500 cal BP) and Late Aleutian (1,500 – contact) (Davis and Knecht 2010; Davis et al. 2016; Hatfield 2010; Knecht and Davis 2001). This record of precontact occupation represents the initial peopling of the Aleutian Archipelago at ca. 9,000 cal BP (Dumond and Knecht 2001; Laughlin 1975), followed by shifts in technology and dwelling construction, presumably in response to Holocene climate change.

With the exception of biface technology, the lithic industries between the Early and Late Anangula phases are quite similar. Flake core technology predominates, with continued use of blade and microblade reduction trajectories (Hatfield 2011). Lithic tool inventories common to both phases include unifacially retouched flakes and blades, side and end scrapers, burins, and microblades. Bifacial projectile points, knives, wedges and adzes are found in the Late Anangula phase. The division between the Early and Late Anangula phases based on the appearance of bifacial technology may be a consequence of small sample size (cf. Mason 2001) and underscores the fact that more detailed technological analyses and a refined chronology are needed to understand the relationship of these two phases. The knapping mechanics of different toolstone packages has been offered as one potential explanation for the decline in blade and microblade production in favor of bifacial implements. According to Aigner (1978; Mason and

Aigner 1987), blade technology is more common when cobble sources of toolstone are utilized, whereas columnar outcrops are better-suited to production of large flakes necessary for manufacture of bifacical implements. Such claims do indeed highlight a pattern of toolstone selection and technological trajectories that is also documented by analysis of Unalaska Bay assemblages (Chapter 4), but do not address the impact of organizational systems on toolstone availability as a potential factor creating assemblage variability between Early and Late Anangula.

Methods And Materials

Survey Methodology

A three-tiered field survey strategy was employed to assess the distribution and variability of lithic resources in Unalaska Bay to gain a better understanding of local toolstone availability. First, systematic sampling of beach gravel deposits was carried out to generate information about the distribution and variation of gravel sources of toolstone within the bay system. Quantitative and qualitative data were collected on lithic materials comprising gravel deposits, including lithic material type, clast size, clast form, and knapping quality. A volume-controlled sample was collected using a systematic unaligned method at five locations to characterize beach gravel deposits and estimate population parameters within the study area (after Shelley 1993; Steinmetz 1962; Wolcott and Church 1991). Unalaska Bay beaches contain multiple lithologies, the majority of which are not archaeologically significant; however, clasts of potential toolstone occur in low frequencies within these mixed contexts. To extend the relevance of the beach gravel content data to the archaeological objectives of this study, a second phase of survey was deemed necessary (cf. Pearson 1996) to more fully characterize local toolstone sources. Each beach was sampled a second time using a grab-sample technique in which clasts of perceived knappable lithic material were targeted and collected as encountered.

Finally, as conditions permitted, inland and coastal areas were surveyed for outcrops of potential toolstone. Survey was conducted entirely by foot and was restricted to deposits exposed along the coastline and to areas accessible by the road system in and around the community of Unalaska/Dutch Harbor or its inland trails. Hand specimens were collected and geographic coordinates recorded at all outcrops or other exposures of *in situ* lithic material exhibiting sufficiently fine groundmass and homogeneity for conchoidal fracture. Materials collected during all components of the field survey constitute the beginning of a lithic comparative collection housed at the Museum of the Aleutians in Unalaska, Alaska.

Five beaches (No Name Cove, Captains Bay, Nateekin Bay, Broad Bay, Waterfall Cove) were selected for survey to encompass the full range of parent materials within the catchment of Unalaska Bay (Figure 3). I make the assumption that the surface of each beach represents a homogenous deposit with regard to lithological content and abundance due to unbiased mixing of material types. Because the lateral distribution of clast size on the beach surface varies in relation to patterns of sediment load transport and near-shore bathymetry, sample collection units were spaced every 50 m along a transect parallel to the shoreline and extending the length of the beach. For each 10 m of beach face width (between mean low tide and the landward surge berm), an additional transect was added. All surface clasts falling entirely within the 50 x 50 cm sample collection units and with a dimension of 4 cm or greater were collected for analysis (Figure 4). During the second phase of survey, the length of the beach was covered in a single winding transect, and potential toolstone clasts were collected as encountered. These combined sampling methodologies produced a composite sample for each beach adequate to describe population parameters of interest to this research.

A total of 1,232 clasts were sampled and analyzed (Table 1). Clasts were monitored for lithic material type, form (cf. Powers Scale, 1935), knapping quality, and metrics. Lithic material was evaluated macroscopically in the field and categorized as macrocrystalline and porphrytic non-glassy lava rock (NGL-AND), fine-grained and porphrytic non-glassy lava (NGL-mg), fine and very fine-grained aphyric non-glassy lava rock (NGL-fg), microcrystalline aphyric volcanic rock (FGV), other volcanic rock lacking in conchoidal fracture (OTH), or cryptocrystalline silicate (CCS). Visual examination of homogeneity and crystallinity were made on fresh fracture surfaces created with a rock hammer, and aided by 10 x magnification with a hand loop.

Representative samples of knappable materials were transported to the laboratory at the Museum of the Aleutians for additional visual examination and description (after Leudtke 1992), and are included in a lithic comparative collection housed in that facility. Quantitative and qualitative data generated during survey were used to calculate and compare lithic material type frequencies for Unalaska Bay beaches, and to identify potential local toolstone source areas. Information gained from field survey was next used to assess local and non-local procurement patterns in early and middle Holocene assemblages.

Artifact Assemblages and Analysis

Attribute level analysis of lithic tools and debitage from two sites positioned near the modern shoreline of Unalaska Bay (Figure 3) was used to compare toolstone procurement patterns and selection between middle and early Holocene occupations. Analysis included all informal and formal tools and cores and a sample of debitage from Margaret Bay site, Level 4

(MB-4) and Level 5 (MB-5), and all artifacts recovered from the single-component Russian Spruce (RS) site (Table 2). Dorsal cortex was recorded based on an ordinal scale (0, <10%, 10-50%, 51-90%, and <90%). Toolstone types were classified by lithology and further sorted based on macroscopic examination of grain size, luster, color, and inclusions (after Leudtke 1992) using up to 100x magnification as needed.

Results

Toolstone availability: beach gravel contents and outcrops

Frequency distribution of 1,232 clasts in the composite sample from five locations demonstrates that toolstone quality cobbles occur in low frequencies on Unalaska Bay beaches (Figure 5). Non-knappable porphrytic andesite (NGL-AND) in all stages of mechanical weathering dominates the lithic deposits of Unalaska Bay. These clasts, derived from the Unalaska Formation and Makushin Volcanic Field, together with unidentified igneous and other non-knappable rocks, comprise the overwhelming majority (n= 876, 80.1%) of beach gravels. Specimens of porphrytic non-glassy lava with groundmass sufficiently fine to permit weak conchoidal fracture (NGL-mg) is the most frequent potential toolstone material present on Unalaska Bay beaches, accounting for more than three-quarters of the total sample of knappable clasts recorded (Table 2).

Good to moderate quality knappable clasts were rare in the volume-controlled sample (3%); the opportunistic sample strategy was more effective at locating these materials. Overall, knappable clasts occur in very low densities across Unalaska Bay beaches (Table 3). Good to moderate quality cobbles of homogenous fine-grained non-glassy lava (NGL-fg), microcrystalline volcanic rocks (FGV), or cryptocrystalline silicates (CCS) were identified on all beaches sampled. The exceptionally low density of knappable clasts in Broad Bay and Nateekin Bay is due to the fact that these are large bay-head beaches composed predominately of sand. Cobbles and pebbles occur lightly scattered across the beach face, but are concentrated in pockets near the river mouths (sampled), on the landward side of the storm surge berm (not sampled), and on the outer margins of the beach approaching the bounding rocky headlands (sampled). Though clasts are dispersed across a large area, Broad Bay and Nateekin Bay gravels contain a notable array of very fine and microcrystalline volcanic rocks (FGV) suitable as toolstone not found on other beaches in the study area. Observed examples of FGV were usually pebble-sized clasts less than 4 cm in maximum dimension, and therefore were not included in the survey samples. Their presence suggests that primary outcrops of good quality toolstone may be located higher up in the Makushin and Nateekin river drainage systems as constituents of the Makushin Volcanic Field. Nateekin Bay is further notable for its high concentration of moderate to good quality material relative to the other beaches sampled, accounting for nearly half of the total knappable clasts documented at that location.

Cobbles of poor quality CCS occurred in very low frequencies at each sample location, even when those specimens unsuitable for knapping due to internal fractures and other structural flaws are considered. Two unique CCS specimens, however, stand out as being exceptionally high quality for use as toolstone; both were collected during targeted survey of Captains Bay beach. Given that two thin veins of chert have been identified within Unalaska Bay during the course of this fieldwork (see below), and the information shared by locals and professionals familiar with local beach contents, it is highly likely that this survey underrepresents the availability of knappable CCS cobbles in Unalaska Bay beach gravels.

Good and very good quality toolstone cobbles are restricted in frequency (n=11, range = 4 – 7.5 cm (L), mean = 5.95 cm, s.d. 1.17), comprising only 3% of the total knappable clasts identified during survey. Five FGV cobbles documented on Broad Bay are homogenous and microcrystalline, nearly glassy in texture. Documentation of FGV cobbles in the local gravels is a particularly significant outcome of the survey, as visually similar materials are common in the artifact assemblages analyzed and may provide an avenue for geochemical sourcing of these artifacts in the future if primary outcrops can be located. As noted above, survey in Captains Bay produced the only nodule classified as very good quality in the sample; this is a rounded cobble of homogenous black CCS of unknown geographic origin.

Two *in situ* thin veins of chert were documented during the course of survey. A vein of mottled red chert exposed on a bluff edge approximately 300 m absl on the northern portion of Amaknak Island was reported by an area local and confirmed by the author. In the exposed area, the vein was 2-3 cm thick and the material was poor quality. Better quality material may occur in unexamined portions of this vein. In contrast to the Amaknak Island vein, the second vein identified during survey consists of good quality grayish green chert. The chert-bearing vein was 2-4 cm thick and within a bedrock exposure visible in lava flow bedrock in the channel of Pyramid Creek.

Survey for primary outcrops of potential toolstone revealed few outcrops in the vicinity of Unalaska Bay. Three outcrops of moderate quality fine grained porphrytic non-glassy lava were mapped and sampled from dike formations exposed on the shoreline in Captains Bay, Broad Bay, and No Name Cove. Macroscopically, the material is similar to much of the NGL-fg observed as cobbles in the respective beach samples. The sample from the Captains Bay outcrop was examined in thin section and identified as andesite (Pavel Izbekov, personal communication

2019). Although visually similar lithics occur in artifact assemblages, directly linking this outcrop to artifacts is not possible in the absence of more precise identification criteria for comparison. Furthermore, the low frequency of comparable material types in the artifact assemblages studied suggests that these materials were not frequently selected as toolstone despite being common in beach gravels. At this stage of the research project, the destruction of artifacts required for geochemical or petrographic analysis for comparison to the outcrops identified during survey is not warranted (cf. Leudtke 1992; Shackley 1998).

Inter-Assemblage Comparisons

A total of 41 toolstone types within five lithological groupings (Table 4) were identified in artifact assemblages from Russian Spruce, MB-5, and MB-4. The distribution of toolstone types across the assemblages shows that 24.4% of toolstone types (n=10) were consistently selected across the three time periods represented while the majority of identified types (n=15, 36.6%) were present in two of the assemblages. Common source areas are represented in all groupings. The presence of cobble and tabular dorsal cortex on artifacts in all three assemblages indicates the consistent use through time of both primary and secondary sources. Each of the three assemblages contained toolstone types restricted to that assemblage alone (n=16, 39%). Based on the number of types identified in each assemblage, toolstone diversity is highest in the MB-5 assemblage (30/41) with RS and MB-4 each having the same number of toolstone types (25/31) (Figure 6). All three assemblages contained quantities of un-typed lithic materials.

Artifacts exhibiting dorsal cortex range from 7 – 19% in the assemblages analyzed and the distribution of cortex frequency between assemblages is similar (Figure 7). The bulk of early stage reduction took place off site during all time periods, possible at the procurement location.

Cortex type provides a useful grouping by which to investigate the variability in source areas exploited. Differences between toolstone type and dorsal cortex presence in the pooled assemblages are statistically significant between material groups ($X^2 = 455.58$, df=8, $p<.0001$). Artifacts made on material from Group 5 (non-glassy lavas) account for 34% of the total cortical assemblage by weight (Table 5). This measure is skewed by the presence of relatively large retouched tools, heavy-duty choppers, and flake cores of Group 5 but it is mirrored in the total count of Group 5 artifacts, over half of which exhibit cobble cortex. Unsurprising, artifacts in Group 2 (Obsidian) have the lowest count of dorsal cortex in all three assemblages consistent with expectations for extensive transport distances.

Cobble cortex accounts for nearly half of the total cortical artifacts in the pooled assemblage (49.7%) but other weathering rinds that are not consistent with fluvial formation are also present. Columnar outcrops result in polished or patinated surfaces that are flat and tabular and these are well represented in the pooled cortical assemblage (36.3%) and strongly associated with Group 3 (FGV) artifacts. Artifacts with roughened and chalky weathered surfaces are likely derived from secondary deposits such as glacial till or residual bedrock outcrops, though this was relatively uncommon among the assemblages analyzed.

Artifact assemblages compared to Beach Cobbles

Knappable material suitable for lithic production occurs in low density within Unalaska Bay, and gravel deposits were utilized as source areas for Group 5 types (cf. NGL-mg) during all site occupations. Cobble cortex on some Group 1(cf. CCS) type artifacts suggests gravel sources were exploited at least on occasion. The low density of CCS cobbles on Unalaska Bay beaches suggests that Group1 cobbles were highly selected on local beaches, or that they were transported from further afield in cobble form. Artifacts with cobble cortex of Groups 1 and 5 toolstone types are more common at MB-4 than the other sites. MB-5 and RS assemblages each have a low frequency of Group 5 cobbles, but unlike MB-4, Group 1 in these assemblages is rarely derived from cobble sources.

The distribution of cobble cortex on artifacts of Group 3 (cf. FGV) is similar to that of Group 1, although artifacts of Group 3 in all three assemblages are overall much less numerous and of a higher quality than are artifacts of Group 1. A relatively small number of Group 3 artifacts exhibit cobble cortex and it is possible that these originated in Unalaska Bay gravels in light of the occurrence of lithologically similar materials in Nateekin Bay,. The MB-5 assemblage contained three tested cobbles of Group 3 that possibly were procured locally. As with the Group 1 cobbles likely procured locally, Group 3 cobbles occur in greatest frequency in the MB-4 assemblage.

Discussion

Local Toolstone Availability

The very low density of quality toolstone on Unalaska Bay beaches surveyed, and the lack of recorded primary outcrops in the vicinity of three archaeological sites suggest that the majority of toolstone was procured from source areas outside of the bay system. Though unpredictable as a source of good to high quality toolstone, Unalaska Bay beaches could have provided reliable points of access for low to moderate quality toolstone particularly suited to heavy duty chipped stone tools and pecked stone artifacts such as net-sinkers. Clast sizes for low to moderate quality material ranging from pebbles to boulders were documented within the study area, and these are not restricted by size in terms of their technological utility. Good quality toolstone is, however, restricted to small cobbles and pebbles and occurs in a very low abundance. The majority of artifacts in the analyzed assemblages are composed of materials that must have been transported from outside of Unalaska Bay. The presence of a variety of fine-grained igneous lithologies as pebbles and cobbles on Nateekin and Broad Bay beaches suggests that primary outcrops of these materials may occur on the northern portion of the Unalaska Island, possibly as constituents of the Makushin Volcanic Field. Potential toolstone outcrops formed from the relatively silicic ashes and ejecta or other volcanogenic deposit from Makushin volcano (Lerner et al. 2018; McConnell et al. 1997) could supply hunter-gatherer toolkits. Eroded clasts from the Makushin Valley field are likely to be more abundant on the western coastline of the island than they are in Unalaska Bay.

Procurement Patterns

Based on the lack of early decortication flakes in all three assemblages, initial shaping and reduction of nodules of most toolstone was done off site, possibly at the procurement location. Cobble sources of Group 5 and Group 1 are a notable exception. The relatively high frequency of cobble cortex, and reconstruction of several nodules (Chapter 4) shows that these materials were reduced on site for the production of flakes, often with evidence of utilization or minor edge modification. These cobbles were likely procured from local beach gravels, and cobbles of Group 1 were more selectively procured than the more abundant and spatially wide-spread cobbles of Group 5. Use of local cobbles in an opportunistic strategy (see Nelson 1991),in response to immediate needs contrasts to the majority of the lithic production system for which required advanced planning and transported toolstone.

Exploitation of both primary and secondary sources is evident in cortical types exhibited on artifacts. Tabular cortex originating in columnar exposures comprises nearly one half of the total cortical assemblage from all three sites, and is most abundant on artifacts of Group 4. MB-4 shows a much greater frequency of utilizing low-grade Group 5 cobbles and moderate quality chert cobbles likely procured from beach gravels within Unalaska Bay, or alternatively, they could originate from Beaver Inlet where cobbles also occur. Elsewhere in the Aleutians, toolstone procurement distances of 10-25 km have been proposed for middle-Holocene sites on Umnak (Mason and Aigner 1987). These studies suggest that site inhabitants often acquired moderate to good quality toolstone from single sources during the middle and early Holocene through an organization of targeted procurement. The current study has documented a similar temporal pattern in the selection of Group 4 toolstone exhibiting cortex characteristics with primary outcrop of columnar formations during the middle Holocene-aged occupations at MB-5 and MB-4.

The majority of artifacts with residual cortex is Group 1-10, a type of obsidian known in the literature as Group D. This material is visually distinctive and has a unique geochemical signature identified from analysis of eastern Aleutian artifacts, but the source is unknown (Reuther et al. 2011). Group 1-10 is found in the Russian Spruce assemblage bearing residual cortical surfaces. The high count of cortical artifacts and greater than expected quantity of cortical frequencies exceeding 50% do not fit a pattern of long-distance procurement. This material, as well as other non-descript types with residual cortical traits were likely procured from exposed till or erosional contexts, very likely in the vicinity of Unalaska Bay.

Toolstone Selection and Transport

Based on cortical frequencies and the availability of material in nearby beach gravels, cobbles of Group 1 and Group 5 were likely procured locally and utilized for manufacture of chopping tools and flakes for as-needed use (Binford 1979; Nelson 1991) rather than in a trajectory involving advanced planning (Kuhn 1992; Parry and Kelly 1987). This pattern distinguishes MB-4 from the older assemblages in the study. Artifacts exhibiting <10% tabular cortex are more abundant than expected, and this low value suggests artifacts of Group 4 predominately, but also high-quality types within Group 1 and Group 3, were either transported from the procurement location as manufactured tools more often than as cores, or that artifacts from these locations spent relatively longer time in a transported toolkit before discard.

