BIRDS, NEEDLES, AND IRON: LATE HOLOCENE PREHISTORIC ALASKAN GROOVING TECHNIQUES

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ABSTRACT

This article considers questions in prehistoric technology by examining organic artifacts from several Alaska Late Holocene sites, including Croxton Site Locality J at Tukuto Lake, western Brooks Range. Examples of bone needle "cores" and needles crafted from large bird humeri are measured and microscopically examined to distinguish possible differences in tools and reduction techniques. Tool handles used to accomplish grooving, including "engraving tool handles," as well as differences between iron and stone bits, are discussed. Archaeometric data, avian ecology, and ethnographic accounts are explored to investigate aspects of needle manufacture, the introduction of iron, and the potential relationships people had to these materials and objects.

KEYWORDS: Avifauna, needles, bone, technology, Ipiutak, engraving

INTRODUCTION

Grooving technologies, the processes by which organic materials were divided and shaped, were frequently put to use by arctic and subarctic cultures. These processes have been studied by archaeologists to some degree and continue to be of interest for understanding tool manufacture. Semenov's well-known *Prehistoric Technology* (1976 [1964]) gives excellent insights into a variety of processes in bone, antler, and ivory reduction pertinent to this paper's focus on grooving bone, especially aspects of metal versus stone bits. Bird bone is known worldwide for use in the manufacture of a variety of small implements, including needles (cf. Gál 2005, 2007), but there has been little detailed analysis of processes associated with needle production. Variations in techniques in the reduction of large bird bones for needle manufacture may be useful in considering the movement of traded material and innovation in material technology during prehistoric times in Alaska.

In addition to the analysis of bird bone cores and the nature of bird bone itself, we consider the construction of tools required to accomplish grooving, including "engraving tool handles" (*sic* Larsen and Rainey 1948) and other handles, as well as bits associated with grooving techniques. The probability of traded iron being used as bit material in the Bering Sea region by the turn of the first millennium AD has been clearly stated, for example, in Gusev et al. (1999) and illustrated in Gusev and Zhilin (2002). Observations on the use of iron have been discussed since at least Collins (1937a). Larsen and Rainey (1948), McCartney and Mack (1973), McCartney (1988), and Bowers (2009) have made direct observations and analysis of traded iron and its impact on technology. Our research tests whether the difference between organic material grooved with iron bits versus stone bits is visible microscopically, specifically in the manufacture of bird bone needles. These efforts are directed toward an underlying

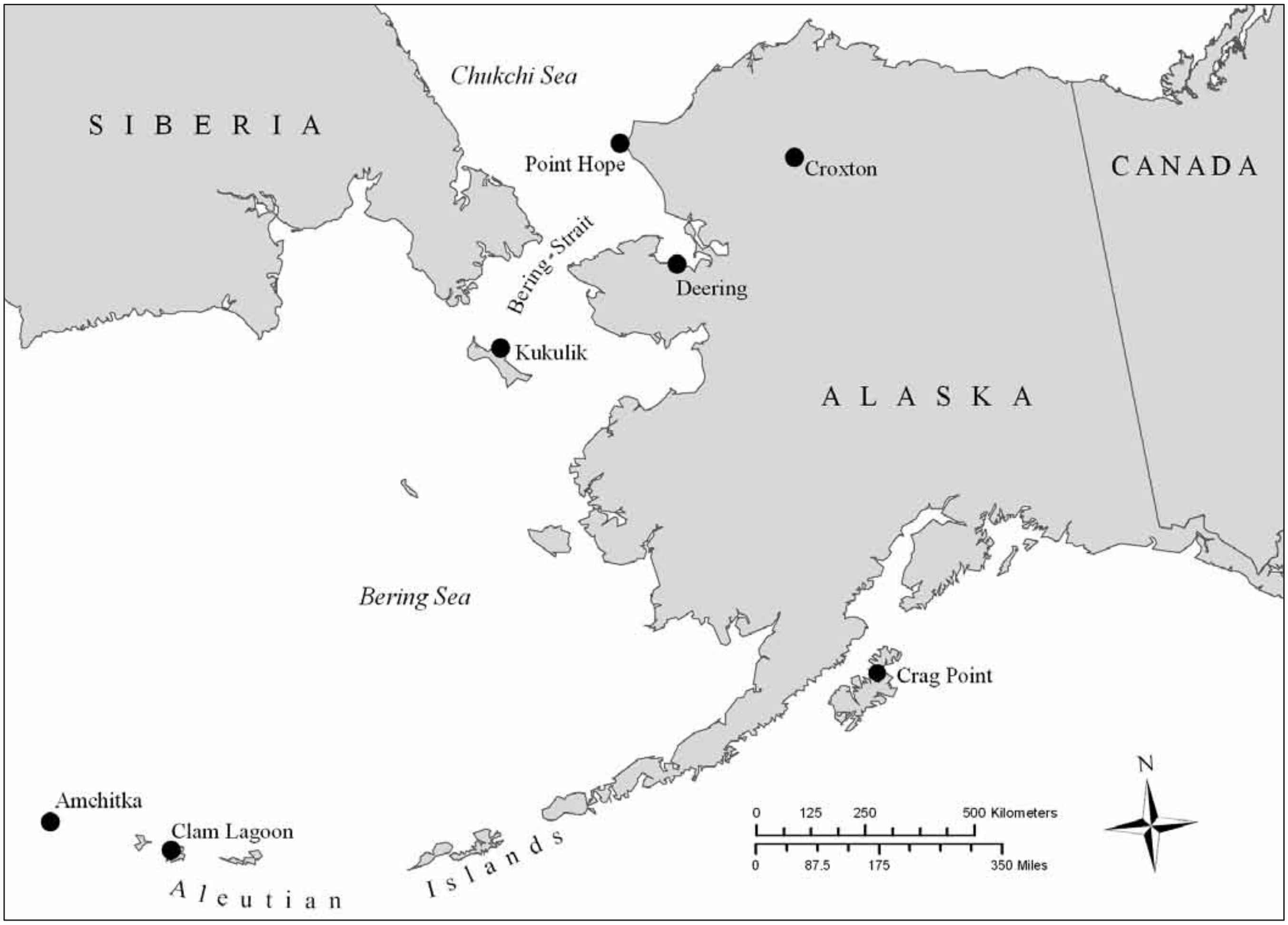

Figure 1. Locations of sites discussed in the text.

goal of understanding relationships people have to objects and how these relationships change over time as the function of objects or manufacturing technologies change.

The spatial extent of bird bone needle cores that exhibit reduction by linear grooving (and are the waste products of needle manufacture) ranges from the Rat Islands in the Aleutian chain to Point Barrow, the northernmost coast of Alaska, to Kodiak Island in the Gulf of Alaska region. In this research we consider selected sites within Alaska (Fig. 1), with artifacts accessible for direct examination, though grooved bird bone cores are present in the organic assemblages of other Alaska sites and in other arctic/subarctic areas. There are differences across Alaska in the types of grooving on bird bones as well as the species of birds used to supply the bone, but wing long bones, especially humeri, appear to be used most consistently. In an attempt to understand spatial and temporal factors in core manufacturing variability, we measured and examined microscopically the grooves, needles, and needle "blanks" (thin strips of bird bone removed or still attached to the core and not yet smoothed and shaped for use as a needle or pin) from seven Alaska archaeological sites dating from 900 BC to AD 1280.

In this study, we generated a range of questions that revolve around bird bone needle manufacture: (1) can the use of introduced material, i.e., iron, be detected by examining grooves on bird bone needle cores; (2) what was the nature of the complete tools used to create the grooves in bird bone reduction sequences; (3) what directed the apparent preference for certain bird species used for the raw material in needle manufacture; and (4) can cultural processes such as settlement strategies or transmission of tool-making techniques be further clarified by the examination of these artifacts.

To explore these questions, we microscopically examined needles and grooves on bird bone cores, considered the nature of the complete tool used to accomplish the grooving (both handle and bit), and contemplated the temporal contexts and cultural milieu in which needles were manufactured and used.

BACKGROUND

Needles have been recovered from a number of sites in the Bering Strait region, some with associated bird bone needle cores, some from sites with dates of occupation before the postulated introduction of iron, and some from after this time. Lithic bits, of course, were used to groove organic material for millennia before the introduction of iron; currently, evidence points to iron use at Alaska sites by at least AD 400 (see Discussion below). For understanding needle manufacturing processes and associated tools, and for considering material availability and the preservation of bird bone artifacts, background information on grooving tools, avifauna taphonomy, ranges of bird species, and dates of sites with needle cores are included here.

GROOVING TOOLS: SCRIBER BITS AND BEAKED BITS

We assume the human hand had similar requirements in the past as today and observed that at least two types of handles attached to bits, potentially meant for grooving, are present at sites with grooved bird bone (for an interesting early discussion of hands and tool handle sizing, see Alpenfels 1955). Commonly today, grooving by hand is accomplished by metal bitted tools with handles of wood (or synthetic material), which are generally lobed or mushroom-shaped at one end, made to provide a surface for the palm of the hand to exert force in a pushing motion (see Untracht 1968 for illustrations as well as explanation of bits, handles and methods). Alternatively, as illustrated in Semenov (1976 [1964]:156), grooving can be accomplished by holding a tool in a near-vertical fashion using a pulling motion. This type of tool has a thick handle with a short bit at the end (Fig. 2). Semenov (1976 [1964]:165) described "claw-shaped" or beaked bits and stated "the slots on Eskimo harpoons shows [*sic*] that the burins [metal bits] employed were claw-shaped with a sharpened point" in order to create the detailed and undercut grooves in toggling harpoons. What he described as handles for these iron bits have a small slot at one end to accept the bit, and recesses below the shoulders to accept lashing for holding the handle sides tightly together, keeping the bit in place. Collins (1937b) and Gusev and Zhilin (2002) describe these bits and handles as present in Siberian sites of Okvik-Old Bering Sea times through Thule. These handles, sometimes completely split into halves with the slot at right angles to the split (as shown by dashed lines on the handle in Figure 2), are found at Croxton and other Ipiutak sites and many Alaska and Canadian Thule sites. E.W. Nelson (1983 [1899]:80–81) also included claw-shaped and other metal-bitted ivory and bone-working tools or "scoring or etching implements" in his inventory of tools of the Bering Strait, some of which have split and slotted handles. Lithic burins are often described with little reference to hafting, but may have been hafted with similar slotted handles.