Obsidian comes from sources at least 125 and 60 km away and the near total lack of cortex in the three assemblages is consistent with long distance transport (Dibble et al. 2005). Obsidian is more frequent in the MB-5 assemblage, where it occurs in the form of large unretouched prismatic blades suggesting transportation of either blanks or cores, but not of finished tools (Chapter 4), and the low count of cortex on obsidian artifacts suggests that nodules were either trimmed prior to transport, or that they remained active in a transported tool kit for a longer period of time. Tracing the treatment of obsidian from source to discard will provide an important line of evidence on the conditions of toolkit provisioning in this region.

Conclusion

Based on the assessment of beach gravel contents, the area surrounding Unalaska Bay is a lithic-poor landscape. Low to moderate quality cobbles of volcanic and siliceous rocks are available in low abundance and were utilized in an expedient manner during the site occupations of the early and middle Holocene. Given this evidence, the vast majority of artifacts from Russian Spruce and Margaret Bay levels 4 and 5 were made on material transported from distances greater than 10 km and, therefore, are non-local. The southwestern portion of Unalaska Island has been identified as potential source area for secondary deposits and primary outcrops of Group 1-type toolstones (Veltre et al. 1986). Group D obsidian was likely procured locally from glacial till or erosional deposits, possibly exposed by lowered sea levels in the early Holocene. This pattern of procurement is in contrast to other obsidian types in the assemblages. In all three assemblages, long-distance transport of obsidian from two identified source areas more than 60 km away is indicated by the low frequency of dorsal cortex on artifacts. The natural distribution of toolstone and the conditions that constrain or provide advantages to mobile hunter-gathers in accessing it are an integral factor in lithic production. Exploitation of non-local toolstone types reflected in the lithic assemblages of Unalaska Bay highlights future-oriented strategies of provisioning and organization of lithic production.

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Table 1. Description of knappable clasts by material, comprehensive sample.

Lithic Type	Count	% knappable clasts	Length (mean cm)		Width (mean cm)	Thickness (mean cm)	Max Dim. Range (cm)
				s.d.			
NGL-MG	280	79.8	6.90	2.8	4.61	2.82	3.5 – 27
NGL-FG	54	15.4	6.78	4.1	5.02	3.39	4 – 26
FGV	5	1.4	5.50	0.8	3.91	2.00	4.5 – 6.5
CCS	8	2.3	6.00	1.3	4.75	2.56	4.5 – 7.5
UNID	4	1.1	6.75	1.5	4.00	1.63	6 – 9
Total	351	100					

Table 2. Assemblages, count, cortical count, dates, and phase.

	Lithics Analyzed	% Cortical	Calendar Years BP (2sigma)	Cultural Phase
Margaret Bay Level 4	1233	18.6	4687 +/-96 5185 +/-93 5415+/-104 5449 +/-97	Late Anangula
Margaret Bay Level 5	1371	12.9	6054 +/-99	Late Anangula
Russian Spruce	1153	15.9	8812 +/-139 8920 +/-137	Early Anangula

*Calibrated with CalPal2007_HULU curve; no corrections applied.

Table 3. Comprehensive sample frequency distribution of knappable clasts: quality, and density by beach.

Sample Location	Knappable Clasts	Low Quality	Moderate Quality	Good Quality	Very Good Quality	Density (area/knappable clasts)
No Name Cove	54	44	10	0	0	1/51 m^2
Captains Bay	77	64	11	1	1	1/27 m^2
Nateekin Bay	61	28	29	4	0	1/508 m^2
Broad Bay	80	61	14	5	0	1/1,138 m^2
Waterfall Cove	79	75	4	0	0	1/23 m^2
Total	351					

Table 4. Toolstone types, their characteristics, and distribution in artifact assemblages.

Material Type	Margaret Bay 4	Margaret Bay 5	Russian Spruce	Cortex	Description
Group 1. Cryptocrystalline Silicates (CCS)					
Group 1-1	Yes	Yes	Yes	CB, RS	Dark green chert
Group 1-2	Yes	-	Yes	CB	Dark green chert with white, purple, and yellow mottling
Group 1-3	Yes	Yes	Yes	-	Gray to dark grayish green chert with red mottles
Group 1-4	Yes	Yes	Yes	CB	Brown mottled chert, grades from smooth to grainy texture
Group 1-5	Yes	-	-	CB	Gray unidentified cf. silicified tuff
Group 1-6	Yes	Yes	Yes	CB	Red mottled chert
Group 1-7	Yes	Yes	Yes	CB	Gray to brownish gray chert
Group 1-8	Yes	Yes	-	CB, TB	Grayish green chert
Group 1-9	Yes	-	-	CB	Gray chert
Group 1-10	Yes	-	-	-	Gray and brown mottled unidentified ccs
Group 1-11	Yes	Yes	Yes	-	Red chert, common impurities, shiny and smooth to dull and grainy
Group 1-12	-	Yes	-	-	Translucent unidentified ccs with brown and yellow mottling
Group 1-13	-	Yes	-	-	White unidentified ccs, dull and grainy
Group 1-14	-	Yes	Yes	CB, RS	Yellowish orange to light brown fine grained quartzite
Group 1-15	-	Yes	-	-	Dark gray chert
Group 2. Obsidian (* denotes pXRF analysis)					
Group 2-1	Yes	Yes	Yes	CB, TB	Black with abundant lithic inclusions and phenocrysts, medium shiny, moderately opaque; Okmok*
Group 2-2	Yes	Yes	Yes	-	Black, pure with faint gray flow banding, shiny, slightly translucent; Okmok*
Group-2-3	-	Yes	Yes	-	Black, common linear basaltic banding and

					phenocrysts, medium shiny, moderately opaque; Okmok*
Group 2-4	-	Yes	Yes	-	Black with a brownish tint, pure, very shiny, moderately translucent; Akutan*
Group 2-5	-	Yes	Yes	-	Akutan*
Group 2-6	-	Yes	-	-	Black with common red streaking, medium shiny, moderately opaque; Okmok*
Group 2-9	-	Yes	-	-	Translucent with a gray tint, pure, shiny; Wiki Peak*
Group 2-10	-	-	Yes	RS	Black with many lithic inclusions and phenocrysts, common gray flow banding and linear basaltic inclusions, shiny to medium shiny, opaque; Group D*
Group 3. Fine-grained Volcanic (*denotes pXRF Analysis)					
Group 3-1	Yes	Yes	Yes	CB, TB, RS	Black with common phenocrysts, medium dull to shiny, smooth, opaque
Group 3-2	Yes	Yes	Yes	TB	Grayish green with few phenocrysts, medium shiny, slightly sugary, opaque
Group 3-3	Yes	Yes	Yes	CB, TB	Black with a brown tint, few phenocrysts, medium shiny to shiny, slightly sugary, opaque
Group 3-4	Yes	-	Yes	TB, RS	Brown with abundant vugs and common phenocrysts, medium dull, smooth, opaque
Group 3-5	-	-	Yes	CB, TB, RS	Black with common faint dark gray flow banding, few phenocrysts, medium shiny, opaque
Group 3-6	-	Yes	-	-	Black with brown tint, pure, medium shiny, slightly sugary, moderately opaque
Group 3-7	Yes	Yes	-	-	Black with brown tint, pure, medium shiny, slightly sugary, moderately opaque; cf. Akutan*
Group 4. Fine-grained Non-glassy Lava					
Group 4-1	-	-	Yes	CB, TB, RS	Black with dull to medium luster, common flow banding including grainy beds, abundant

					phenocrysts
Group 4-2	-	-	Yes	CB, RS	Dark gray to greenish gray with common flow banding
Group 4-3	-	-	Yes	-	Dark gray, dull luster, grainy texture
Group 4-4	Yes	Yes	Yes	CB, TB	Black with common plagioclase, dull to slightly shiny, smooth to slightly grainy, opaque; (BA-7)
Group 4-5	Yes	Yes	-	TB	Brown with opal streaking, dull, smooth, brittle, opaque (BA-2)
Group 4-6	Yes	Yes	-	TB	Gray with opal streaking, dull, smooth, brittle, opaque (BA-3)
Group 4-7	Yes	-	-	-	Dark reddish gray, dull and slightly grainy, opaque (BA-12)
Group 5. Medium grained and bimodal Non-glassy Lava (cf. Andesite)					
Group 5-1	Yes	Yes	Yes	CB	Gray with bimodal matrix and abundant phenocrysts, dull, grainy, opaque (BA-8)
Group 5-2	Yes	Yes	-	-	Dark gray with common phenocrysts, dull, grainy, opaque (BA-5)

Table 5. Cortex Quantity by lithic material group, all sites pooled, total assemblages counts and percent total assemblage [Excludes unidentified (n=35)].

	Group 5		**Group 4**		**Group 3**		**Group 2**		**Group 1**	
	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	F Weight (g)
NONE	143	.052	983	.170	360	.023	601	.089	1056	.132
<10%	34	.015	60	.014	31	.006	7	.001	29	.010
10-50%	71	.138	95	.04	33	.010	11	.005	59	.031
51-90%	30	.168	22	.015	8	.004	7	.008	21	.015
>90%	24	.019	14	.001	4	.008	1	-	13	.001
Total Cortical Assemb.	159	34%	191	7%	76	2.8%	26	1.7%	122	5.7%

Figure 1. Unalaska Island and site locations within Unalaska Bay.

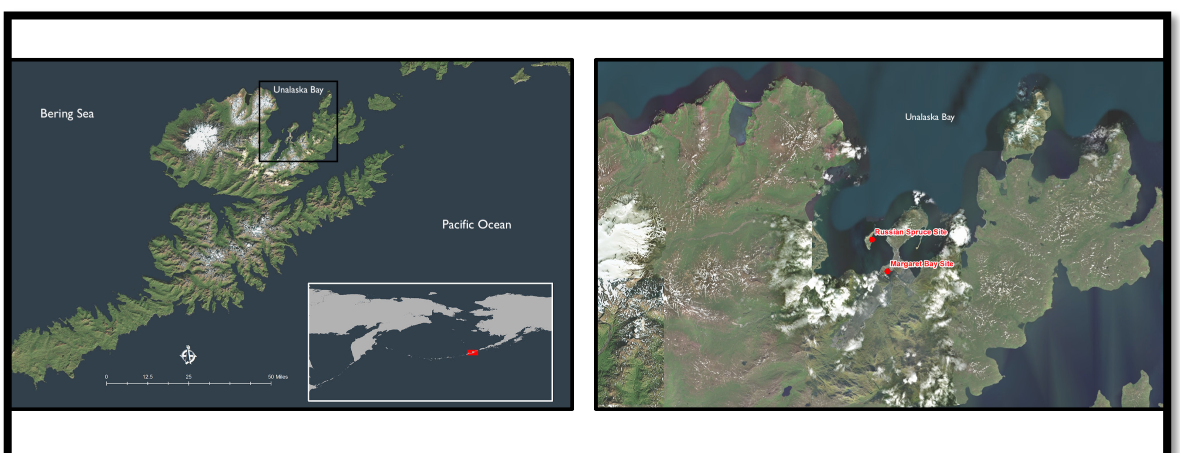


Figure 2. Unalaska Island with mapped geologic formations.

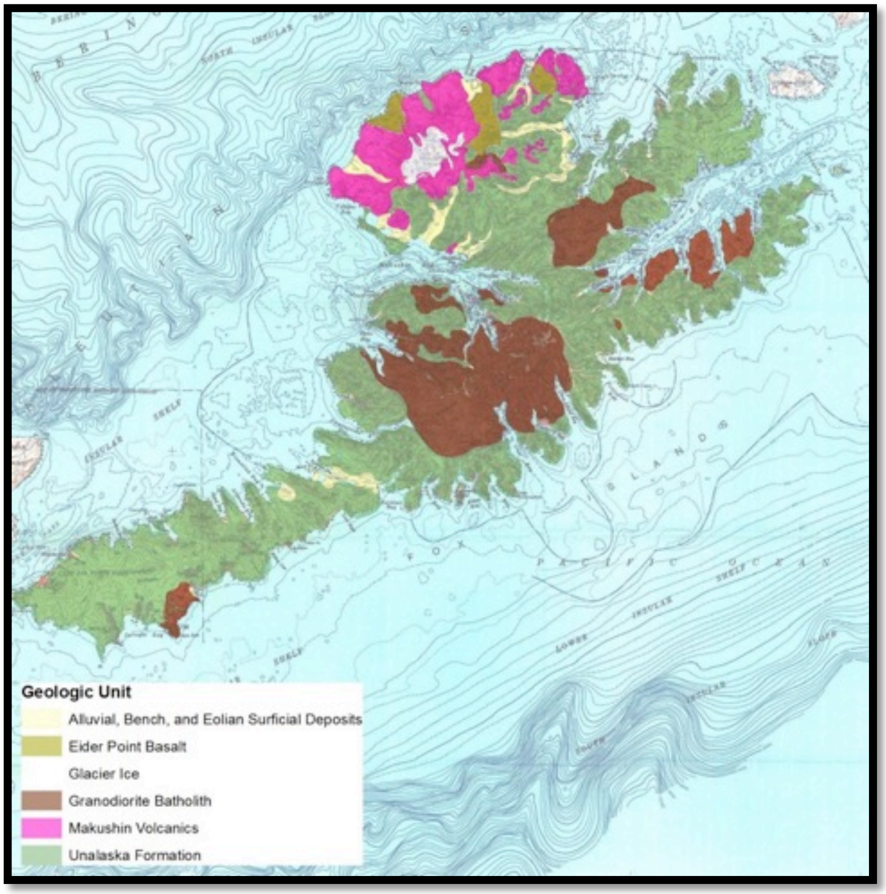


Figure 3. Location of surveyed areas and archaeological site locations in Unalaska Bay on USGS topographic map, Unalaska Quadrangle, scale is 1:63,360, contour interval is 100 feet.

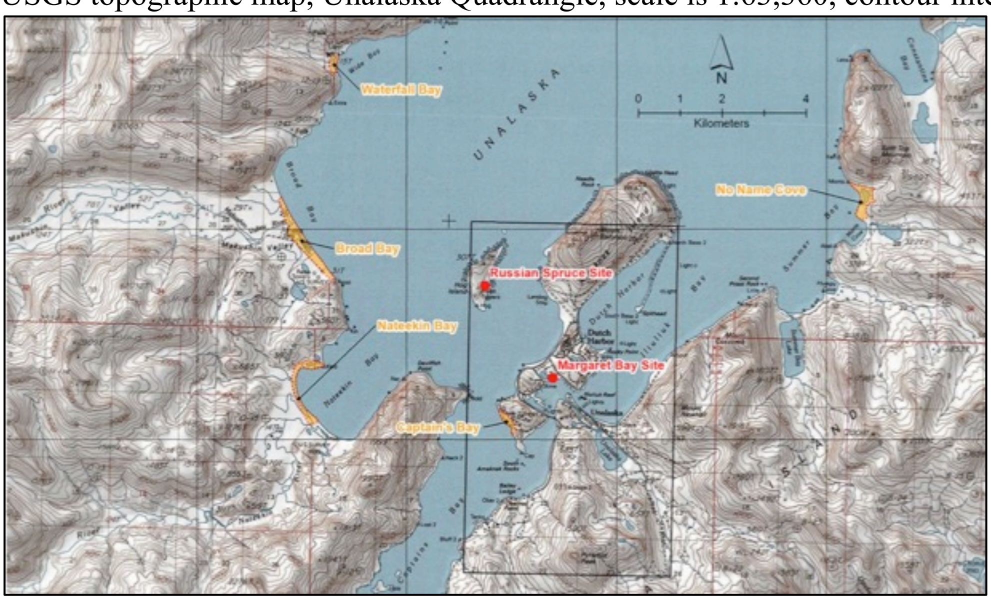


Figure 4. Sample location and volume controlled sample units for pocket beaches: Captains Bay (A), No Name Cove (B) and Waterfall Cove (C).

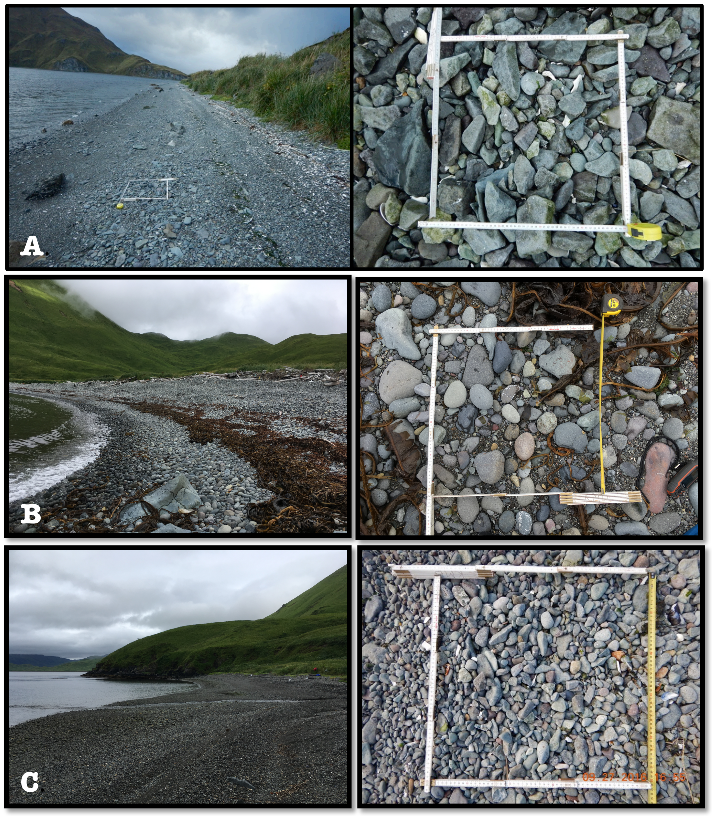


Figure 5. Beach gravel contents by sample location, n=1232.

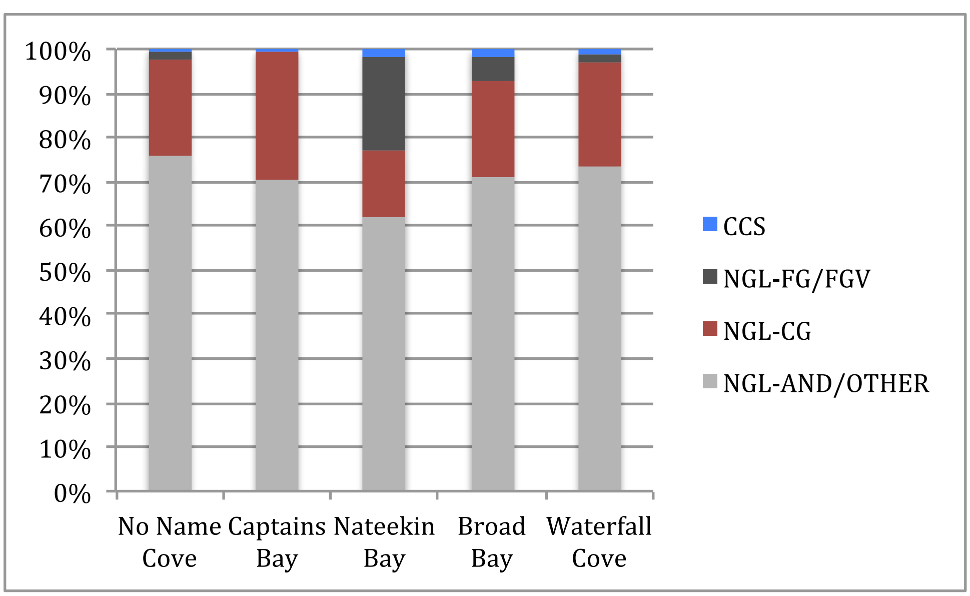


Figure 6. Toolstone selection by site as proportion of total artifact assemblages (excluding unidentified materials, n=33).