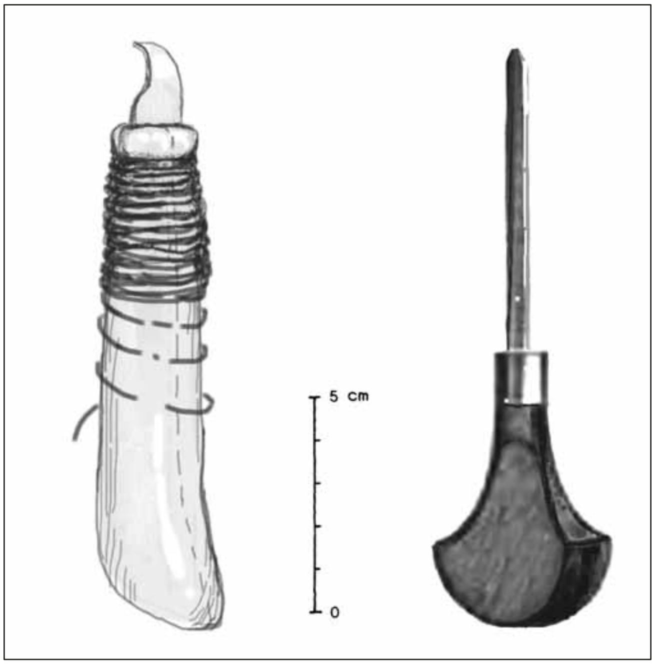

Figure 2. Left, handle with slotted end and beaked metal bit (based on Nelson 1899:Plate 36) and, right, sketch based on one type of modern graver and handle.

Tools meant for more delicate work have a narrower handle large enough for a comfortable fit between the fingers. The engraving tool handles labeled as such by Larsen and Rainey (1948:plate 8, numbers 15–24) and similar to what was found at Tukuto Lake are thin, delicate implements seemingly designed for maximum visibility while working, very similar to modern scribers, scalpels, or pens with midhandle thickening for finger control (see Fig. 3). Several examples of these handles in archaeological collections are decoratively carved and have slotted perforations in the midsection of the handle.

Other researchers have referred to these handles when describing scoring, scratching, incising, graving, and etching (Collins 1937b; Dumond 2001a; Giddings and Anderson 1986; Morrison 1988; Nelson 1983 [1899]; Stanford 1976). We will refer to these tool handles henceforth as *scriber* handles, with the caveat that any number of materials may have been used in the slots at their tips,

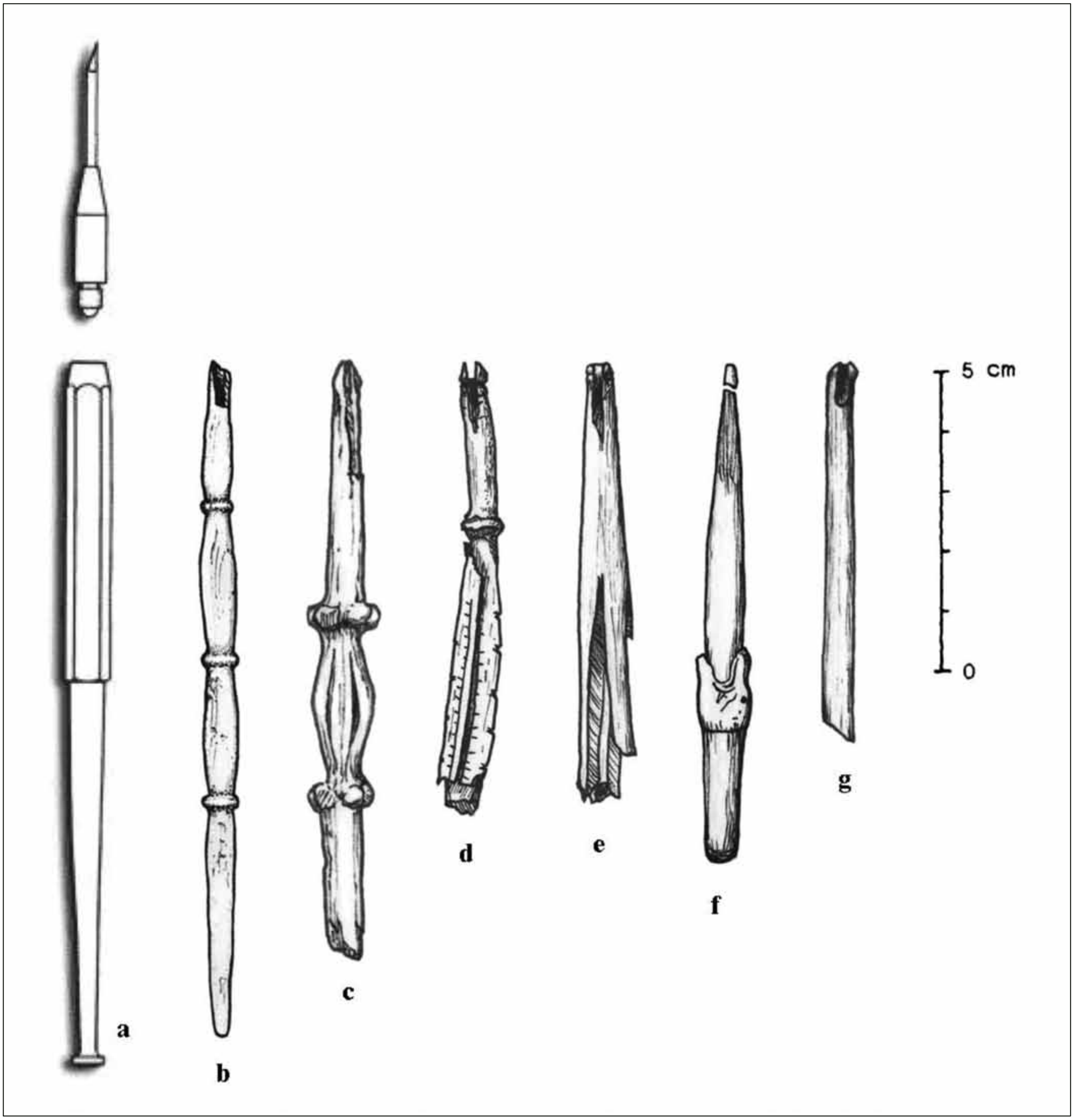

Figure 3. Handles: (a) modern scriber handle and bit of metal; (b–f) handles/fragments of ivory; and (g) handle fragment of bone. Source: (a) Canemco and Marivac Tools Catalog #283-5 and 283-50; (b) Croxton UA2000-066-0516; (c) Pt. Hope 1-1941-4899; (d) Pt. Hope 1-1941-4405; (e) Pt. Hope 1-1941-4618; (f) Deering DRG-99-1724; (g) Pt. Hope 1-1941-4461. Note: all artifacts are from University of Alaska Museum of the North.

including charcoal or other colored pigments, and may essentially have been multipurpose tools. The choice of the term scriber avoids confusion implied with the term *engraving*, a complex art form separate from grooving, shaping and reduction sequences discussed here. The term *burin* we reserve for lithic bit descriptions (e.g., Giddings 1956). Multiuse of these scriber tools is also supported by Larsen and Rainey's Point Hope Ipiutak finds of both nonmeteoric iron and ground squirrel teeth as bits in scriber handles (for an example of a scriber with a ground squirrel tooth as bit, see Rainey 1941:368 plate 3). As with modern scalpels and scribers, these pencil-shaped tools may have been optimally used by drawing or pulling the tool toward the user, and may have been used in working softer material, such as wood, as well more resistant antler, bone, or ivory. These tools are included in this discussion because of their potential role in grooving, and in holding needles or iron bits at their tips, not because any known link exists to bird bone needle manufacture.

The thought that iron bits were used in the Bering Sea region, particularly in association with Ipiutak artifacts, is not new. Handles have yielded iron fragments in bit slots from Point Hope, Deering, and St. Lawrence Island (Bandi 1969; Bowers 2009; Collins 1937b, 1961; Larsen and Rainey 1948; Witthoft and Eyman 1969:20). In Siberia, Gusev and Zhilin (2002:144) note the presence of iron at nine sites (for further discussion regarding iron as a trade material in the Bering Strait see Mason 1998 and Discussion below).

To summarize, fine decoration on wood, ivory, bone, or antler requiring less force could have been accomplished with bits of stone, iron, or other material installed in thin scriber handles, sometimes with thickened central portions for added control. Grooves of more depth on decorated objects or those used in the manufacture of toggling harpoons or other shaped objects may have required heavier handles for the application of greater force; handles may have been slotted at one end and lashed to pinch two halves to hold a bit in place. Grooves for major reduction of large linear portions of organic material may have required a larger handle with enough surface area to comfortably transfer greater force. There are, of course, other handles and hafting styles, but for clarity, we chose to examine those types described above, with the assumption that they were relevant to bone reduction sequences on material such as bird bone. Bits for grooving would have been initially of lithic material, and lithic burins, as shown through experimentation and microscopic examination, have different groove characteristics than iron (see Gusev and Zhilin 2002:140).

BIRD BONE TAPHONOMY

As noted above, the bone element used nearly exclusively for needle manufacture was the humerus, one of the major wing long bones, although occasionally the ulna was used. Several interesting taphonomic points are relevant here: avian long bone structure has a relatively compact cortex or lamella, which enhances its capacity to be polished to a smooth finish with minimal effort; this compactness also appears to inhibit fungi and bacteria from entering bird bone and thereby inhibits degradation (Nicholson 1996). Lack of vascularization may discourage absorption of material that might be attractive to scavengers, discouraging consumption of bird bone compared to other bone. In addition, humeri of some bird species are hollow but do not contain marrow (MacGregor 1985), which would perhaps make manipulating the bone during the manufacturing process easier in comparison to bones with marrow, as well as make it less desirable to scavengers. However, other less-desirable characteristics of bird bone, including small size in general, may discourage preservation (cf. Gál 2005). More work is required to understand marrow and bone dynamics in regard to bird bone taphonomy.

Research has shown that avifauna humeri tend to have thicker cortical walls at the central portion of the shaft (central diaphysis), while shaft portions nearer the ends (the metaphysial region) are thinner (Higgins 1999). This characteristic would encourage snapping needles from the core at the termination of grooves nearest the proximal and distal articulations and would tend to give a naturally tapered shape along the length of the needle. Still other research suggests wing bones are differentially preserved relative to other elements of the skeleton; for purposes of deciphering taphonomic agents and processes and for understanding patterns of material use, this is of interest (Bovy 2002). For biomechanical research on bird bone and small mammal bone such as fox, see Bernath et al. 2004, Cubo and Casinos 2000, McAlister and Moyle 1983, and Suhai et al. 2006.