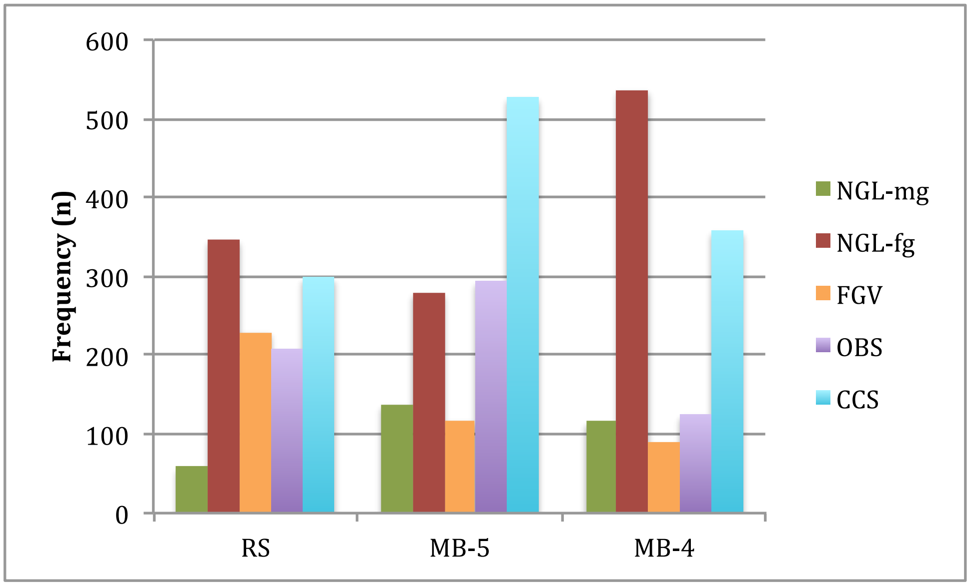
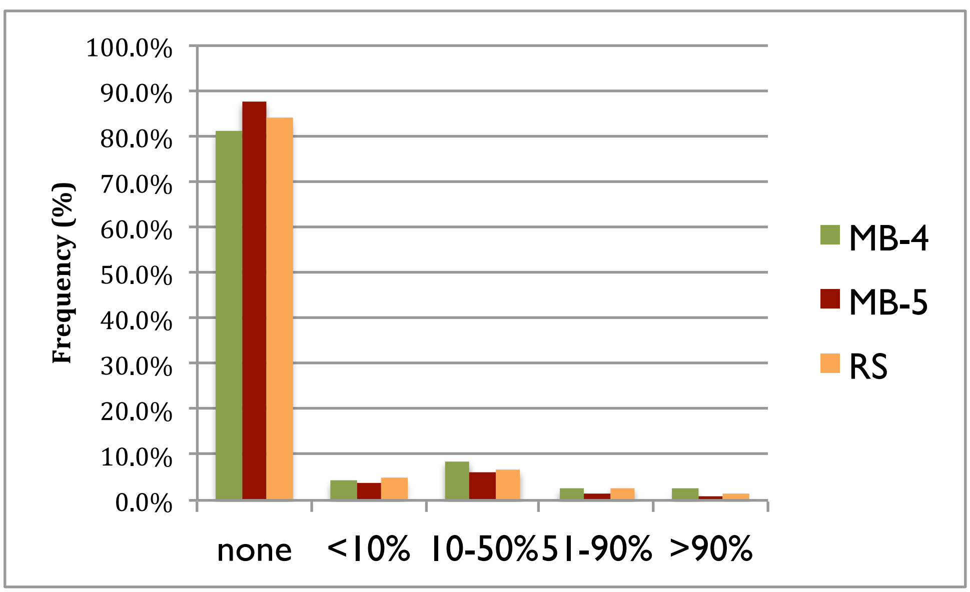


Figure 7. Frequency distribution of artifacts and dorsal cortex quantity.



Chapter 3: Microblade Technology in Unalaska Bay, Eastern Aleutian Islands, Alaska

In preparation for: PaleoAmerica

Abstract

Microblades form a distinctive tool class reflecting specific prepared-core technological industries that are widespread in Beringia, including during the initial peopling of Alaska (e.g., Swan Point ca. 14,200 cal BP), and persisting through the Holocene. Microblade technology occurs in the eastern Aleutian Islands from initial occupation ca. 9,000 years ago until approximately 3,000 years ago. The relationship of Aleutian microblade technology to that of mainland Alaska and greater Beringia is not well understood. Here, results from the analysis of microblade technology at four levels of the stratified Margaret Bay site and at the Russian Spruce site in Unalaska Bay in the eastern Aleutian Islands, Alaska, demonstrate variability in production techniques and microblade core morphology between ca. 9,000 and 3,500 cal BP.

Introduction

Microblade production is a notable but largely unexamined component of early and middle Holocene lithic assemblages in the eastern Aleutian Islands, particularly in comparison to microblade studies elsewhere in Alaska. Lithic assemblage variability in the unique maritime economic context of Aleutian prehistory provides an opportunity to investigate changes in microblade technology from an adaptive perspective outside of the model of highly mobile big game hunters common in the interior settings of Alaska and Siberia (see Goebel 2002). Toward that end, in this paper I describe and compare technological characteristics of microblade cores and production debris from five assemblages in Unalaska Bay (Figure 1) spanning a period from ca. 9,000 to 3,500 cal BP. The goals of this analysis are to (1) provide baseline data on Aleutian microblade metrics, production technology, and core morphology for intra and inter regional comparison, and (2) determine if microblade production technology within Unalaska Bay remains static or changes through time.

Research Context

Microblade technology occurs in the eastern Aleutian Islands with the earliest known occupations at Anangula (Del Bene 1992; Gomez Coutouly 2015), Uknodok (Hatfield 2011; Knecht and Davis 2001), and Russian Spruce (Dumond and Knecht 2001). These three sites comprise the documented components of the Early Anangula phase (Davis et al. 2016; Davis and Knecht 2010; Knecht and Davis 2001), a temporal sub-division of McCartney's Anangula tradition (1984), characterized by the presence of blade and microblade technology and an abundance of unifacially-retouched flake and blade tools (Aigner 1970, 1978; Del Bene 1981, 1992; Dumond and Knecht 2001; Laughlin 1975; Pittenger 1986).

Microblade technology has been central to questions surrounding the origins of earliest inhabitants of the eastern Aleutian Islands and their relationship to other microblade-using technological complexes in Beringia and the North Pacific. Based on analyses of the Anangula lithic assemblage, for many years the only recorded early-Holocene site in the Aleutians, Aleutian archaeologists asserted that it was not a microblade site (e.g., Aigner 1970:63), thus distancing the Anangula tradition from the microblade-using technocomplexes of mainland Alaska. This position continued to be held by Aleutian scholars for decades McCartney and Veltre 1996), and as a result, comparisons of Aleutian microblade technology to adjacent regions are only recently available (Gomez Coutouly 2011, 2015). Some scholars working on the Alaska mainland or adjacent regions have taken a contrary position to Aigner and included Anangula in reviews of Alaskan microblade sites (e.g., Ackerman 2008:75-76; Dumond 1987). Discovery and subsequent excavations at a series of early and middle Holocene sites in Unalaska Bay in the 1990s identified microblades as a definite component of early Holocene assemblages (Dumond and Knecht 2001; Knecht et al. 2001). Information from these investigations also demonstrated that the proportion of microblades in prehistoric toolkits and the techniques of microblade production are not consistent through time. As elsewhere in Alaska, microblades are virtually absent from Aleutian sites by ca. 3,000 years BP (Davis and Knecht 2007; Hatfield 2006, 2011; Wilmerding and Hatfield 2012).

While there is unquestionably a microblade component at Anangula and other early and middle Holocene sites in the eastern Aleutians, the cultural-historical relationship of Aleutian microblades to other post-Beringian and North Pacific traditions remains poorly understood. Spatial and temporal variability in microblade core architecture across these regions has been conceived as representative of cultural affinities in which core forms are essentially equated to populations and used as proxies for population migrations. Alternatively, variability in core morphology has been suggested to be a function of the particular mechanical constraints or advantages imposed by use of different toolstone packages (e.g., cobbles versus tabular nodules), particularly in the abundance of tabular forms in the Pacific Northwest. While the utility of tracing population contact and movement through artifact types is well established in the history of archaeology, the surficial equation of end-product typology (Dibble et al. 2016) is problematic in that it appeals simply to a “shared way of doing things” rather than seeking an understanding of hunter-gatherer adaptation (cf. Yesner and Pearson 2002). Analytical emphasis on variation in microblade production techniques, both within and between technocomplexes, has the potential to shed light on the selection of microblade technology as an adaptive solution. That is, microblades were hafted and used to arm tools, and the designs of tools and toolkits are selected for the beneficial qualities, such as portability, versatility, reliability, maintainability, and lethality (Bleed 1986; Ellis 1997; Guthrie 1983; Nelson 1997), that tool design confers on the technological system as a whole.

An increasing body of research from within Beringia – including the eastern Aleutian Islands – and in adjacent regions (e.g. China, Korea, Japan, the Pacific Northwest) highlights the diverse economic and environmental conditions in which microblades are found (Ackerman 2011) as well as regional variability in microblade production techniques (Bleed 2002; Gomez Coutouly 2018; Takakura 2012). Across Alaska, microblades occur in terminal Pleistocene and early Holocene lithic assemblages of the interior Denali technocomplex and variants of the American Paleoarctic tradition (APAt) found in both inland and coastal settings (Ackerman 1996; Dumond 2011; Lee 2007; Steffian et al. 2002). An early trend to view technological variability as seen in the Alaskan record in terms of cultural-historical relationships has more recently been supplanted by studies focusing on the adaptive benefits of microblade technology in varied ecological or economic settings (Graf 2010; Potter 2011; Rasic 2011; Wygal 2011).

Region-wide comparisons in microblade production variability are beyond the scope of this paper, but toward that end, a detailed analysis of microblade technology in Unalaska Bay was undertaken to generate an empirical basis for comparison of microblade production at Aleutian sites and with that from adjacent regions. The diachronic approach taken in this study assesses variability in Aleutian microblade technology through time. Due to the unique, maritime economic adaptation of the Aleutian inhabitants as originally highlighted by Laughlin (1967) and Aigner (e.g. 1970:69), the Aleutian microblade industries provides a record in which to investigate the organizational and/or functional advantages of microblade technology outside of the context of residentially mobile big game hunting, and to explore what the "microblade adaptation" means for maritime-oriented foragers.

Microblade Technology In Unalaska Bay

Lithic assemblages from five excavated and radiocarbon-dated contexts are utilized for metric and qualitative comparison of microblade technology during the early and middle Holocene in Unalaska Bay (Figure 1). Microblade and blade related technology from the lithic assemblages of Russian Spruce (RS) and from Margaret Bay Level 2 (MB-2), Level 3 (MB-3), Level 4 (MB-4) and Level 5 (MB-5) are utilized in this study. Site details and assemblage summaries are available in Chapter 1 of this dissertation and in the literature (e.g., Dumond and Knecht 2001; Knecht et al. 2001).

At Margaret Bay and Russian Spruce, as elsewhere in the Aleutian Islands, blade and microblade production occurs alongside unprepared flake-core and occasional bipolar reduction strategies (Chapter 4). For this analysis, assemblages were sorted for identifiable elements of blade and microblade technology and a suite of morphometric attributes was recorded for blades, microblades, and cores or debitage associated with their production (Table 1). Time constraints precluded a thorough sorting of uncatalogued debitage for MB-2, MB-3 and MB-4. Analysis of materials from these assemblages are restricted to morphometric comparisons and they are excluded from some aspects of analysis. For MB-5 and RS, the complete assemblages were analyzed, including uncataloged debitage.

Microblades and blades are defined here based on morphometric characteristics derived from their production technologies. Specifically, both blade and microblades are products of a prepared core reduction strategy that differs significantly from unprepared flake-core reduction in terms of energy, time, and skill (Bleed 2002; Inizian et al. 1992; Pelegrin 2012). Presumably, the benefits of investing in a prepared core strategy lie in the production of somewhat uniform blanks and/or an enhanced ratio of usable stone to waste (i.e., material conservation) (Sheets and Muto 1972). Following Owen (1988), blades are elongated blanks with roughly parallel margins and at least one dorsal arrise reflecting the removal of prior blades from a prepared core. Microblades are objective pieces derived from the systematic reduction of specifically prepared cores (Kobayashi 1970; Morlan 1970, 1976; Sanger 1968), and also exhibit parallel margins and arrises reflecting prior removals. Microblades are produced through pressure flaking (Gomez Coutouly 2018) by techniques in which cores are hand-held or that employ a holding device during detachment (Flenniken 1987; Pelegrin 2012). The highly controlled process of pressure flaking gives microblades their extreme edge regularity and diminutive size noted above, and distinguishes microblade technology from blades, large or small, that are produced with percussion. Pressure flaking is identified on microblades and associated core maintenance debitage by traits such as small, flat platforms, an overhanging lip, and pronounced but diminutive bulbs of percussion (Gomez Coutouly 2018).

The total count of microblade core or core fragments recovered from the study sites is low (n=22); however, in context of these lithic assemblages not unusual – cores and core fragments from all reduction trajectories are uncommon. Core rejuvenation flakes and other core maintenance debitage, as well as complete and segmented microblades, represent on-site reduction of microblade cores. When sorted by lithic material types, the count of cores represented by maintenance debitage added to the number of cores present in the assemblage increases the number of microblade cores worked on these sites to 50. Debitage produced in the course of blade or microblade production includes a variety of flake types reflecting core preparation, rejuvenation, and maintenance. Identification of these elements produced within a microblade trajectory allowed for reconstruction of the technological processes of shaping and preparing microblade cores in Unalaska Bay assemblages.

The importance of microblade technology in the technological systems analyzed relative to other tool manufacture trajectories can be only roughly estimated. This is because of the analytical noise created by technological attributes of debitage shared by early stages of microblade core preparation and other core reduction techniques and the lack of complete reduction sequence reconstruction in any of the assemblages analyzed. Based on debitage from the assemblages in this study and the number of microblade technological elements identified in each assemblage, a conservative estimate suggests that on-site microblade production and composite tool re-tooling decreased through the Holocene, a trend also noted in prior investigations (e.g., Hatfield 2011; Knecht et al. 2001). Contrary to expectations, however, microblade technology is more frequent in Level 5 of Margaret Bay than all other assemblages analyzed, suggesting that reliance on this technology persisted later into the Holocene than previously recognized.

Microblade core morphology and rejuvenation techniques

Tables 2 and 3 summarize the characteristics of the 22 microblade cores from five Unalaska Bay sites examined for this analysis. Core measurements were made following Magne (1996). The majority of microblade cores and microblades are made from siliceous sedimentary rocks (hereafter, chert) or very fine grained to microcrystalline volcanic rocks (hereafter, FGV). These lithic materials occur in assemblages as fluvial cobbles and unrolled nodules originating from columnar outcrops. Though these materials were selected over other material types for microblade production, the bulk of the non-microblade elements in the lithic assemblages are also made from these two materials (Chapter 4), often in the form of large flakes and blades. This fact eliminates size constraints of toolstone nodules as a factor in material selection for microblade technology. Both tabular nodules and beach cobbles have physical characteristics that could be operationalized in the initial preparation of microblade cores, and these conditions may have served to determine core architecture more so than the properties of the lithic material itself. For example, split cobble fragments possess favorable edge-angle geometry, allowing initial face trimming from a natural platform, also known as the Horoka technique (Gomez Coutouly 2018; Kobayashi 1970; Morlan 1970), a method common in blade and bladelet production globally. Cores set up in this way tend toward a conical or sub-conical morphology as they are reduced, though this is not the only reduction scenario in which conical shaped microblade cores could be produced. Tabular nodules often posses natural right angles at the meeting of two planes that can be used as a natural "crest" for initial removal of microblades. This practice is documented among the microblade-related debitage at both MB-5 and RS.

The shapes of Unalaska Bay cores are varied, with conical and wedge-shaped forms occurring in roughly equal numbers (Table 2). Less common forms are also present, including sub-conical, prismatic, and end-flakes. Temporally, conical forms are exclusively seen at the early Holocene RS site (Figure 2), while later in time, wedge-shaped forms possessing a distinctive keel were produced from thick flakes or other fragments (Figure 3). With the exception of the conical cores from the early Holocene, Unalaska Bay core forms are generally crude in appearance and are somewhat irregular. Evidence for at least one rotation is documented on 36% of the cores. Battering or the removal of thick shaping flakes is common on the distal ends. Distal battering due to anvil support or removal of large irregular shaping flakes is common on many of the conical and sub-conical forms. Lateral surfaces (e.g. sides) were shaped by removal of thinning flakes or bladelets or left in an unmodified state. Shaping flakes generally originate from the platform, but distal removals as well as removals from the back are common, particularly when the core is formed on a flank or tabular fragment.

No evidence was noted for the use of the Yubetsu technique common during the terminal Pleistocene and early Holocene in Alaska, in which segments of bifaces are utilized as cores, leading to the classic "wedge-shaped" core morphology (Gomez Coutouly and Holmes 2018; Gomez Coutouly et al. 2019). In Unalaska Bay, some microblade cores approximate this wedge-shaped morphology, but via a process of intentional keel formation through bifacial or unifacial shaping of thick flakes or other fragments. Thick flakes also serve as cores that are semi-keeled as a virtue of their naturally constricting edge morphology, and this may or may not be enhanced with additional shaping. Prismatic forms on tabular nodules are often rotated with new platforms established at the opposing end or at a ninety-degree angle.

Core rejuvenation and maintenance debitage occur in all assemblages, but in very low quantities (Table 4). Platform rejuvenation techniques vary according to core architecture. Platform rejuvenation of conical or sub-conical forms produces distinctive tablet or trimming flakes. This type of rejuvenation occurs in RS and MB-5. No debris associated with platform rejuvenation of wedge-shaped cores was identified in the assemblages. Rotated microblade cores produce a unique form of maintenance debitage as a core is rotated and the former platform edge is used as a dorsal ridge from which working of new core face is initiated. These "platform edge" flakes were also noted during technological analysis of the early-Holocene Anangula assemblage from Umnak Island (Aigner 1978:55; Pittenger 1986:61). These rejuvenation flakes are common in the RS assemblage, and a single specimen occurred at MB-4, although no rotated or tabular microblade cores were recovered from that occupation. Figure 4 shows four examples of platform edge flake from RS. In one case, the initial attempt to use an abandoned platform edge as a guiding ridge failed, but the second attempt detached a ridged microblade with a pseudo-crest created by the platform edge.