AVIFAUNA RANGE AND SEASONALITY

Geese are large, vocal birds, with some species, such as lesser snow geese (*Chen caerulescens*), greater white-fronted geese (*Anser albifrons*), and a lesser Canada goose species

(*Branta canadensis taverneri*) currently seasonally available along Kotzebue and Norton sounds as well as in areas between Point Hope and Point Barrow (Rothe 2009). Emperor geese (*Chen canagica*) presently have a much smaller range, with small breeding populations on the Seward Peninsula, the Yukon-Kuskokwim Delta, and the Aleutian chain. Greater Canada geese (*Branta canadensis*) usually range south of the Seward Peninsula (Ridgely et al. 2007). A number of subspecies of Canada geese, and black brant (*Branta bernicla nigricans*), have localized ranges in coastal areas such as Cook Inlet and the Yukon-Kuskokwim Delta. In general, spring geese migrations take place in May, nesting begins by early June, and return migrations to points thousands of miles distant occur in late August. Geese are most numerous during seasonal migrations and vulnerable during the molt for about a month over the summer.

Albatrosses are migratory in a more limited way, shifting from winter to summer ranges within the North Pacific. The black-footed albatross's (*Phoebastria nigripes)* range is slightly farther north into the Bering Sea than the Laysan (*Phoebastria immutabilis*); both are large, silent pelagic feeders that come ashore only to breed. Large breeding colonies are located on Hawaii and other outlying islands in the Pacific and on several Japanese islands (Bird Life International 2011). Geese and albatross ranges are of course subject to change over time.

For geese species, wing molt that limits flight is significant: this loss of flight feathers occurs for snow geese in mid-June, beginning with sub-adults and ending with breeding adults in August. Birds are essentially flightless and vulnerable for twenty-one to twenty-eight days; wing molt begins in breeding pairs about two to three weeks after chicks hatch. Drives involving large groups of people for procuring waterfowl were recorded by Klein (1966) in the Yukon-Kuskokwim Delta, with social aspects of such activities noteworthy. Also, a "molt-migration" by non-breeding birds has been recorded for snow geese, in which flocks move from nesting grounds to another less vulnerable location for a period of time during wing molt before rejoining breeding pairs (Hohman et al. 1992). Snow geese are strongly philopatric (returning to their birth location). Bird bone cores from Ipiutak sites appear to be from fully grown birds, and research has shown seasonal availability of waterfowl may have influenced settlement strategies (Burch 1972; Holliday 1998; McFee n.d.; Milne and Donnelly 2004; Ray 1964).

ASSOCIATED DATES[1]

Ipiutak houses from which the bird bone cores, needles, and scriber handles were recovered are not specifically dated by radiocarbon techniques, but Mason (2006) suggests that the Ipiutak occupation of the Point Hope spit began before AD 600 with the majority of the occupation dating between AD 650 and 870. The bird bone cores and iron-tipped scriber from Deering were recovered from an Ipiutak house that dates between cal. AD 680 and cal. AD 890 (1230 ± 40 ^{14}C yr BP [Beta-138562] in Bowers 2006). Bird bone cores and needles were also recovered from the Deering *qargi* that have similar dates to the Ipiutak house (Larsen 2001). Radiocarbon age estimates on hearth charcoal and organic artifacts at Croxton Locality J indicate that the Ipiutak occupation(s) date between cal. AD 420 to cal. AD 980 (1350 ± 140 ^{14}C yr BP [GX-8633] and 1135 ± 135 ^{14}C yr BP [GX-8634]; although controversial, the inland Ipiutak occupation at Croxton may extend to cal. AD 1170 to cal. AD 1280 (790 ± 40 ^{14}C yr BP [Beta-132909]) and into more recent time periods than considered by other cultural historical frameworks established for late Holocene northern Alaska prehistory (Gerlach 1989; Gerlach and Mason 1992; Reuther 2003; Reuther and Gerlach 2005).

Several other artifacts confirmed Croxton Localities J and K as another example of inland Ipiutak occupation (Gerlach and Hall 1988) with similarities to the Bateman site (Reanier 1992), Feniak Lake (Hall 1974; McFee n.d.) and Hahanudan Lake (Clark 1977). A possible farther north example of Ipiutak is at the coastal site of Nuvuk (BAR-00011) at Point Barrow, which recently yielded a bird bone needle core and artifacts typical of Ipiutak assemblages (Jensen 2009).

The selected Aleutians sites (ADK-00103, RAT-00031, RAT-00036, and RAT-00060) have less secure dating than the northern Ipiutak sites (see Dumond 2001b and Dumond and Bland 1995 for discussion on reliability of radiocarbon dates from the western Aleutians). Desautels et al. (1971) provided dates on charcoal recov-

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[1] All ^{14}C yr BP dates quoted in the text were calibrated to 2σ using CALIB 5.0 calibration program and the INTCAL04 terrestrial model atmospheric radiocarbon curve (Reimer et al. 2004; Stuiver et al. 2005). None of the ^{14}C yr BP dates quoted were produced on marine samples that would require a reservoir correction.

ered from RAT-00031 and RAT-00036: cal. 100 BC to cal. AD 380 (1890±95 ^{14}C yr BP [I-4737]) for RAT-00031 and cal. 720 BC to cal. 40 BC (2245±95 ^{14}C yr BP [I-4738]) for RAT-00036. The archaeological component at the Clam Lagoon site (ADK-103) has been suggested to date to around cal. 800–900 BC or younger (~2700 ^{14}C yr BP in O'Leary 2001:224).