Microblade Characteristics

Size

Tables 5a – e summarize metric and attribute data on microblades included in this study. Measurements were made following Sanger and others (1970). On average, Unalaska Bay microblades are 5-6 mm in width and less than 1.5 mm thick. Based on 51 complete specimens, total microblade length ranges from 16 to 42 mm, and is also consistent with the length of core faces in the assemblages. Width is among the most distinctive and consistent traits characteristic of microblades (Cook 1968). Unalaska Bay microblades have uni-modal width distribution and do not differ substantially between assemblages, with modal points ranging only in tenths of millimeters [RS = 5.27 mm; MB-5 = 5.23 mm; MB-3 = 4.98 mm; MB-2 = 5.55 mm].

Toolstone selection

Microblades were produced on a narrow range of toolstone types; although cores recovered from Unalaska Bay sites are restricted to varieties of chert and FGV, obsidian is also represented by microblades and microblade core maintenance debitage (Figure 5). Comparing the distribution of lithic material in microblade production between assemblages, there is notable selection for chert at the expense of obsidian and FGV in the Margaret Bay assemblages, whereas FGV occurs in higher than expected frequencies at Russian Spruce (Pearson's X^2 =

154.81, df=4, p<.001, V = .3583). The absence of obsidian microblade cores in Unalaska Bay assemblages is likely a factor of the small sample size. Given that obsidian is widely utilized in other reduction trajectories at these sites, its underrepresentation in microblade production is unexpected, particularly in light of the frequent selection of obsidian in microblade production elsewhere in Beringia. One possible explanation lies in the fact that much of Aleutian obsidian is riddled with impurities and inclusions, but that very high-quality FGV and cherts are available.

Relation to blades and bladelets

Blades and microblades can be distinguished in Unalaska Bay by their divergent production technologies resulting in objective pieces differing in size and morphometric attributes. Blades are detached by percussion rather than pressure and exhibit diffuse bulbs of percussion and large platforms. Unalaska blades are generally crude, forming thick, heavy-duty blanks that are triangular in cross-section. Frequency distribution of blade and microblade widths from the four Margaret Bay assemblages analyzed demonstrates a bimodal distribution (Figure 6). The pooled blade widths peak in number between 5 and 10 mm, with a sharp decline at 11 mm, the maximum width observed for microblades in these assemblages. A second mode, more evenly distributed between 20 and 25 mm, represents percussion blades as well as a small number of pressure flaked bladelets. The results presented here corroborate the pattern of microblade-width distribution at Russian Spruce detected earlier by Dumond and Knecht (2001), and together these data provide strong evidence for distinctive blade and microblade reduction trajectories.

Technological analyses of blade and microblade cores from Anangula on neighboring Umnak Island (Aigner 1978, Del Bene 1981, 1992; Pittenger 1986) suggested that blade and microblade production occur within the same reduction strategy. That is, as a prismatic blade core is reduced, the blades become progressively smaller. Reconstruction of the technological sequences of blade and microblade production from analytical nodules at Russsian Spruce and Margaret Bay revealed that although the same nodule of toolstone may be used for both blade and microblade reduction trajectories, particularly when the Horoka technique is utilized, the sequence of blade to microblade production is not a continuous process, as has been argued for Anangula (Chapter 4). There is a distinct separation in the methods by which blades and microblades are produced, and the transformation of a blade core to a microblade core is marked by a clear series of technological steps in platform and face preparation (Pelegrin 2012). At Unalaska Bay sites, the intermediary steps in microblade core preparation result in the production of small pressure-flaked bladelets that do not conform to the regular edge morphology that is a defining attribute of microblades. Such blanks are few in number in Unalaska Bay sites, accounting for 7.1% of the total blade/microblade assemblages. The more frequent occurrence of bladelets at Russian Spruce (16.3% of blade/microblade assemblage) is a factor of the number of microblade cores prepared on-site (Chapter 4) and the common use of the Horoka method of microblade production. A single core from MB-5 (#6068) exhibits several bladelet scars in addition to trimming flakes originating from opposing and rotated platforms; the irregular shape of this core, which is approaching a roughly wedge-shaped form, and its unusually large size identify it as an example of early microblade core preparation resulting in bladelet production.

Segment Representation and Edge Modification

Complete microblades are outnumbered by microblade segments (Table 6). Whether this is a factor of taphonomy or intentional segmentation of microblades is not easily determined. With MB-4 excluded due to its small number of microblades, the proportion of segments in the remaining four assemblages is overall very similar, with no evident pattern in representation. Based on the few recovered specimens from Alaska and the arctic, the use of microblades as lateral insets in organic shafts does not preclude the inclusion of an entire microblade; however, segmented microblades were utilized more frequently.

Macroscopic evidence for intentional, but minor edge modification or utilization is uncommon but does occur in all assemblages analyzed (Table 5 a-e). Microblades exhibiting regular retouch for a continuous length of 5 - 10 mm or other intentional reshaping are limited to the two earliest occupations, RS and MB-5. Retouched microblade segments account for very low proportion of the total microblades in each assemblage, ranging from 1.7% at MB- 5 (n=4) to 5.4% at Russian Spruce (n=7). The infrequent edge retouch documented in this study is similar to contemporaneous sites of southwest Alaska (Dumond 2011; Fitzhugh 2004), and does not suggest a technological pattern of intentional re-shaping of microblades as is seen, for example, in Dorset microblade industry (McGhee 1970; Owen 1987, 1988). In three cases, one at Russian Spruce (#767) and two at MB-5 (#4290, #4389), microblade segments have been intentionally reshaped with convergent bimarginal unifacial retouch forming a nearly pointed tip. No evidence of intentional backing was seen on any of the edge-modified microblades in this analysis.

Discussion

Microblades are produced for use as inserts in composite projectile technology in post-glacial contexts within Alaska and northeast Siberia (Goebel 2002; Gomez Coutouly 2016; Lee and Goebel 2016). Though this technology is often associated with terrestrial hunting, and particularly of large game such as bison and caribou (Graf 2010; Rasic 2011), microblades and/or portions of organic incised shafts have also been recovered in coastal settings around the Gulf of Alaska (Lee 2007; Steffian et al. 2011), pointing to their potential utility in a mixed economic context. In the Aleutian Islands, which are lacking in terrestrial fauna, the use of microblade inset composite projectiles or thrusting spears during the early Holocene is supported by the lack of other lithic projectile technologies in the toolkit. Seasonal variation in resource distribution for which microblade-armed tools are required could also contribute to a toolkit reliant on microblade insets during the early Holocene. As is well documented in the use of microblade-inset knives in the high arctic (Owen 1987, 1988), microblades may serve a variety of purposes related to cutting and processing, and need not be associated exclusively with extractive tasks and projectile technologies. The persistence of microblade production alongside more specialized lithic projectile points in the middle Holocene of Unalaska Bay suggests that the utility of microblades did not overlap with that of stone tipped projectiles, either due to seasonal variation in resources targeted, or in the complimentary tasks for which the two different technologies were employed.

The diversity of core forms exhibited in Unalaska Bay sites signals a versatile production strategy associated with microblade technology. Maintainability of composite tools is a design trait frequently linked to microblade and microlithic composite tools because it allows for continued functionality without time stress (Bleed 1986; Myers 1989). In the maritime context of the Aleutian Islands, maintainability of a diverse toolkit may be enhanced through the production of microblades by a range of methods without the constraints on portability or material conservation common to terrestrial hunters in seasonally frozen regions. The fluidity of microblade production in Unalaska Bay suggests that microblades were consistently in demand, but without stresses on material or time.

By separating components of microblade technology in each assemblage according to lithic material type, with the added benefit of nodule reconstruction (Chapter 4), it is possible to estimate the number of microblade cores that were transported to or from each site, and the relative intensity of on-site microblade production. A total of 41 nodules involving microblade technology were identified (Chapter 4), and these demonstrate a degree of fluidity as cores were transformed for microblade production subsequent to the production of bladelets or flakes. A range of lithic material types comprise cores and core-maintenance debitage. Transported cores that passed through the site are visible through maintenance debris. Unique examples of toolstone types in the microblade assemblage indicate re-tooling of equipment with either transported blanks or discarded segments.

Conclusion

As in the greater Beringia, microblade technology in Unalaska Bay entails pressure flaking of specifically prepared cores dedicated to the production of uniform and diminutive blanks for use in composite tools. A variety of microblade core forms are present in Unalaska Bay sites, and core maintenance debitage indicates frequent core rotations and frontal rather than platform rejuvenation. During the middle Holocene, wedge-shaped cores produced via the campus method are present but alongside much less standardized forms. Conical core morphology predominates in the early Holocene record, though this view is likely skewed by the highly exhausted nature of the discarded cores at Russian Spruce. Evidence for core rotation and use of natural corners on tabular nodules, in addition to platform rejuvenation on conical forms prepared via the Horoka method, point to the use of techniques adapted to the lithic material at hand and highlights versatility in Aleutian microblade production. The size and characteristics of microblades remain static through the Holocene record, despite the documented diversity in core morphology. Percussion blade production and pressure-flaked microblade production are two distinct reduction trajectories based on attributes linked to production technology and size. Aleutian microblades may have been utilized in a wide range of composite tool types, and the results presented here do not link microblades with any particular tool type. The adaptability and diversity evident in microblade production in the Holocene record of Unalaska Bay suggests that regionally microblade technology is characterized by a high degree of versatility, a trait that can likely be extended to the function of microblade-inset tools in the toolkit, in addition to production technology.

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Table 1. Microblade production technology in analyzed assemblages.

	MB-2	MB-3	MB-4	MB-5	Russian Spruce
Microblades (complete and segments)	83	50	12	229	129
MB Core	3	0	3	8	8
MB Core Rejuvenation	5	6	4	21	19
Trimming/Shaping Debitage & CRF	6	5	0	5	12
Total MB Reduction Trajectory	97	61	19	261	168
% of Assemblage	**n/a (but <1%)**	**n/a (but <1%)**	**1.5% (19/1233)**	**19% (261/1371)**	**14.6% (168/1153)**

Table 2. Microblade core morphology and metrics.

Specimen #	Form	Direction	# of Platfroms	Platform Angle	Plat. Length (mm)	Plat. Width (mm)	# Faces	Face Length (mm)	Face Width (mm)	Core Height (mm)	Wgt (g)
MB-2											
498	Wedge	Uni	1	65°	40.72	16.4	1	21.08	15.85	26.29	18.56
1247	Wedge	Uni	1	-	63.93	21.53	-	-	-	24.37	28.65
1737	Wedge	Uni	1	-	62.86	13.8	-	-	-	22.88	18.4
MB-4											

7715	Wedge	Uni	1	95º	15.71	11.04	2	37.21	11.04	36.83	9.3
7716	Prismatic	Bi	2	75º	2.8	7.1	1	23.9	7.1	25.53	2.2
7773	Wedge	Uni	1	83º	16.81	14.01	1	33.84	15.09	37.61	12.4
MB-5											
4473	Flake	Uni	1	-	37.51	17.91	1	25.69	19.91	36.08	21.4
4474	Sub-Conical	Uni	1	90º	37.81	23.35	1	32.78	29.06	34.44	53.41
4684	Sub-Conical	Uni	1	77º	18.84	22.79	1	19.91	25.69	24.17	13.01
4877	Prismatic	Bi	2	90º	26.76	19.44	2	56.32	13.66	54.89	36.9
4891	Wedge	Uni	1	69º	58.87	26.63	1	34.53	25.91	31.82	39.4
4937	Wedge	Uni	1	77º	82.85	28.35	1	36.53	22.71	36.93	87.6
6032	Wedge	Uni	2	69º	36.68	18.52	1	26.34	18.64	26.14	18.2
6068	Sub-Wedge	Uni	1	80º	75.14	31.56	1	55.75	30.65	39.98	108.7
RS											
45	Conical	Uni	1	65º	17.51	18.21	1	23.06	18.09	18.21	6.0
46	Conical	Uni	1	74º	21.66	15.15	1	20.83	15.38	20.08	7.7
55	Sub-Conical	Uni	1	65º	23.75	18.22	1	21.6	18.77	28.29	15.6
551	Conical	Uni	1	75º	21.56	19.45	1	22.21	19.45	27.03	16.2
761	Conical	Uni	1	65º	20.39	14.33	1	24.09	20.39	27.55	8.1
916	Prismatic	Bi	2	65º	26.8	16.73	2	23.34	21.29	28.81	15.0
1079	Conical	Uni	1	85º	18.13	20.13	1	28.77	17.43	28.52	12.7
n/a	Flake	Uni	1	77º	45.39	7.89	1	45.18	7.91	45.21	24.9

*Platform and face metrics refer to the last utilized

Table 3. Microblade core characteristics.

Specimen #	Form	Lithic Material	# Platforms	Platform Shape	Platform Treatment	Distal Treatment	Production Tech.	# rotations	Condition
MB-2									
498	Wedge	Chert	1	Oval	None	-	Campus	-	Rejuvenated
1247	Wedge	Chert	1	Oval	None	Bifacial shaping	Horoka	-	Preform
1737	Wedge	FGV	1	Irreg.	None	Bifacial shaping	Horoka	-	Preform
MB-4									
7715	Wedge	Chert	1	Triangular	Flaking	Bifacial Shaping	Unspecified	-	Exhausted
7716	Prismatic	Chert	2	Triangular	Flaking	Battering	Irregular	1	Exhausted
7773	Wedge	Chert	1	Triangular	Flaking	Bifacial Shaping	Unspecified	-	Failed
MB-5									
4473	Flake	Chert	1	Oval	Flaking	Bifacial Shaping	Campus	-	Preform
4474	Sub-Conical	Chert	1	Oval	Flaking	Flat	Horoka	-	Failed
4684	Sub-Conical	Chert	1	Oval	Flaking	Flat	Horoka		Preform
4877	Prismatic	Chert	2	Oval	-	Flat	Unspecified	1	Functional
4891	Wedge	Chert	1	Oval	Flaking	Bifacial Shaping	Unspecified	-	Failed
4937	Wedge	Chert	1	Oval	Flaking	Bifacial Shaping	Unspecified	-	Failed
6032	Wedge	Chert	2	Oval	None	Unifacial Shaping	Campus	1	Failed
6068	Sub-Wedge	Chert	1	Oval	Flaking	Bifacial Shaping	Campus	1	Functional

RS									
45	Conical	Chert	1	Round	Flaking	None	Unspecified	-	Exhausted
46	Conical	Chert	1	Oval	Flaking	None	Unspecified	1	Exhausted
55	Sub-Conical	Chert	2	Oval	None	Flat	Horoka	2	Preform
551	Conical	Chert	1	Round	Flaking	Flat	Unspecified	-	Exhausted
761	Conical	FGV	1	Oval	Flaking	None	Horoka	-	Exhausted
916	Prismatic	FGV	1	Oval	Flaking	Bifacial Shaping	Irregular	1	Failed
1079	Conical	CCS	1	Round	Flaking	None	Horoka	1	Functional
n/a	Flake	FGV	1	Oval	None	None	Campus	-	Functional

Table 4. Microblade core preparation and maintenance debitage.

	Face Rejuven. Flake			Platform Rejuv. Flake		Platform Lip Flake	Crest		Ridge
	Skeg	Opposing	Other	Tablet	Other		Prep	Nat.	
MB-2	1	-	3	-	-	-	1	-	
MB-3	-	1	5	-	-	-	-	-	
MB-4	1	-	2	-	-	1	-	-	
MB-5	5	-	10	3	-	-	-	1	2
RS	1	-	3	2	1	7	1	1	3

Table 5.a. Russian Spruce microblades characteristics.

	N*	Range (mm)	Mean (mm)	s.d.	Median (mm)
Russian Spruce					
Length					
Complete	14	15.84 – 32.92	25.79	4.98	25.25
Proximal	66	4.84 – 30.37	15.83	6.42	15.4
Medial	24	4.61 – 23.8	11.74	4.36	11.07
Distal	17	6.46 – 25.48	14.93	4.15	14.89
Width					
Complete	14	4.02 – 7.51	5.62	0.88	5.55
Proximal	65	3.41 – 7.91	5.45	1.04	5.4
Medial	24	3.04 – 6.71	5.35	1.01	5.7
Distal	16	2.84 – 6.86	4.81	1.07	4.77
Thickness					
Complete	14	0.98 – 2.59	1.82	0.49	1.8
Proximal	66	0.65 – 2.48	1.45	0.37	1.41
Medial	24	0.66 – 2.31	1.29	0.44	1.28
Distal	17	0.6 – 2.49	1.42	0.5	1.34
Total					
Thickness	121	0.6 – 2.59	1.45	0.44	1.4
Width	120	2.84 – 7.91	5.34	1.00	5.33
No. Arrises		1 – 2			
Edge Retouch	7				

* Conjoined segments are measured as a single item, and damage to some microblade precludes width measurements and are excluded; thus, metrics for measured segments differs slightly from segment counts.

Table 5.b. Margaret Bay 5 Microblade characteristics.

	N 229	Range (mm)	Mean (mm)	s.d.	Median (mm)
Margaret Bay 5					
Length					
Complete	29	16.79 – 41.71	26.35	6.74	26.15
Proximal	113	6.89 – 35.68	17.0	4.89	16.56
Medial	41	6.81 – 33.48	15.27	5.06	14.11
Distal	46	9.65 – 31.66	18.19	4.77	17.93
Width					
Complete	29	3.7 – 8.22	5.41	1.16	5.19
Proximal	113	3.57 – 9.75	5.89	1.33	5.63
Medial	41	3.0 – 8.79	5.08	1.43	4.65
Distal	46	2.0 – 7.91	5.37	1.36	5.29
Thickness					
Complete	29	0.9- 2.39	1.41	0.41	1.32
Proximal	113	0.7 – 3.34	1.42	0.51	1.32
Medial	41	0.67 – 2.87	1.25	0.50	1.08
Distal	46	0.77 – 2.68	1.51	0.51	1.42
Total					
Thickness		0.67 – 3.34	1.40	.50	1.31
Width		2.0 – 9.75	5.54	1.41	5.27
No. Arrises		1 – 3			
Edge Retouch	4				

Table 5.c. Margaret Bay Level 4 Microblade Characteristics.

	N **12**	**Range (mm)**	**Mean (mm)**	**s.d.**	**Median (mm)**
Margaret Bay 4					
Total					
Thickness		0.83 – 2.25	1.4	.36	1.38
Width		3.86 – 7.39	5.99	1.08	6.01
No. Arrises		1 – 2			
Edge Retouch	0				

Table 5.d. Margaret Bay Level 3 Microblade Characteristics.

	N 50	Range (mm)	Mean (mm)	s.d.	Median (mm)
Margaret Bay 3					
Length					
Complete	3	18.13 – 34.69	25.67	8.38	24.19
Proximal	28	8.45 – 22.62	16.87	3.72	17.03
Medial	14	6.05 – 22.8	13.8	4.22	13.22
Distal	5	13.22 – 19.71	16.25	2.47	15.45
Width					
Complete	3	4.98 – 5.90	5.58	0.52	5.85
Proximal	28	4.03 – 8.93	6.35	1.27	6.14
Medial	14	4.23 – 8.13	6.1	1.35	6.23
Distal	5	3.56 – 6.18	5.1	1.01	5.41
Thickness					
Complete	3	1.22 – 1.98	1.64	0.39	1.72
Proximal	28	0.81 – 2.37	1.44	0.39	1.4
Medial	14	0.94 – 2.44	1.46	0.50	1.35
Distal	5	0.95 – 1.85	1.37	0.35	1.44
Total					
Thickness	50	0.81 – 2.44	1.45	0.41	1.37
Width	50	3.56 – 8.93	6.11	1.30	5.83
No. Arrises		1 – 2			
Edge Retouch	0				

Table 5.e. Margaret Bay Level 2 Microblade Characteristics.