A bird bone core from St. Lawrence Island at the Kukulik site was associated with material dating from the protohistoric occupation of the island (Geist and Rainey 1936). The core assemblage from Crag Point relates to the Kachemak deposit that dates between cal. 90 BC and cal. AD 1250 (1890 ± 90 ^{14}C yr BP and 910 ± 60 ^{14}C yr BP in Clark 1984 and Jordan 1992).

METHODS

Cores, needles, and blanks were examined under a 26–130 digital zoom microscope (Carson Optical zPix 200 MM-740). Numbers of grooves on each core, maximum groove width, maximum cortical thickness, groove depth, and the range of spaces between grooves (widths of needle blanks) were recorded and photographed. Cortical thickness on cores was measured at the point where needle blanks were snapped or cut from the bone; cortical thickness on needle blanks and needles was the maximum thickness along the length of the blank or needle. Needles were measured and described in relation to common needle sizing (Talbot 1943). Discussions in the literature of bird bone use in general were reviewed, as well as taphonomic properties of bird bone. In addition, six scriber handles or handle fragments were examined, with particular attention paid to measurements of the slot in which a bit would have been placed (Table 3). When possible, we identified the avian species, genus, or subfamily from which the cores were made (Tables 1 and 2) using personal and University of Alaska Museum of the North ornithological reference collections.

At the Croxton Site Localities J and K on Tukuto Lake (XHP-00311), the initial excavations in 1981–82 by Gerlach (Gerlach and Hall 1988; Gerlach 1989) recovered eleven needle cores crafted from geese humeri; six are examined here. In 2000, we recovered from Locality J an additional needle core and needle core fragment with a needle blank attached (which prompted this study). The Point Hope Ipiutak Site (XPH-00003) has at least nine needle cores in its assemblage; from the Deering Ipiutak component (KTZ-00299) there are seven cores and as many needle blanks and needles, many of which were added to our data set. From the Croxton site in 2000, we recovered an engraving tool handle very similar to those pictured in Larsen and Rainey's 1948 Ipiutak monograph (see Fig. 3b).

Bird bone needle cores have been recorded at a number of sites throughout the Aleutian Islands (Jochelson 2002 [1925]) and have also been recovered at Mink Island (XMK-030), a site located across the Shelikof Strait from Kodiak Island (Bjorn Iverson, pers. comm., 2008). From Aleutian sites on Amchitka Island in the Rat Islands group (RAT-00031, 00036, and 00060), from Clam Lagoon on Adak Island (ADK-00202), and from Crag Point on Kodiak Island (KOD-00044), ten needle cores and eight needle blanks were added to our study. A single bird bone core collected by Geist in 1931 was examined from the St. Lawrence Island Kukulik site.

Experimental grooving was performed on bone from several species of birds with metal and stone bits for the purposes of understanding problems associated with grooving in general and needle manufacture specifically. These experiments are ongoing and are not discussed here.

RESULTS

A total of thirty-two bird bone needle cores, twenty-two needle blanks, and five needles were examined. In our data set of identifiable elements, all needle cores are either distal or proximal humeri except one, which was a proximal ulna. Many cores have numerous grooves that terminate at the proximal or distal end of the bone and include the articulation (Fig. 4). Some cores are on cut long bone fragments without articulations, which makes species identification difficult (Fig. 5). The characteristics and placements of grooves on bird bone humeri created during the manufacture of needles appear to reflect differences in bit material and methods of bone reduction (Figs. 6 and 7).

GROOVES

Grooves made with stone, according to studies by Gusev and Zhilin (2002), have different types of parallel lines in groove troughs and have slightly more rounded shoulders. While some grooves on cores from Ipiutak sites excavated in the past were not clearly visible due to var-

Table 1. Bird bone cores, needles, and needle blanks (C = Core, N = Needle, NB = Needle Blank). Anserini are members of the geese tribe in the Anserinae waterfowl subfamily; Unid. Avian is unidentified avian species. All artifacts are from UAMN collections.

Site	Accession Number	Species	Element	Side	Max. Cortical Thickness
Ipiutak, Pt. Hope	1-1941-4389; H33; C	Anserini	Dist. Humerus	Right	1.3 mm
	1-1941-4590; H38; C	*B. canadensis*	Prox. Humerus	Left	1.0 mm
	1-1941-4591; H38; C	*B. canadensis*	Prox. Humerus	Right	1.3 mm
	1-1941-940; DH-1; C	*C. caerulescens*	Prox. Humerus	Left	1.3 mm
	1-1941-4533;H36; C	Anserini	Dist. Humerus	Right	1.3 mm
	1-1941-5100;H59; C	Anserini	Prox. Humerus	Right	1.1 mm
	1-1941-103;H59; NB	Unid. Avian	?	?	1.5 mm
	1-1941-5306; H66; C	*C. caerulescens*	Dist. Humerus	Left	1.2 mm
	1-1941-5307; H66; C	*C. caerulescens*	Prox. Humerus	Left	1.1 mm
	1-1941-5304; H66; C, NB	*C. caerulescens*	Prox. Humerus	Right	1.4 mm
Croxton, Localities J & K	UA2000-066-0529; C	*C. caerulescens*	Prox. Humerus	Left	1.1 mm
	UA2000-066-0478; NB	*C. caerulescens*	Prox. Humerus	Left	1.5 mm
	UA81-119-383;N	Unid. Avian	?	?	1.3 mm
	UA81-119-384; C	*C. caerulescens*	Prox. Humerus	Right	1.0 mm
	UA81-119-476; C	Anserini	Dist. Humerus	Right	1.3 mm
	UA81-119-530; NB	Unid. Avian	?	?	1.3 mm
	UA81-119-541; C	*C. caerulescens*	Dist. Humerus	Right	1.1 mm
	UA81-119-613; C	*C. caerulescens*	Prox. Humerus	Right	1.0 mm
	UA81-119-2027; C	*C. caerulescens*	Prox. Humerus	Right	0.9 mm
Deering	DRG-99-1808; C	*C. caerulescens*	Dist. Humerus	Left	0.9 mm
	DRG-99-1034; C	Anserini	Dist. Humerus	Left	1.2 mm
	DRG-99-296; C	*C. caerulescens*	Prox. Humerus	Right	1.2 mm
	DRG-99-1892; C	*B. canadensis*	Prox. Humerus	Left	1.3 mm
	DRG-99-1243; C	*C. caerulescens*	Prox. Humerus	Left	1.0 mm
	DRG-99-700; C	Anserini	Prox. Humerus	Right	1.7 mm
	DRG-99-459; NB	Unid. Avian	?	?	1.4 mm
	DRG-99-448; NB	" "	?	?	1.2 mm
	DRG-99-1335:NB	" "	?	?	1.4 mm
	DRG-99-1941 (4 pcs); NB	" "	?	?	1.6 mm
	DRG-99-1167; NB	" "	?	?	1.3 mm
	DRG-99-NLUR 4143; NB	" "	?	?	1.2 mm
	DRG-99-NLUR 4120; C	" "	?	?	1.3 mm
	DRG-98-007;N	" "	?	?	1.5 mm
Kukulik	1-1931-2804; C	Unid. Avian	?	?	1.3 mm
Crag Point, Kodiak	UA86-202-579; C	Unid. Avian	?	?	1.4 mm
	UA86-202-787; C	" "	?	?	1.0 mm
	UA86-202-790; C	" "	?	?	2.0 mm
	UA86-202-800; C	*Phoebastria* sp.	Prox. Ulna	Left	1.6 mm
	UA86-202-970; NB	Unid. Avian	?	?	1.2 mm
	UA86-202-1589;N	" "	?	?	1.2 mm
	UA86-202-1600;N	" "	?	?	1.4 mm
	UA86-202-1712; NB	" "	?	?	1.7 mm
	UA86-202-1917; C	" "	?	?	1.1 mm
	UA86-202-2273; NB	" "	?	?	1.2 mm
Amchitka	UA72-55-2036; NB	Unid. Avian	?	?	1.5 mm
	UA72-57-0195; C	" "	?	?	1.2 mm
	UA72-57-0410; NB	" "	?	?	1.6 mm
	UA72-57-2187; NB	" "	?	?	1.1 mm
	UA72-57-3158a; C	" "	?	?	2.1 mm
	UA72-58-257; C	" "	?	?	0.9 mm
Clam Lagoon	UA383-4548; C	*Phoebastria* sp.	Dist. Humerus	Right	1.2 mm
	UA383-4549; C	*Phoebastria* sp.	Prox. Humerus	Right	1.9 mm

Table 2. Groove characteristics on bird bone cores, and needle blanks (C = Core, N = Needle, NB = Needle Blank). All artifacts are from UAMN collections.