	N **83**	**Range (mm)**	**Mean (mm)**	**s.d.**	**Median (mm)**
Margaret Bay 2					
Length					
Complete	5	15.95 – 30.56	22.41	5.72	20.64
Proximal	33	8.92 – 25.95	15.41	4.34	14.63
Medial	31	7.26 – 24.1	14.87	4.0	14.97
Distal	14	13.6 – 26.39	20.41	4.03	20.91
Width					
Complete	5	5.02 – 8.41	6.24	1.37	6.03
Proximal	33	3.53 – 8.37	5.93	1.05	5.92
Medial	31	2.75 – 9.13	5.60	1.41	5.55
Distal	13*	3.46 – 7.99	5.93	1.33	5.73
Thickness					
Complete	5	1.01 – 2.67	1.65	0.68	1.45
Proximal	33	0.67 – 2.48	1.38	0.38	1.43
Medial	31	0.82 – 2.91	1.51	0.50	1.4
Distal	14	1.13 – 2.81	2.07	0.56	2.09
Total					
Thickness	83	0.67 – 2.91	1.56	0.53	1.46
Width	82*	3.46 – 9.13	5.80	1.25	5.69
No. Arrises		1 - 3			
Edge Retouch	1				

* edge modification on one microblade prevented width measurements

Table 6. Microblade segment representation as count and proportion of assemblage.

	Complete		Proximal		Medial		Distal	
	n	%	n	%	n	%	n	%
MB-2 (n=83)	5	6.0	33	39.8	31	37.3	14	16.9
MB-3 (n=50)	3	6.0	28	56.0	14	28.0	5	10.0
MB-4 (n=12)	-	-	6	50.0	6	50.0	-	
MB-5 (n=229)	29	12.7	113	49.4	41	17.9	46	20.0
Russian Spruce (n=129)	13	10.1	69	53.5	29	22.5	18	13.9

Figure 1. Location map of Unalaska Island and sites within Unalaska Bay.

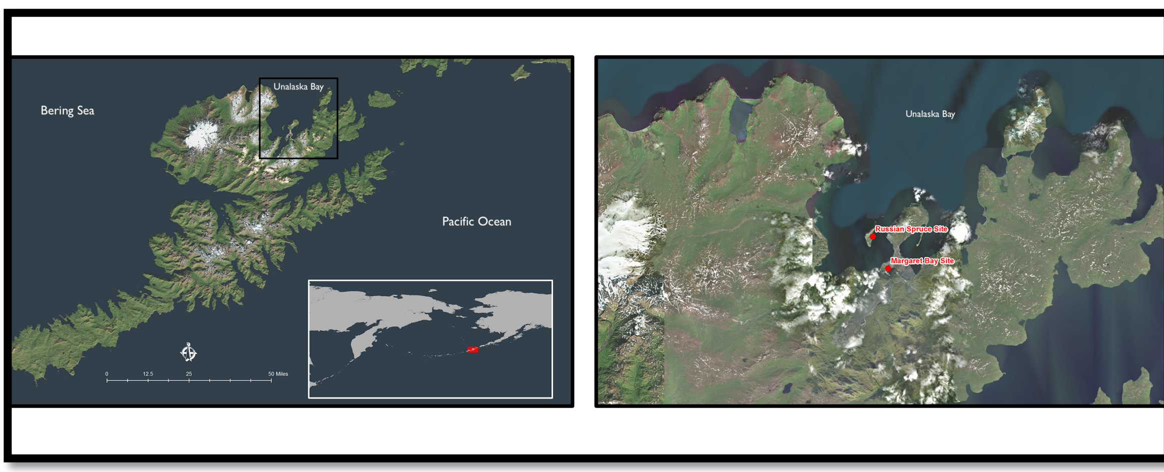


Figure 2. Conical cores, Russian Spruce (left to right: #761, #45, #551 and #1079).

Figure 3. Wedge-shaped cores (Left: Margaret Bay Level 5, #4937; Right: Margaret Bay Level 4, #7715)

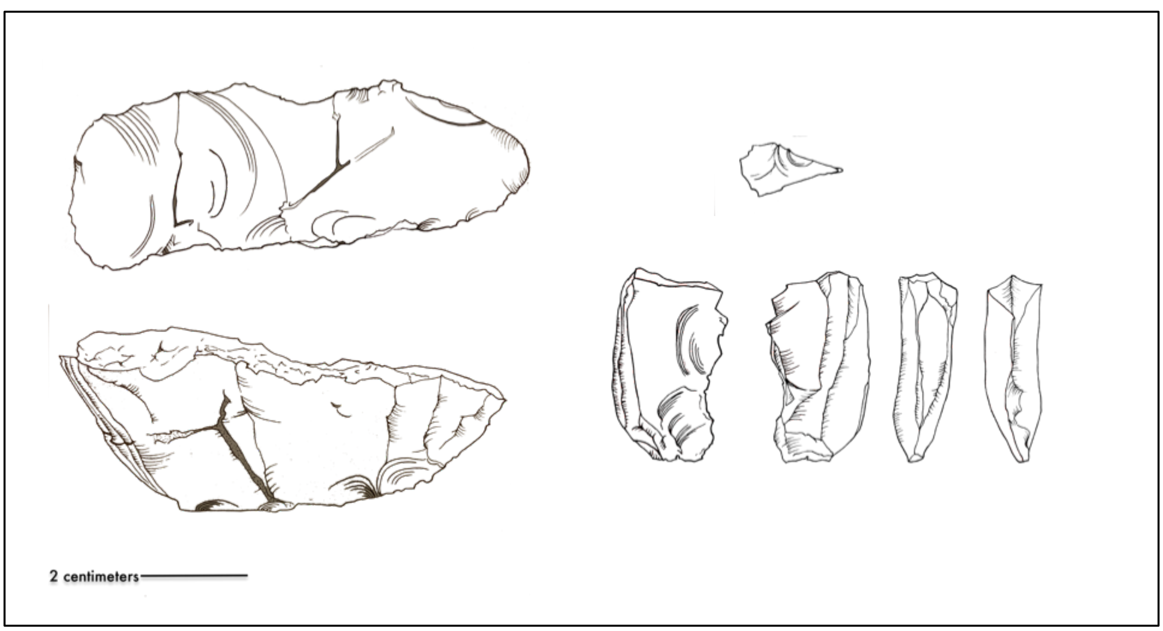


Figure 4. Platform edge flakes, Russian Spruce.

Figure 5. Count of Microblade technology in assemblages

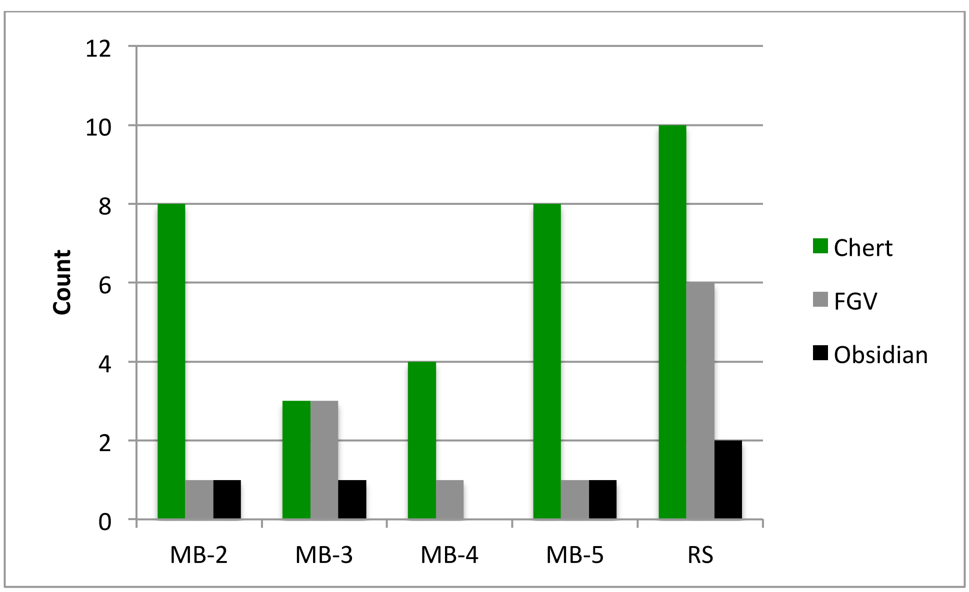
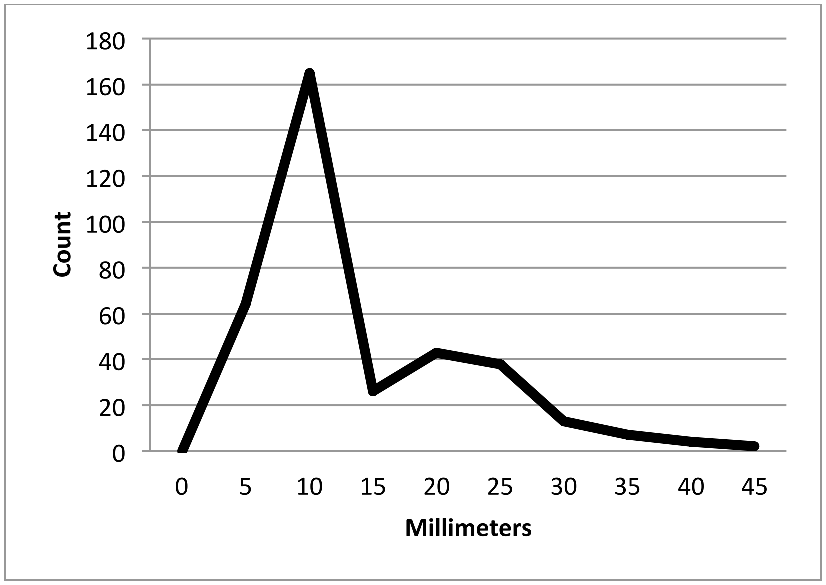


Figure 6. Frequency Distribution of blade and microblade widths from Margaret Bay.



Chapter 4: Minimum Analytical Nodule Analysis and Toolstone Provisioning: Explaining lithic assemblage variability of early and middle Holocene Maritime Hunter-Gatherers in Unalaska Bay, Eastern Aleutian Islands, Alaska

In preparation for: Arctic Anthropology

Introduction

This paper investigates the role of planning and lithic-material provisioning strategies in the production of lithic technology among coastal hunter-gatherers of the Aleutian Islands during the early and middle Holocene (ca. 9,000 to 4,500 cal B.P.). The regional archaeological record consists of numerous hunter-gatherer sites reflecting long-term coastal adaptation and a maritime-focused economy that extends to the early Holocene (Aigner 1976; Laughlin 1967, 1975). Yet, little is known about the organization of technology across this extensive spatial and temporal span. Lithic assemblages are the material outcome of an array of short-term decisions and long-term strategies related to subsistence pursuits, mobility, and settlement systems employed by past hunter-gatherers. These integrated and future-oriented strategies include lithic material selection and economy, tool and toolkit design, toolstone provisioning strategies, and the staging of tool production in space and time in accordance with the constraints or demands of the subsistence settlement system within which they occur.

This study is designed to assess diachronic lithic-assemblage variability in the early and middle Holocene archaeological records in the Aleutian Islands from the perspective of technological provisioning. Three lithic assemblages from Unalaska Bay, one of the most extensively investigated regions in the Aleutian Islands, were analyzed and compared. Materials were selected from the sites of Russian Spruce and Margaret Bay (Level 4 and 5), each of which possess a large lithic assemblages from which prior analyses have demonstrated gradual change through time in lithic tool inventories and production technologies (Dumond and Knecht 2001; Hatfield 2006, 2011; Knecht et al. 2001). The paucity of extensively excavated sites in the Aleutian Islands, and few in well-dated contexts, limits wide-scale regional analyses. This study uses a comparative framework based on site-level reconstruction of production technologies, and investigation of toolstone selection and lithic material economies within a single bay system on Unalaska Island. The objective of this research is to gain an understanding of assemblage variability in the context of material provisioning and future-oriented strategies in the early and middle Holocene of Unalaska Bay.

Research Background

Unalaska Bay is a large embayment on the north side of Unalaska Island in the eastern Aleutians, opening to the Bering Sea (Figure 1). The margins of the bay contain hunter-gatherer settlements with abundant lithic artifacts but infrequent preservation of faunal remains. Five broadly continuous techno-cultural phases are recognized in eastern Aleutian Islands based largely on lithic artifact inventories and, beginning in the middle Holocene, traits of structural remnants (Davis at al. 2016; Davis and Knecht 2010; Hatfield 2010; Knecht and Davis 2001). By ca. 4,000 years BP, a centralized settlement pattern was established (Corbett 1991; Frohlich 2002), resulting in large permanent or semi-permanent settlements with numerous semi-subterranean houses, food storage pits, and midden deposits.

In contrast, early-Holocene sites in Unalaska Bay have the appearance of short-term occupations rather than intensively re-used centralized locations characteristic of the later record. The effect on toolkit design or assemblage compositions of seasonal or spatial variability in the distribution of subsistence resources has received little attention in Aleutian archaeology.

Bifacial projectile points do not occur before ca. 7,000 years ago (Knecht et al. 2001; Rogers et al. 2009; Wilmerding and Hatfield, 2012), and the underlying causes or conditions leading to the addition of bifacial technology and the implied shift in the design of hunting equipment have not been identified. The addition of end-hafted bifacial spear and dart points to a microblade-oriented toolkit could be an outcome of functional demands within a single technological organization, as has been argued for Northern Archaic populations in interior Alaska (Potter 2011; Rasic 2011). Seasonal patterns in available prey resources and strategies employed to access them also would lead to variability in settlement needs where long and short-term occupations and investment in structural features, are scheduled based on the needs of subsistence economies. Anticipating lithic-tool needs for extractive and processing activities are essential to ensure that tools are available when and where they are needed. Patterns of transportation and spatio-temporal staging of lithic production are evidence of planning in the organizational system, and these patterns can be archaeologically evaluated. The large and diverse lithic assemblages of Unalaska Bay provide an opportunity to approach assemblage variability from the perspective of planning through investigation of provisioning strategies that operate to maintain sufficient toolstone in the technological system (Kuhn 1992).

Lithic material for production of chipped stone tools (hereafter, lithic tools) is not abundant in Unalaska Bay (Chapter 2) and, therefore, the majority of toolstone was acquired from distances greater than 10 km and transported to the sites where it was eventually discarded. Direct access to lithic material may be gained through multiple strategies, including embedded procurement in which toolstone is collected in the course of other activities distant from the residential base, targeted procurement through logistical mobility, opportunistically, or through trade. Procurement may under some circumstances be the primary purpose of movement (residential or logistical) where camps or specialized sites are positioned to access material (Binford 1979; Kelly 1995), This is not the case in Unalaska Bay where the availability of quality toolstone is low. Infrequent procurement and utilization of beach gravels for lithic tool production is evidenced by the presence of cobble cortex in the assemblages. Though they comprise a relatively minor portion of the lithic production system, beach cobbles served a range of other technological needs, such as hammerstones, net-sinkers, and lamps. Beach cobbles for such purposes could be collected from almost any gravel deposit within Unalaska Bay.

Much higher-quality toolstone transported to Unalaska Bay was utilized for the majority of lithic production, and, therefore, represents a degree of planning quite different from the use of local cobbles. Geographic locations for most of the lithic materials in the assemblages are not currently known. However, a wide range of siliceous sedimentary and igneous material types attributed to diverse formation contexts were selected and suggests the use of multiple source areas. Obsidian is the only lithic material for which geologic outcrops are documented at Okmok and Akutan, and each of these sources were utilized by Aleutian hunter-gatherers during the early and middle Holocene (Cook 1995 Nicolaysen et al. 2012; Reuther et al. 2011). The use of these source areas located on neighboring islands indicates inter-island transport of lithic material from distances of 60 to 150 km.

Technological Provisioning and Predictability

Toolstone sources are rarely located where lithic tools are most commonly used, and mobile hunter-gatherers must therefore plan in advance to acquire adequate amounts of toolstone to ensure that technological needs can be met as they arise. Maintaining a sufficient supply of operational tools in the technological system requires that the activities for which tools are needed and the rate at which the toolkit will become depleted can be at least generally anticipated in advance. Archaeological and ethnographic case studies demonstrate the importance of advanced planning to ensure that toolstone and other technological needs are met, enabling the production, transport, and deployment of lithic tools when and where they are needed (Binford 1979; Hofman 1999; Kuhn 1992, 1995; Sellet 2013), and to configure these activities in space and time such that procurement of toolstone is not in conflict with other critical activities, namely subsistence pursuits (Torrence 1989). Toolstone and the implements made from it are thus transported across the landscape, resulting in considerable material and technological variability at any given site (Sellet 2006). Untangling the relationships within and between lithic production, artifact transport, and material economy within the archaeological assemblages provides a view of future-oriented strategies enacted by people in the past as they made their livings.

Strategies for maintaining requisite supplies of material are to provision either places or people with materials and/or tools (Kuhn 1992, 1995). Provisioning strategies used within the same technological system may vary seasonally or according to other factors that control mobility or access to resources. For lithic technology, provisioning is conditioned by the nature of the lithic landscape, the frequency of residential moves, and the amount of redundancy in land use and site occupation, among others factors. For example, when activities and their material requirements can be known with some certainty and there is redundant use of the location, lithic material can be stockpiled for later use, or tools may be staged at the location of anticipated activity. Conversely, where activities are not known with certainty of there is low redundancy in land use, this strategy cannot work and tools and the materials with which to make them are carried along at all times in order to fulfill unspecified needs. Kuhn (1995:23) makes an important distinction between transporting items for their *utility,* meaning in the form of finished and maintainable tools, and transporting items for their *potential* to create tools. A classic example of the former is a microblade core capable of providing a supply of usable blanks as they are needed, but itself designed in a highly portable form due to its small size. When people are provisioned, the extent of forward planning may result in patterns of incremental tool replacement as tools wear out. Episodes of mass production and gearing up for future needs (Sellet 2013) are examples of provisioning a place.

Redundancy in land use and the degree of predictability in the activities for which tools are needed, as well as the time and intensity of toolkit attrition between opportunities for toolkit replenishment are all factors that interplay in provisioning decisions. Toolstone selection resulting in assemblage variation may be driven by time or energy constraints in other aspects of the technological system, such as foraging or land use that may restrict access to toolstone source areas. Because Kuhn's provisioning concept links lithic technological decisions regarding lithic production and design to toolstone procurement, transport, and economy, it articulates these features of the technological system to anticipated mobility and land use.

Lithic tools were essential in a variety of extractive and processing tasks for the coastal hunter-gatherers of the Aleutian Islands, such as hunting and working skin, bone, and wood. Currently, the sub-arctic marine environment of the eastern Aleutian Islands is highly productive (Ladd et al. 2005), but it is not spatially or temporally uniform. The degree of uncertainty and environmental variability experienced by Holocene hunter-gatherers as a result of global and local processes associated with post-glacial climate change (Thorson and Hamilton 1986) required technological strategies for risk mitigation. Comparing technological provisioning between sites within a single bay system will provide a measure of future-oriented aspects of lithic production and land use.

Methods and Materials

Lithic data were collected from the middle Holocene-aged assemblages of Margaret Bay Level 4 (MB-4) and Level 5 (MB-5) and the single-component early Holocene site Russian Spruce (RS), all located within 2 km of each other in Unalaska Bay, on the northern portion of Unalaska Island (Figure 1). Site details and assemblage characteristics are summarized in Chapter 1 and in the literature (e.g., Dumond and Knecht 2001; Knecht et al. 2001). These assemblages correspond chronologically to the Early and Late Anangula Phases that have been argued on a techno-typological basis to represent gradual changes within a unified technological system (Davis and Knecht 2010; Davis et al. 2016; Hatfield 2006, 2011; Knecht and Davis 2001). A gap of nearly 3,000 years between documented Early and Late Anangula sites, however, remains cause for caution in attributing technological shifts to *in situ* development alone. A better understanding of site function and seasonal land use is an important factor to consider in evaluation of the degree of similarities between the two phases, but little relevant information is available. Anticipation of lithic material needs and the provisioning strategies employed are reflected in lithic production technology in Unalaska Bay assemblages. Evaluation of assemblage variability from the perspective of these future-oriented strategies through analysis of the toolstone selection and procurement, artifact transport, and the spatial and temporal staging of tool production provides a line of evidence from which settlement and land use variability between the early and middle Holocene may be inferred.

Information related to lithic material circulation was gained through implementation of a system for classification of toolstone types based on macroscopically visible properties (Chapter 2), and further augmented use of Minimum Analytical Nodule Analysis (MANA). MANA is an analytical technique similar to refitting, in which pieces derived from the same core or nodule are grouped based on common traits of color, inclusions, luster, and texture (Larson 1994; Larson and Ingbar 1992; Larson and Kornfield 1997; Wykoff 1992). As such, reconstructed nodules provide a perspective on production technologies, transportation of tools and cores, and lithic economies that is complimentary to standard technological analyses. Refitted or conjoining artifacts often occur within a reconstructed nodule, but they are not a requirement of the method. Artifacts less than 2 cm in maximum dimension were excluded from MANA because they possess small surface area and distinguishing material traits could not be assessed with confidence. The diversity of lithic materials in the RS, MB-5 and MB-4 assemblages facilitated nodule identification in this study. This applies equally to obsidian, as Aleutian obsidians are relatively impure, exhibiting variability in patterns of inclusions, flow banding, translucency, and color.

All cores, tools, and blade/microblades recovered from each of the three assemblages, and samples of the abundant debitage from each site are included in the lithic analysis. Doral cortex values are assigned based on an ordinal scale (none, <10% 10-49%, 50-90%, >90%). Unifacial flake and blade tools are common to all assemblages. With the exception of the two bifacially-retouched scrapers identified in the Russian Spruce assemblage during this analysis, biface technology is restricted to the middle-Holocene assemblages. It is important to note that biface technology in all three assemblages is a function of tool production from flake blanks and does not represent a core organization technology. Blades and microblades are defined here based on morphometric attributes derived from their specific production technologies. Following Owen (1988), blades are elongated blanks with roughly parallel margins, and at least one dorsal arrise reflecting the removal of prior blades, either unidirectionally or bidirectionally, from a prepared core. Blades in Unalaska Bay assemblages exhibit platform and bulbar morphologies consistent with use of percussion for detachment. In Unalaska Bay, blades served as blanks for production of formal and informal unifacially edge-modified tools.

Microblades are objective pieces derived from the systematic reduction of specifically prepared cores (Kobayashi 1970; Morlan 1970, 1976; Sanger 1968) and, as a consequence, also exhibit parallel margins and arrises reflecting prior removals. Microblades are strongly linked to the pressure-flaking production method (Flenniken 1987; Gomez Coutouly 2018; Inizian et al. 1992), which is a highly controlled process resulting in uniformity in blank form and size (Pelegrin 2012). The standardization of microblades in morphometric terms is likely a primary factor for which this method of core organization was employed. In Unalaska Bay assemblages, microblades are less then 11 mm wide, an average of 25 mm long, and are detached from conical, wedge-shaped and prismatic cores (Chapter 3).

Results

A total of 186 analytical nodules were identified in this study, and a tabular summary is in the Appendix. A comparable number of nodules were reconstructed from each of the three assemblages, though there are important qualitative differences between nodules at each site. The average number of elements per analytical nodule is 11.2 at RS (median =6), 8.6 at MB-4 (median =5), and 4.9 at MB-5 (median =3). Russian Spruce and MB-4 each produced nodules with sequences of numerous technologically-related elements as a result of nodule reconstruction

(Figure 2). The low number of extensive sequences at MB-5 suggests a difference in the degree of continuity in reduction sequences on site from the other two assemblages, a statistically significant difference (Pearson's X^2 =7.9, df=2, p=.0193, *V*=.2061) when the number of nodules with more than 10 elements are compared to the number with 10 or fewer. The majority of the 186 nodules consist of 2-5 elements, and this number again differs in MB-5, where 71% of nodules contain 2-5 elements compared to 53% at MB-4, and 45% at RS (single item nodules were not utilized in this study – though cases of unique material were identified among tools and debitage in each of the assemblages). Artifacts refitted in a technological sequence were far more common within RS nodules (n=10, artifacts = 31, 2.7%) than the other sites. Cores were not common in nodules from MB-5 or MB-4, occurring in only 13.6% and 20% of total nodules, respectively. In contrast, at RS most cores (71.4%) were fit into nodules. Combined, these findings indicate that on-site lithic reduction, transport, and discard patterns differ between the three locations, an issue explored further below.

Core Reduction Trajectories

Flake, blade, and microblade reduction trajectories are represented at each site (Figure 3). In addition to these reduction trajectories, debitage generated through tool edge modification occur in all three sites, but are underrepresented in this analysis due to their small size. Bifacial thinning flakes and bifacially retouched implements are common in MB-4 and MB-5, though bifacial technology accounts for only 9% and 2.6% of their total respective lithic inventories, respectively. Burin spawls are present in all three assemblages, but are much more numerous at RS. The prevalence of flakes and other debris not diagnostic to a specific reduction trajectory is a combination of at least two processes: the production of flakes to serve as tool blanks from unprepared flake cores, and the initial shaping of blade or microblade cores. Consequently, the importance of flake core reduction relative to other core organizations in the technological systems at each site is ambiguous. Using MANA and with close monitoring of the toolstone types, comparisons between sites in terms of core reduction trajectories are possible. This allows for (1) an accounting of prepared cores that were worked on site but not recovered and made visible through analytical nodules containing core maintenance or shaping debris; (2) visibility of the technological steps involved as cores are converted to other reduction trajectories; and (3) a more accurate determination of transportation of cores, tools, and blanks to and from the sites.

Cores and core maintenance are represented in 57 nodules (Appendix). Table 1 summarizes the count of actual cores by assemblage and reduction trajectory, as well as the minimum numbers of cores represented in each assemblage through identification of core maintenance debitage of distinct toolstone types. Analytical nodules containing informal flake cores, fragments, or core maintenance debitage were identified in each assemblage and range from 45 to 2 elements per nodule. Some of the nodules show evidence for on-site reduction of locally available cobbles (Chapter 2) for the production of flake blanks. Given the ambiguity in distinguishing flake core reduction from early shaping of cores for other reduction trajectories, no attempt is made here to reconstruct their reduction trajectory using nodule evidence. Analytical nodules do, however, provide an important perspective on the technological sequences involved as nodules were transformed from blade or diminutive flake cores into microblade cores.

Microblade Reduction

Microblade core morphology and production techniques in Unalaska Bay sites are diverse and described in detail elsewhere (Chapter 3). Numerically, there is a distinct contrast between the predominance of conical-shaped microblade core forms in the RS assemblage to wedge-shaped forms in the two Margaret Bay assemblages. Most microblade cores have single or opposing prepared platforms; however, rotated microblade cores are also common at Russian Spruce. Maintenance of microblade cores, regardless of core type, creates distinctive and recognizable debitage with attributes derived from the parent core morphology, making cores shaped or reduced on site and subsequently transported from the site visible through nodule analysis. A single nodule from MB-4 (MB4-33) contains microblade technology and shows two steps in a sequence of microblade core preparation and maintenance. Two flakes are technologically undiagnostic and represent early stages of core reduction; at the end of the sequence represented by the nodule, a distinctive type of microblade core preparation flake that acts as an impromptu crest (i.e. platform edge flake, see Chapter 2) was detached, meaning (1) that the core was rotated earlier in the sequence; (2) continued microblade production following the removal of the recovered platform edge flake, and (3) the microblades produced and the core was transported from the site in still usable form.

On-site reduction of microblade cores is evident in five nodules from MB-5 (MB5-32, MB5-40, MB5-41, MB5-42, and MB5-50) containing core maintenance debitage but no microblade cores. These nodules demonstrate a sequence of microblade core reduction similar to that in MB4-33, but also reveal a stage in microblade core lateral and frontal trimming that results in production of pressure flaked bladelets (Figure 4). In addition, eighteen nodules from MB-5 are composed entirely of microblade or microblade segments with refitted elements, suggesting that on-site production of microblade blanks commonly occurred during site occupations. The sequence of microblade production at RS follows a reduction trajectory like that of MB-5, with intermediary steps of bladelet production evident in six nodules (RS-14, RS-19, RS-37, RS-42, RS-46and RS-53), three of which also contain cores or core fragments. At both RS and MB-5, the sequences of bladelet and microblade production are occasionally preceded by production of prismatic blades.

Blade Core Reduction

Blade cores are missing from these Unalaska Bay sites, a situation that requires explanation given the presence of numerous large prismatic blades and blade tools in the assemblages. Blade and blade tools are represented by a range of toolstone types, facilitating reconstruction of nodules and identification of blade core maintenance flakes from individual cores. Blade technology is least common in the MB-4 assemblage, where unretouched blades and blade tools comprise only 1.4% (n=15) of the total lithic assemblage. Two blade core maintenance flakes of distinct toolstone material point to blade cores at least minimally worked on site (Table 1). Five blades or informal blade tools occur within three nodules that also contain abundant generalized reduction debitage, and platform rejuvenation that preceded blade production. Other production trajectories within these nodules include utilized or marginally retouched flakes, biface shaping, and manufacture of bifacial projectile points and burin production. In addition to the blades in these nodules, eight distinct toolstone types are represented by unretouched and informal blade tools; it is not possible to determine with the available evidence if the eight blade cores from which these were generated passed through the site or if the transported toolkit consisted of blade blanks.

At MB-5, blade core maintenance flakes and other diagnostic debitage are represented by eight toolstone types, including seven in reconstructed nodules, accounting for on-site reduction of at least 9 blade cores (Table 1). The majority of the MB-5 blade assemblage (n= 190, 80%) consists of a range of untyped toolstone and no associated blade core maintenance debitage. Nodules with components of blade technology exhibit very little evidence of generalized flaking debris in contrast to MB-4, suggesting that rather than being produced on site, most blades were either transported as blanks or that blade cores entered the site in a diminutive condition with low prismatic blade core utility. The former option is supported by the clear link of prismatic blade, bladelet, and microblade production exhibited in three reconstructed nodules in the MB-5 assemblage. When the evidence for prismatic blade production is compared, two distinct trajectories for blade core reduction took place at MB-5. The single example of a prismatic blade core recovered from the three sites occurs within an analytical nodule (MB5-55) in MB-5. The nodule consists of two nearly refitting core fragments and a flake detached in the shaping process. The blade core is relatively informal, and from the extant fragments appears to have been rotated 90 degrees at least one time, a technique that is also documented among the abundant evidence for prismatic blade production at Anangula (Aigner 1978; Del Bene 1981, 1992; Pittenger 1986). Five additional nodules consist of large prismatic blades, core maintenance debitage, an early stage biface, and few pieces of generalized flaking debitage.

Blade technology relative to other reduction trajectories is more common at RS than at MB-4 or MB-5. As at the other locations, evidence for on-site reduction of prismatic blade cores is sparse. At least seven blade cores were worked to some extent on site based on maintenance debitage in four nodules plus debitage from three unique toolstone types. An additional 15 material types account for the remaining 53% (n= 35) of the inventory of blades and blade-related debitage. Production of prismatic blades is documented in two nodules: RS-58 and RS-61. The process represented at RS is similar to MB-5; each nodule also contains a small amount of generalized flaking and blade core maintenance debitage, unretouched and marginally retouched blades, and three formal scrapers.

As at MB-5, blade production technology contains a diminutive component at RS and links each to microblade production. Though the overall count of bladelets is low at MB-5 (n=12), they fit into four nodules that demonstrate the fluidity between bladelet and microblade core reduction as a core is reduced in size. Bladelets are small, thin pressure flaked blades with irregular edges and are distinct from microblades as end products (Chapter 3). Through MANA it is possible to see how they were produced as a preparatory step in microblade production. Bladelets are less common at RS than at MB-5, but a single bladelet core and core maintenance debitage comprised of seven unique material types indicates that bladelet production took place at RS as preliminary steps in shaping a prismatic microblade core.

Artifact Transport

Cores were transported to and from Unalaska Bay sites, and flake, blade and microblade cores were worked on at the sites (Table 1). Nodule reconstruction indicates that large blades were also transported, either as blanks or as edge-modified or other shaped tools. Tools with cortex are rare in the three artifact assemblages. Unrolled tabular cortex originating from columnar outcrops indicates procurement from source areas other than secondary gravel deposits that are available locally. As such, the presence of tabular cortex provides a general measure for artifact transport to Unalaska Bay (Chapter 2). There is a statistically significant difference in the distributions of cobble and tabular cortex in the MB-4, MB-5 and RS tool assemblages (Pearson's X^2= 11.9375, p<.01) (Table 2). Cobble cortex on flake tools indicates that cobbles were selected for lithic production in greater than expected frequencies at MB-4. Artifacts with tabular cortex or other weathered surfaces indicating procurement from localities occur in the greatest frequencies at Russian Spruce. At all three sites, informal tools dominate the retouched artifact assemblages, and these are predominately unimarginally and unifacially retouched flakes and blades.

As a whole, formal tools exhibit even less cortex than do informal tools and were rarely included in analytical nodules, suggesting that they entered the sites as finished tools. As an example, exhausted blade tools were repurposed for the production of transverse burins at RS. At MB-4 and MB-5, projectile points account for the majority of formal tools (Figure 5) and these are almost entirely lacking in cortex. The intensive reduction in shaping projectile points in conjunction with a strong preference for use of fine-grained volcanic toolstone with little internal distinctions, made inhibited inclusion of these artifacts in analytical nodules. The volume of debitage of similar material argues against the transportation of finished projectiles and indicates that these were likely produced on site, particularly at MB-4.

Transported Cores

The fact that no blade cores, exhausted or otherwise were recovered suggests that prepped and active cores were transported from the sites following at least some on-site blade production or core preparation. Based on the length of complete blades within nodules, cores with heights between 5 and 8 cm were either transported away from each of the sites, or to areas of the sites that were not excavated. Bladelet cores were prepared and transported from RS, possibly in the process of re-tooling the toolkit with fresh microblade cores. At RS, of the eight microblade cores recovered, six are exhausted with no evidence of on-site maintenance, suggesting that people arrived at this location with a microblade toolkit in need of refurbishment. Two microblade cores were produced and reduced on-site and then abandoned due to technical errors inhibiting further reduction. Ten microblade cores were identified through maintenance debitage alone, and these cores were prepped on site and transported.

Discussion

Provisioning strategies employed at Unalaska Bay sites emphasize transportation of blade and microblade cores or other tool-making potential during the early Holocene occupation at RS and the middle Holocene occupation at MB-5. In each of the three assemblages, analyzed cores are transported to and from the sites alongside informal flake and blade tools in a segmented sequence of lithic production. While blade and microblade cores remain a component of transported toolkits at MB-4, they are grossly outnumbered by generalized flake production. Together with a greater reliance on use of locally available cobbles (Chapter 2), the record at MB-4 reflects a provisioning strategy focused on place rather than people.

The majority of tools in these and other Aleutian assemblages are informal, generally involving one or more retouched edge. Informal tools are often associated with stockpiled toolstone in a centralized location, and therefore, rarely is in short supply (Parry and Kelly 1987). For mobile groups where tasks requiring lithic tools occur at dispersed locations, transportation of large blanks may provide a more versatile and economical solution for maintaining an operational toolkit (Kuhn 1994). In Unalaska Bay, informal tools would have served many technological purposes perfectly well, as they did in other hunter-gatherer contexts (Kelly 1995).

Microblade cores in the toolkits at RS and MB-5 further highlight provisioning toolkits with technological potential, and how microblade production was a process segmented across time and space.

Foraging Distances

The inhabitants of RS, MB-5, and MB-4 exploited a wide variety of toolstone types. Toolstone was obtained from local or near local beach and residual deposits as well as from primary outcrops. With the exception of obsidian (discussed below), toolstone in the analyzed assemblages cannot be confidently linked to geological outcrops, and distance of transport cannot be determined. Nevertheless, a similar geographic range is represented by the use of toolstone types common to all three assemblages. Obsidian nodules or cores originating from Akutan and Okmok were transported to Unalaska Bay from distances of 45 and 150 km. Okmok obsidian, in the form of a cores or unworked nodules and possibly even large prismatic blades, were transported to MB-5, where flake and blade cores were reduced on site, prepped, and transported.

Chert cobbles occur in low density on Unalaska Bay beaches and can also be found within a 30 km foraging range on some beaches of Beaver Inlet. These cobbles, as well as low-quality cobble of andesite, were utilized infrequently at all three sites. However, this unplanned technology is more common at MB-4, viewed both from reconstructed nodules indicating local procurement and on-site reduction and the frequency of retouched flakes with cobble cortex.

Transport costs and procurement strategies in a maritime context differs from land-based systems of most hunter-gatherers in which weight, time, and energy expended can be calculated based on knowledge of the terrain and the time required for transit (Kelly 1995). In this coastal setting, watercraft would be required for most foraging activities and for both inter and intra-island transportation (Figure 6). Obsidian procurement, for example, requires oceanographic knowledge and skill, time, and energy for travel, but also entails the costs of producing ocean-going watercraft. Toolstone procurement costs are high in this context unless they are embedded in other activities.

Seasonality

Seasonal organization in settlement patterns and subsistence regimes are integral to planning for hunter-gatherers (Kelly 1995). In the eastern Aleutian Islands, resident species such as sea lion, harbor seal, and cod compose a substantial portion of the subsistence inventories during the middle and late Holocene (Corbett and Yarborough 2016). Northern fur seals migrate through the ocean passes bi-annually. Hunting sea mammals was most active during the breeding season, when animals could be taken at haul outs or in rookeries (Crockford 2012). Birds, salmon, berries, and roots are restricted to summer and fall availability (Table 3). Frequent hazardous sea conditions, storms, and rain during late fall to early spring inhibit opportunities for open-ocean hunting of sea mammals or deep-sea fishing for cod. Foraging during winter likely was constrained to within the protected bay systems, where seals and halibut could be obtained. Ethnographic accounts from the early nineteenth century in Unalaska Bay remark on the scarcity of stored food by the end of winter (Merck 1980:100). During the late Holocene, a seasonal cycle of subsistence had developed that relied on storage of dried fish and meat for winter consumption.

The faunal record at MB-4 suggests that seasonal “gearing up” for intensive and predictable summer subsistence activities with the production of lithic projectile points may have been in place by ca. 5,000 cal BP. Winter and spring are the times for tool manufacture and repair among ethnographically documented sea mammal hunters (Krupnik 1993). Seasonality of the MB-4 faunal inventory is forthcoming. However, rookery-aged individuals are common in the assemblage (Crockford and Frederick 2007) as are other seasonally restricted species of birds. The lithic and faunal assemblages at MB-4 indicate the intensive use of this location as a residential base across multiple seasons. MB-5 and RS lack faunal remains, but their lithic tool inventories and patterns of lithic production provide a perspective on seasonality and site function. MANA presented here supports the contention of the site's excavators that RS represents a special use camp. The continuous sequence of lithic production from transported nodules and discard of exhausted and re-purposed tools point to a single component site of relatively short occupation duration. Season of occupation cannot be stated with certainty, however, the focus on production of burins presumably for wood or bone working, and the refurbishing of a transported toolkit together suggest that the site served as a hunting camp where equipment was manufactured and maintained.

The pattern of site function at MB-5 is less clear. Based on reconstruction of few continuous reduction sequences during MANA and the large number of discarded non-local cores, this location was occupied repeatedly, possibly on a seasonal basis. The pattern of repeated use, and production and maintenance of a transported toolkit conform to expectations of a special use location (Binford 1980). The repeated use of this location, as opposed to that of RS, may be a factor of increasing landscape stability after 7,000 years ago, and associated increase in the predictability of obtaining subsistence resources from this location. Anticipated redundancy in land use, whether on a seasonal basis as at MB-5 or as a long-term occupation of a residential base at MB-4, explains the temporal shift toward the provisioning of place identified in the three assemblages in this study. The information gained from this analysis demonstrates that temporal trends in lithic assemblages can be explained as adaptive responses by hunter-gatherers in land use and technological organization to levels of uncertainty in environmental conditions. More detailed paleoenvironmental and landscape reconstructions are needed in Unalaska Bay to link the temporal trend visible in the archaeological record to increased predictability in resource distributions and seasonality.

Conclusion

At each of the three sites, cores and large blanks were transported, emphasizing technological potential over utility in the composition of the toolkit. The virtual absence of blade cores in these Unalaska Bay assemblages is noteworthy given the presence of blades and blade tools in all three assemblages and the abundance of large prismatic blade cores at the early Holocene site of Anangula on neighboring Umnak Island. At Unalaska Bay, blade cores were repurposed from blade or bladelet cores to microblade cores, endowing the lithic technological system with a degree of fluidity and versatility. The segmentation of blade and microblade core reduction and evidence for microblade re-tooling at RS reflects anticipation of toolstone needs and the transportation of unifacial blade tools and cores. All three Unalaska Bay sites employ a strategy by which technological potential is transported as a component of a transported toolkit. At MB-4, the increase in use of local chert cobbles and the prolific production of bifacial projectile points signals a shift to emphasis on provisioning place. Though aspects of core and blank transport remain, a strategy of provisioning this location with specialized hunting weapons is also apparent. This pattern appears to have been in place during occupations at MB-5, though not as clearly delineated due to the overprinting of occupation debris within this assemblage.

Minimum analytical nodule analysis has highlighted variation in the lithic assemblages of three Unalaska Bay sites and attempted to relate it to anticipatory strategies in technological provisioning.

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Table 1. Counts of cores in the assemblage and the minimum number of cores (mnc) reduced on site based on core maintenance debitage.

	MB-4		MB-5		Russian Spruce	
	Cores	MNC	Cores	MNC	Cores	MNC
Flake	16	7	47	5	5	8
Blade	-	2	1	8	-	7
Bladelet	-	-	-	-	1	7
Microblade	3	-	8	2	8	10
Bipolar	-	-	2	-	-	-
Tested Cobble	1	-	7	-	-	-
Total Cores worked on site	29		80		46	

Table 2. Frequencies and cortex types for formal and informal tools (no microblades).

	Cobble Cortex (%)	**Tabular Cortex (%)**	**No Cortex (%)**
MB-4	6.3	2.2	91.5
MB-5	3.2	3.5	93.3
RS	2.9	6.3	84.6

Table 3. Seasonal availability of subsistence resources based on modern environmental conditions.

	Summer	Fall	Winter	Spring
Sea Lion	+	+	+	+
Harbor Seal	+	+	+	+
Fur Seal	-	+	-	+
Sea Birds, nesting	+	-	-	-
Cod	+	+	+	+
Halibut	+	+	+	+
Salmon	+	+	-	-
Shellfish/Reef	+	+	+	+
Berries/Roots	+	+	-	-

Figure 1. Location of Unalaska Island and site locations within Unalaska Bay.

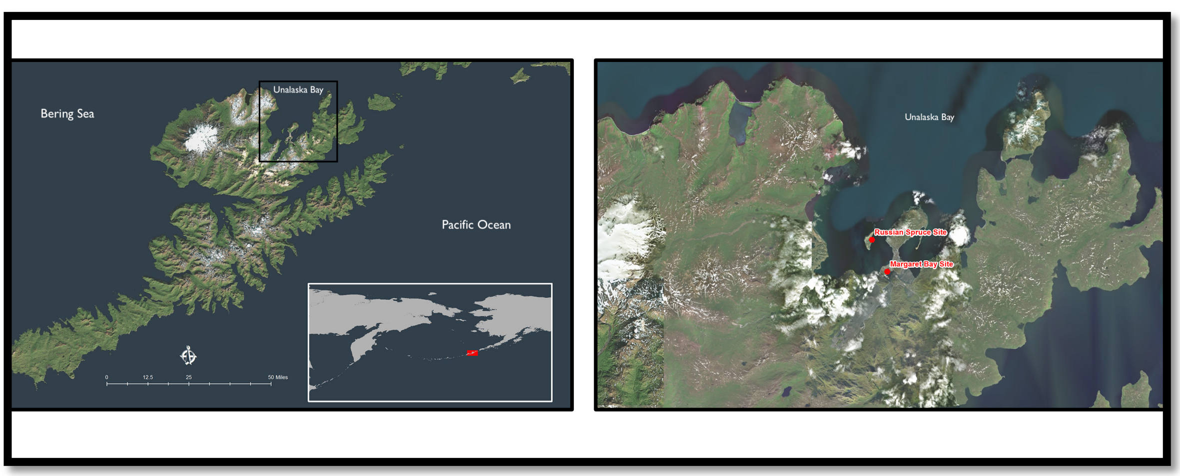


Figure 2. Frequency distribution of count of elements composing analytical nodules.

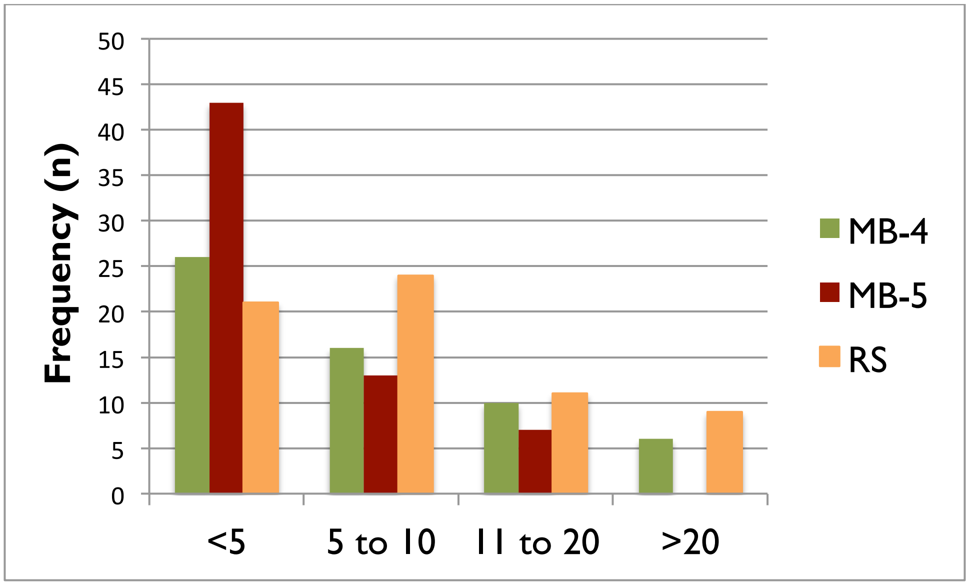


Figure 3. Frequency distribution of core reduction trajectories at three occupations in Unalaska Bay.

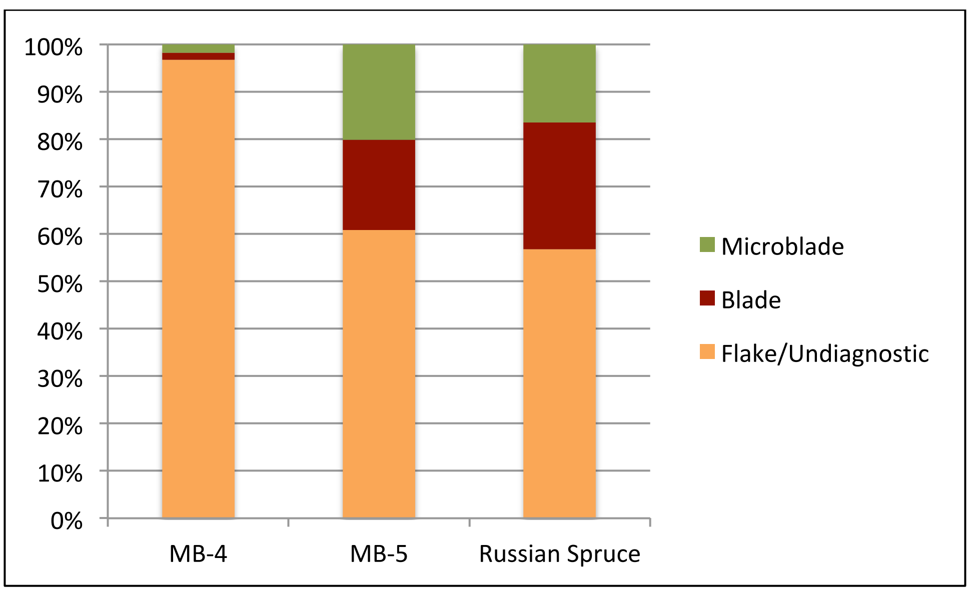


Figure 4. Analytical nodules MB5-37 (left) and MB5-42 (right) depicting elements of blade, bladelet and microblade production.

Figure 5. Frequency distribution of tool classes in three Unalaska Bay assemblages.

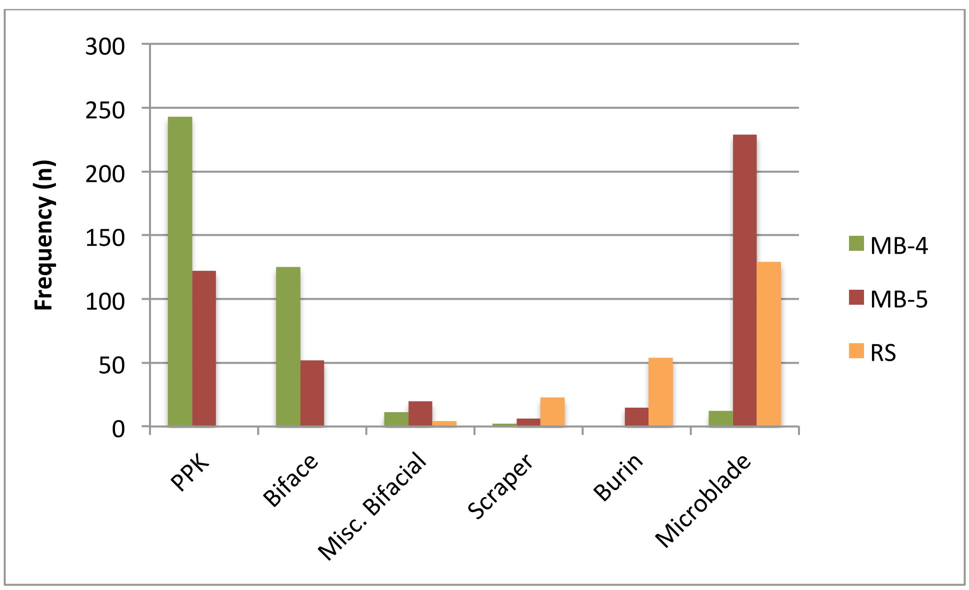
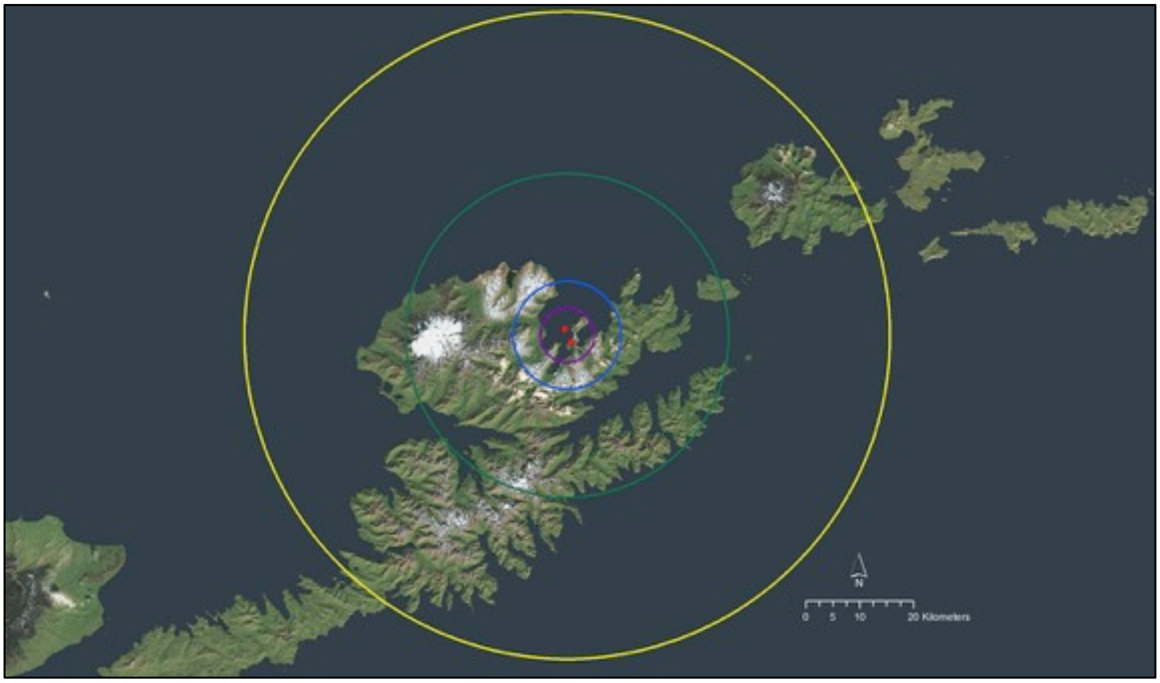


Figure 6. Foraging radii at 5, 10, 30 and 60 km from Unalaska Bay sites.



Chapter 5: Conclusion

Over the last seven decades, a great deal of information has been acquired by Aleutian archaeologists, an impressive accomplishment given the remoteness of the island chain and challenging conditions of conducting field work in the region. Research that identifies the intertwined effects of resource distribution and subsistence-settlement systems and other causal factors leading to variation in lithic production systems are needed to gain a better understanding of Aleutian hunter-gatherer organization. To my knowledge, no research in the Aleutian Islands prior to that presented here has focused specifically on the organization of technology as a framework for investigating lithic assemblage variability.

The organizational perspective applied in this dissertation enhances our understanding of (1) the archaeological record in Unalaska Bay, (2) hunter-gatherer adaptions related to technological provisioning, and (3) future-oriented lithic production strategies. Through reconstruction of the technological system and identification of tool and core transport patterns, this dissertation has demonstrated that anticipated mobility was a primary factor in structuring lithic production at the site-level during the early and middle Holocene. Characterization of the local lithic landscape allowed for the distinction between local and non-local toolstone types, and for evaluation of their different roles within lithic production systems. Reliance on a highly maintainable toolkit emphasizing tool-making potential in the form of microblade cores and large blades implies a relatively high degree of mobility and technological versatility during the early Holocene at Russian Spruce. This trend is also evident in the lithic assemblage of Level 5 at Margaret Bay, but is overprinted by repeated use of the location. Increasing predictability in subsistence resource distribution leading to longer-term site occupation is inferred from the shift to a lithic production strategy focused on provisioning of the location with targeted inland lithic resources and a greater reliance on locally available toolstone evident in Level 4 at Margaret Bay.

The model developed in this dissertation is an initial step toward explaining assemblage variability in behavioral terms, and should be refined or altered through further analyses of Unalaska Bay sites using the abundant lithic assemblages already unearthed. The maritime hunter-gatherers of the Aleutians have no known analog in prehistory or in the ethnographic record, and for millennia these people have successfully lived in a geologically and climatically dynamic landscape unlike any other area of the world. The organization of technology in this highly productive but technologically demanding setting is a model of adaptive success and innovation. Planning ahead for toolstone needs is fundamental to mitigating risk, and is shown here to be central to the technological organization of early and middle Holocene hunter-gatherers.

Appendix

Margaret Bay 4 Nodules

Nodule	n	Wgt. (g)	Material	Cortex Type	Material Quality	IFT	FT	BIPOLAR	FLAKE	BLADE	MICRO BLADE	TOOL PROD	CORE / CRF	CORE REJUV
MB4-01	4	59	FGV	Cobble	Good	yes	-	-	yes	-	-	-	Flake	-
MB4-02	28	121.7	FBA	Tabular	Good	-	yes	-	yes	-	-	yes	-	-
MB4-03	12	76.1	FBA	Tabular	Good	yes	yes	-	yes	-	-	yes	-	-
MB4-04	6	5.1	FBA	-	Moderate	-	-	-	yes	-	-	yes	-	-
MB4-05	12	21.7	FBA	-	Moderate	yes	-	-	yes	-	-	yes	-	-
MB4-06	12	30.2	FBA	-	Moderate	-	-	-	yes	-	-	yes	-	-
MB4-07	18	71.1	FBA	-	Moderate	yes	yes	-	yes	-	-	yes	-	-
MB4-08	4	39.6	FBA	-	Poor	-	-	yes	yes	-	-	-	-	-
MB4-09	2	31	UNID	Cobble	Poor	-	yes	-	yes	-	-	-	-	-
MB4-10	10	17.4	FGV	Tabular	Good	-	-	-	yes	-	-	yes	-	-
MB4-11	9	55.2	FGV	Tabular	Good	-	-	-	yes	-	-	yes	-	-
MB4-12	28	88.7	FGV	Tabular	Good	-	-	-	yes	-	-	yes	-	-
MB4-13	2	5.4	FBA	-	Good	-	-	-	yes	-	-	-	-	-
MB4-14	44	112.72	OBS	Tabular	Good	yes	-	-	yes	yes	-	yes	-	-
MB4-15	14	49.4	OBS	-	Moderate	yes	-	-	yes	-	-	-	-	-
MB4-16	6	28.7	OBS	-	Good	yes	-	-	yes	yes	-	-	-	Flake
MB4-17	29	40.2	OBS	-	Very	yes	-	-	yes	yes	-	yes	-	-

		9			Good									
MB4-18	2	1.6	OBS	-	Very Good	-	-	-	yes	-	-	-	-	-
MB4-19	23	95.2	CCS	Cobble	Very Good	yes	yes	-	yes	-	-	yes	-	-
MB4-20	14	42.9	CCS	-	Good	yes	-	-	yes	-	-	-	-	-
MB4-21	3	26.4	CCS	Cobble	Good	-	yes	-	yes	-	-	-	-	-
MB4-23	7	81.8	CCS	Cobble	Good	-	-	-	yes	-	-	-	Flake	-
MB4-24	3	83.8	CCS	-	Good	-	-	-	yes	-	-	-	Flake	-
MB4-25	4	45.2	CCS	-	Good	-	yes	-	yes	-	-	-	Flake	-
MB4-26	5	8.6	CCS	-	Good	-	-	-	yes	-	-	-	-	-
MB4-27	2	51.4	CCS	-	Very Good	-	-	-	yes	-	-	-	-	-
MB4-28	4	14.7	CCS	Cobble	Very Good	-	yes	-	yes	-	-	-	-	-
MB4-29	3	2.9	CCS	-	Good	-	-	-	yes	-	-	-	-	-
MB4-30	2	25	CCS	-	Good	-	-	-	yes	-	-	-	-	-
MB4-31	22	50.3	CCS	Cobble	Very Good	-	-	-	yes	-	-	yes	-	-
MB4-32	2	1.89	CCS	-	Very Good	-	-	-	-	-	yes	-	-	Micro-blade
MB4-33	3	16.3	CCS	-	Good	yes	-	-	yes	-	yes	-	-	Micro-blade
MB4-34	3	52.2	CCS	-	Good	-	yes	-	yes	-	-	-	-	-
MB4-35	3	37.6	CCS	-	Good	-	-	-	yes	-	-	yes	-	-
MB4-36	8	17.3	CCS	-	Good	-	-	-	yes	-	-	yes	-	-
MB4-37	8	19.4	CCS	-	Good	-	-	-	yes	-	-	yes	-	-
MB4-38	10	16.6	CCS	-	Very Good	-	-	-	yes	-	-	yes	-	-

MB4-39	6	33	CCS	Cobble	Moderate	-	-	-	yes	-	-	-	-	-
MB4-40	5	26.9	CCS	Cobble	Poor	yes	-	-	yes	-	-	-	-	-
MB4-41	12	109.5	CCS	Cobble	Moderate	yes	-	-	yes	-	-	-	-	Flake
MB4-42	2	1.2	CCS	-	Good	-	-	-	yes	-	-	-	-	-
MB4-43	3	47.5	CCS	Cobble	Moderate	-	-	-	yes	-	-	-	Flake	-
MB4-44	2	129.8	CCS	Cobble	Good	-	-	-	yes	-	-	-	Flake	-
MB4-45	4	14.1	CCS	-	Very Good	-	-	-	yes	-	-	yes	-	-
MB4-46	2	97	CCS	Cobble	Moderate	-	-	-	yes	-	-	-	-	-
MB4-47	5	24.9	CCS	Cobble	Good	-	-	-	yes	-	-	-	-	-
MB4-48	4	2.3	CCS	-	Very Good	-	-	-	yes	-	-	-	-	-
MB4-49	3	5.2	CCS	-	Very Good	-	-	-	yes	-	-	-	-	-
MB4-50	13	90.17	CCS	-	Very Good	yes	yes	-	yes	-	yes	yes	-	Flake
MB4-51	5	7.5	CCS	-	Very Good	-	-	-	yes	yes	-	yes	-	Flake
MB4-52	3	17.8	CCS	-	Very Good	-	yes	-	yes	-	-	-	-	-
MB4-53	7	11.4	CCS	-	Very Good	-	-	-	yes	-	-	-	-	-
MB4-54	5	7.1	CCS	-	Good	-	-	-	yes	-	-	-	-	-
MB4-55	3	6.2	CCS	Cobble	Good	-	-	-	yes	-	-	-	-	-
MB4-56	11	26.5	CCS	-	Very Good	-	yes	-	yes	-	-	-	-	-
MB4-57	9	27.4	CCS	-	Very	-	-	-	yes	yes	-	yes	-	-

					Good									
MB4-58	19	105.9	CCS	Cobble	Moderate	-	-	-	yes	-	-	yes	-	-
MB4-59	2	15	CCS	-	Good	yes	-	-	-	-	-	-	-	-

Margaret Bay 5 Nodules

Nodule	**n**	**Wgt. (g)**	**Material**	**Cortex Type**	**Material Quality**	**IFT**	**FT**	**BIPOLAR**	**FLAKE**	**BLADE**	**MICROBLADE**	**TOOL MANUFACTURE**	**CORE/ CRF**	**CORE REJUV**
MB5-01	3	48.6	FGV	Tabular	Good	-	-	-	yes	-	-	-	Flake	-
MB5-02	5	8.2	FBA	Tabular		-	-	-	-	-	-	yes	-	-
MB5-03	6	36.6	FBA	Tabular		yes	-	-	yes	-	-	yes	-	-
MB5-04	4	38.3	FBA	Tabular		-	-	-	yes	-	-	-	-	-
MB5-05	3	23.4	FBA	Tabular		-	-	-	yes	-	-	-	-	-
MB5-06	14	48.6	FBA	Tabular		-	-	-	yes	-	-	-	-	-
MB5-07	4	37.6	FBA	Tabular		-	-	yes	-	-	-	-	-	-
MB5-08	7	324.8	NGL	Cobble	Poor	-	-	yes	yes	-	-	-	-	-
MB5-09	8	162	NGL	Cobble	Poor	yes	-	yes	yes	-	-	-	-	-
MB5-10	8	214.2	NGL	Cobble	Poor	-	-	yes	yes	-	-	-	-	-
MB5-	2	183.	NGL	Cobble	Poor	yes	-	-	yes	-	-	-	Flake	-

11		3												
MB5-12	4	305.2	NGL	Cobble	Poor	-	-	-	yes	-	-	-	Flake	-
MB5-13	2	370.8	NGL	Cobble	Poor	yes	-	-	yes	-	-	-	Flake	-
MB5-14	2	5	FGV	-	Very Good	-	-	-	-	-	-	yes	-	-
MB5-15	8	19.7	FGV	-	Very Good	-	-	-	yes	-	-	yes	-	-
MB5-16	12	17.8	FGV	Tabular	Very Good	-	-	-	yes	-	-	yes	-	-
MB5-17	2	8.3	NGL	-	Poor	-	-	-	yes	-	-	-	-	-
MB5-18	3	10	CCS	-	Good	-	-	-	yes	-	-	-	-	-
MB5-19	3	6.7	CCS	-	Good	yes	-	-	yes	yes	-	-	-	-
MB5-20	2	0.18	CCS	-	Good	-	-	-	-	-	yes	-	-	-
MB5-21	2	51.9	CCS	-	Good	-	-	-	yes	-	-	-	Flake	-
MB5-22	4	1	CCS	-	Good	-	-	-	-	-	yes	-	-	-
MB5-23	2	4.6	CCS	-	Good	-	-	-	-	yes	-	-	-	Blade
MB5-24	4	9.57	CCS	-	Good	-	-	-	yes	yes	-	-	-	-
MB5-25	6	19.4	CCS	Cobble	Good	-	-	-	yes	-	-	-	-	Flake
MB5-26	3	8	CCS	-	Good	-	-	-	yes	-	-	-	-	-
MB5-	4	8	CCS	-	Good	-	-	-	yes	-	-	-	-	-

27														
MB5-28	2	3	CCS	-	Good	-	-	-	yes	-	-	yes	-	-
MB5-29	2	0.14	CCS	-	Good	-	-	-	-	-	yes	-	-	-
MB5-30	5	17.2	CCS	-	Good	-	-	-	-	yes	yes	-	-	Bladelet/Microblade
MB5-31	4	13.7	CCS	-	Good	-	-	-	yes	yes	-	-	-	Blade
MB5-32	19	2.34	CCS	-	Very Good	-	-	-	-	-	yes	-	-	Micro blade
MB5-33	2	0.24	CCS	-	Very Good	-	-	-	-	-	yes	-	-	-
MB5-34	2	0.4	CCS	-	Very Good	-	-	-	-	-	yes	-	-	-
MB5-35	3	0.3	CCS	-	Very Good	-	-	-	-	-	yes	-	-	-
MB5-36	2	0.12	CCS	-	Very Good	-	-	-	-	-	yes	-	-	-
MB5-37	11	12.14	CCS	-	Very Good	-	yes	-	yes	yes	yes	-	-	Bladelet/Micro blade
MB5-38	2	19.6	CCS	Cobble	Very Good	-	-	-	-	yes	-	-	-	-
MB5-39	2	2.5	CCS	-	Very Good	-	-	-	yes	-	-	-	-	-
MB5-40	17	4.98	CCS	-	Very Good	-	-	-	-	-	yes	-	-	Micro blade
MB5-	3	16.2	CCS	-	Very	-	-	-	yes	-	yes	-	-	Micro

41					Good									blade
MB5-42	8	6.13	CCS	-	Very Good	-	-	-	-	yes	yes	-	-	Micro blade
MB5-43	3	23.9	CCS	Tabular	Very Good	yes	yes	-	yes	-	-	-	-	Flake
MB5-44	2	3.4	CCS	-	Very Good	-	-	-	-	-	-	yes	-	-
MB5-45	2	1.07	CCS	-	Very Good	-	-	-	-	yes	?	-	-	-
MB5-46	2	6.8	CCS	-	Poor	-	yes	-	yes	-	-	-	-	-
MB5-47	2	0.1	CCS	-	Good	-	-	-	-	-	yes	-	-	-
MB5-48	2	54.8	CCS	-	Good	yes	-	-	yes	-	-	-	Flake	-
MB5-49	3	74.2	CCS	-	Very Good	yes	-	-	yes	-	-	-	Flake	-
MB5-50	3	0.42	CCS	-	Very Good	-	-	-	-	-	yes	-	-	Micro blade
MB5-51	2	106.8	CCS	-	Good	yes	-	-	yes	-	-	-	Flake	-
MB5-52	3	4.2	CCS	-	Good	-	-	-	-	yes	-	-	-	-
MB5-53	11	285.1	OBS	-	Good	yes	yes	-	yes	yes	-	-	-	Blade
MB5-54	7	47.8	OBS	-	Good	yes	-	-	yes	yes	-	-	-	Blade
MB5-55	10	313.09	OBS	Tabular	Good	yes	-	-	yes	yes	-	-	Blade	Blade
MB5-56	6	59.9	OBS	-	Good	yes	-	yes	yes	-	-	-	-	Flake
MB5-	7	88.5	OBS	-	Good	yes	-	-	yes	yes	-	-	-	Blade

57		1												
MB5-58	2	12.7	OBS	-	Good	-	-	-	-	yes	-	-	-	-
MB5-59	2	13.82	OBS	-	Good	-	-	-	-	yes	-	-	-	-
MB5-60	4	0.89	OBS	-	Very Good	-	-	-	-	-	yes	-	-	-
MB5-61	4	0.5	OBS	-	Very Good	-	-	-	-	-	yes	-	-	-
MB5-62	19	1.71	OBS	-	Very Good	-	-	-	-	-	yes	-	-	-

Russian Spruce Nodules

Nodule	**n**	**Wgt. (g)**		**Cortex Type**	**Material Quality**	**IFT**	**FT**	**BIPOLAR**	**FLAKE**	**BLADE**	**MICROBLADE**	**TOOL MANUFACTURE**	**CORE /CRF**	**CORE REJUV.**
RS-01	2	15.5	NGL	Cobble	Poor	-	-	-	yes	-	-	-	-	-
RS-02	6	96.7	NGL	Cobble	Poor	-	-	-	yes	-	-	-	-	-
RS-03	4	52.4	NGL	Cobble	Poor	-	-	yes	yes	-	-	-	-	-
RS-04	6	124.8	NGL	Cobble	Poor	-	yes	yes	yes	-	-	-	Flake	-
RS-05	6	24.7	NGL	Cobble	Poor	-	-	-	yes	-	-	-	-	-
RS-06	3	2.7	NGL	Cobble	Poor	-	-	-	yes	-	-	-	-	-
RS-07	2	10.2	CCS	-	Very Good	-	yes	-	-	?	-	-	-	-
RS-08	2	5.6	CCS	-	Very Good	-	yes	-	-	yes	-	yes	-	-
RS-09	5	0.6	CCS	-	Good	-	-	-	-	-	yes	-	-	-
RS-10	6	57.4	CCS	-	Good	yes	yes	-	-	yes	-	-	-	Blade
RS-11	8	14.8	CCS	-	Good	yes	yes	-	-	yes	-	yes	-	-

RS-12	5	1.1	CCS	-	Good	-	yes	-	-	yes	yes	yes	-	Micro blade
RS-13	7	27.9	CCS	-	Very Good	-	-	-	-	yes	yes	-	Micro blade	Micro blade
RS-14	3	26.3	CCS	-	Very Good	-	-	-	-	yes	yes	-	Bladelet/ Micro blade	Bladelet / Micro blade
RS-15	3	11	CCS	-	Moderate	-	-	-	yes	-	-	-	-	Flake
RS-16	2	47.7	CCS	-	Very Good	-	yes	-	yes	-	-	-	-	-
RS-17	8	20.4	CCS	-	Very Good	yes	yes	-	-	yes	-	yes	-	Blade & Micro blade
RS-18	4	26.3	CCS	Tabular	Very Good	yes	yes	-	-	yes	-	-	-	Blade
RS-19	4	9.1	CCS	-	Very Good	yes	-	-	-	yes	yes	-	-	Bladelet > Micro blade
RS-20	4	8.2	CCS	-	Good	yes	yes	-	-	yes	-	yes	-	-
RS-21	6	10.2	CCS	-	Very Good	-	yes	-	-	yes	-	yes	-	-
RS-22	4	6.1	CCS	Tabular	Very Good	-	yes	-	-	yes	-	yes	-	-
RS-23	2	0.5	CCS	-	Very Good	-	-	-	-	-	-	yes	-	-
RS-24	3	3	CCS	-	Good	-	yes	-	-	yes	-	yes	-	-
RS-25	3	16.5	CCS	-	Very Good	-	-	-	-	-	yes	-	Micro	-

													blade	
RS-26	45	200.9	CCS	Residual, Cobble	Moderate	-	-	-	yes	-	-	-	-	Flake
RS-27	46	129.5	CCS	Residual	Moderate	yes	-	yes	yes	-	-	-	-	-
RS-28	26	83.6	CCS	Residual	Moderate	yes	yes	yes	yes	yes	-	-	-	-
RS-29	8	22.7	CCS	Cobble	Good	yes	yes	yes	yes	-	-	yes	-	Flake
RS-30	19	75.1	FBA	Tabular, Residual	Moderate	yes	yes	-	yes	yes	-	-	-	-
RS-31	20	177.2	FBA	Tabular	Good	yes	yes	yes	yes	yes	-	yes	-	-
RS-32	19	11.4	FBA	-	Very Good	-	-	-	-	-	yes	yes	Micro blade	Micro blade
RS-33	5	28.6	FBA	Tabular	Very Good	-	-	yes	yes	-	-	-	-	-
RS-34	14	61.5	FBA	Tabular	Good	yes	?	yes	yes	-	?	-	Micro blade	Flake
RS-35	46	164.9	FBA	-	Very Good	yes	yes	yes	yes	yes	yes	yes	Micro blade	Micro blade
RS-36	19	53	FBA	Tabular	Good	yes	yes	yes	yes	yes	-	yes	-	-
RS-37	34	9.7	FBA	-	Very Good	-	-	-	-	?	yes	-	-	Bladelet > Micro blade

RS-38	3	0.3	FBA	-	Very Good	-	-	-	-	-	yes	-	-	-
RS-39	4	8	FBA	-	Very Good	-	yes	-	-	yes	yes	-	-	-
RS-40	7	17.4	FBA	Residual	Poor	yes	yes	-	yes	yes	-	-	-	-
RS-41	5	34.3	FBA	Cobble	Poor	-	-	yes	yes	-	-	-	-	-
RS-42	10	3.2	FBA	-	Moderate	-	-	-	yes	yes	-	-	Bladelet/ Microblade	Bladelet / Microblade
RS-43	8	29.7	FBA	-	Moderate	yes	yes	-	yes	yes	-	-	-	-
RS-44	7	39.2	FGV	Residual	Good	yes	yes	-	yes	yes	-	-	-	-
RS-45	14	91.5	FGV	Residual, Cobble	Good	yes	yes	yes	yes	yes	-	-	-	-
RS-46	31	57.6	FGV	Tabular, Residual	Very Good	yes	yes	-	-	yes	yes	-	-	Bladelet > Microblade
RS-47	24	51.6	FGV	Tabular	Very Good	yes	-	-	yes	yes	yes	-	-	Blade & Microblade
RS-48	5	1.7	FGV	-	Very Good	-	-	-	-	-	yes	-	-	-
RS-49	5	11.4	FGV	-	Good	yes	-	-	yes	yes	-	-	-	-
RS-50	45	53.8	FGV	Tabular	Good	-	-	yes	yes	-	-	yes	-	-
RS-51	5	7.5	FGV	-	Moderat	yes	-	-	-	yes	-	yes	-	-

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RS-52	3	28.8	FGV	Residual	Moderate	-	-	-	yes	yes	-	-	-	-
RS-53	20	133.7	FGV	Tabular/Residual	Very Good	yes	yes	yes	yes	yes	?	yes	Bladelet/Micro blade	Bladelet / Micro blade
RS-54	3	0.5	FGV	-	Very Good	-	-	-	-	-	yes	-	-	-
RS-55	9	78.1	OBS	-	Very Good	yes	yes	-	yes	yes	-	-	-	-
RS-56	9	1.3	OBS	-	Very Good	-	-	-	-	-	yes	-	-	-
RS-57	7	1.2	OBS	-	Very Good	-	-	-	-	-	yes	yes	-	-
RS-58	16	64.8	OBS	-	Good	yes	yes	-	-	yes	-	-	-	Blade
RS-59	5	1.1	OBS	-	Very Good	yes	-	-	-	yes	yes	-	-	-
RS-60	11	1.6	OBS	-	Very Good	-	-	-	-	?	yes	-	-	Micro blade
RS-61	12	262.4	OBS	Residual	Moderate	yes	-	-	yes	yes	-	-	Flake	Blade
RS-62	30	288.9	OBS	Residual	Moderate	-	-	yes	yes	-	-	-	Flake	-
RS-63	3	109.5	OBS	Tabular	Moderate	yes	-	yes	yes	-	-	-	-	Flake
RS-64	2	20.8	OBS	-	Moderate	yes	-	-	-	-	yes	-	-	-
RS-65	17	287.6	OBS	-	Moderate	yes	yes	yes	yes	yes	-	-	-	-