Site	Accession Number	Number of Grooves Per Core	Max. Width of Grooves	Range of Spaces Between Grooves/ Needle Width	Groove Type (Stone/ Metal)
Ipiutak, Pt. Hope	1-1941-4389; H33; C	11	1.0 mm	1.4 to 2.6 mm	Metal
	1-1941-4590; H38; C	10	0.7 mm	1.1 to 3.1 mm	Metal
	1-1941-4591; H38; C	12	0.9 mm	1.5 to 2.4 mm	Metal
	1-1941-740; DH-1; C	11	0.9 mm	0.8 to 3.5 mm	Metal
	1-1941-4533;H36; C	7+	0.8 mm	1.6 to 2.1 mm	Metal
	1-1941-5100;H59; C	11	0.7 mm	0.6 to 2.2 mm	Metal
	1-1941-5103;H59; NB	1	0.8 mm	1.3 mm	?
	1-1941-5306; H66; C	10	1.1 mm	1.2 to 1.7 mm	Metal
	1-1941-5307; H66; C	9	1.2 mm	1.2 to 1.9 mm	Metal
	1-1941-5304; H66; C, NB	8	0.8 mm	0.6 to 2.8 mm	Metal
Croxton Localities J & K	UA2000-066-0529; C	11	0.7 mm	1.6 to 3.9 mm	Metal
	UA2000-066-0478; NB	3	0.8 mm	1.2 to 4 mm	Metal
	UA81-119-383;N	N/A	N/A	2.2 mm	Metal?
	UA81-119-384; C	6	1.1 mm	1.8 to 3.1 mm	Metal
	UA81-119-427; NB	N/A	N/A	4.9 mm	?
	UA81-119-476; C	11	1.2 mm	1.4 to 2.5 mm	?
	UA81-119-530; NB	1	0.8 mm	2.8 to 4.2 mm	Metal?
	UA81-119-541; C	11	1.2 mm	1.6 to 2.6 mm	Metal
	UA81-119-613; C	11	1.2 mm	1.3 to 2.7 mm	Metal
	UA81-119-2027; C	8	1.1 mm	1.4 to 2.5 mm	Metal
Deering	DRG-99-1808; C	9	2.5 mm	1.7 to 2.5 mm	Metal
	DRG-99-1034; C	6	1.1 mm	1.3 to 3.0 mm	Metal
	DRG-99-296; C	8	0.9 mm	1.5 to 2.8 mm	Metal
	DRG-99-1892; C	10	0.5 mm	1.2 to 4.1 mm	Metal
	DRG-99-1243; C	~5	N/A	2.5 to 3.9 mm	?
	DRG-99-700; C	14	1.1 mm	1.5 to 3.2 mm	Metal?
	DRG-99-459; NB	N/A	N/A	1.5 mm	?
	DRG-99-448; NB	N/A	N/A	1.6 mm	Metal
	DRG-99-1335; NB	N/A	N/A	1.8 mm	Metal
	DRG-99-1941; NB	N/A	N/A	0.8 to 3.2 mm	Metal
	DRG-99-1167; NB	N/A	N/A	4.7 mm	?
	DRG-99-?NLUR 4143; NB	N/A	N/A	1.8 mm	?
	DRG-99-?NLUR 4120; C	1	1.1 mm	1.5 mm	Metal
	DRG-98-007;N	N/A	N/A	1.9 mm	?
Kukulik	1-1931-2804; C	4	0.9 mm	1.9 to 4.0 mm	Metal
Crag Point, Kodiak	UA86-202-579; C	9	0.4 mm	0.9 to 2.5 mm	Stone
	UA86-202-787; C	5	0.6 mm	0.7 to 1.5 mm	?
	UA86-202-790; C	5	0.9 mm	1.0 to 3.4 mm	Stone?
	UA86-202-800; C	4	1.0 mm	1.3 to 4.5 mm	Stone
	UA86-202-970; NB	1	0.2 mm	0.4 to 1.4	Stone
	UA86-202-1589;N	N/A	N/A	2.5 mm	?
	UA86-202-1600;N	N/A	N/A	1.8 mm	?
	UA86-202-1712; NB	N/A	N/A	1.5 mm	?
	UA86-202-1917; C	2	0.8 mm	2.6 to 4.8 mm	?
	UA86-202-2273; NB	3	0.5 mm	1.0 to 2.8 mm	Stone?
Amchitka	UA72-55-2036; NB	1	1.1 mm	2.2 to 3.9 mm	Stone
	UA72-57-0195:C	5	1.0 mm	1.5 to 4.1 mm	Stone
	UA72-57-0410; NB	1	1.0 mm	2.0 to 4.4 mm	Metal?
	UA72-57-2187; NB	1	0.8 mm	0.6 to 2.6 mm	Stone
	UA72-57-3158a; C	6	1.3 mm	1.1 to 6.3 mm	Stone
	UA72-58-257; C	4	1.1 mm	3.7 to 3.9 mm	Stone
Clam Lagoon	UA383-4548; C	7	1.2 mm	1.7 to 4.6 mm	Stone
	UA383-4549; C	10	1.4 mm	1.4 to 3.9 mm	Stone

Table 3. Scriber handle and scriber socket (slot) dimensions. All artifacts are from UAMN collections.

Site	Accession Number	Scriber Handle Length	Scriber Handle Max. Dia.	Scriber Handle Tip Dia.	Bit Slot Dimensions		
					Length	Depth	Width
Deering	DRG-99-1724 (NLUR3800) ivory	81.7 mm (reworked)	8.6 mm	2.6 mm	7.4 mm	1.4 mm	2.6 mm
Croxton	UA2000-66-0516 ivory	114.3 mm complete	6.3 mm	3.6 mm	8.0 mm	1.5 mm	2.0 mm
Ipiutak, Pt. Hope	1-1941-4461; H36 bone	62.7 mm fragment	4.9 mm	4.1 mm	7.8 mm	2.3 mm	2.2 mm
Ipiutak, Pt. Hope	1-1941-4405; H35 ivory	74.4 mm fragment	7.1 mm	4.2 mm	8.7 mm	2.2 mm	1.2 mm
Ipiutak, Pt. Hope	1-1941-4618; H40 ivory	73.2 mm fragment	8.7 mm	4.5 mm	9.5 mm	2.6 mm	1.2 mm
Ipiutak, Pt. Hope	1-1941-4899; H53 ivory	101.3 mm nearly complete	9.2 mm center 11.2 mm "knobs"	4.8 mm	6.9 mm	2.4 mm	1.3 mm

Figure 4. Grooves on proximal articulations of bird bone humeri used in needle manufacture: a) albatross, Clam Lagoon, Adak, Aleutian Islands (UA383-4549); and b) goose, Ipiutak, Pt. Hope (1-1941-4591).

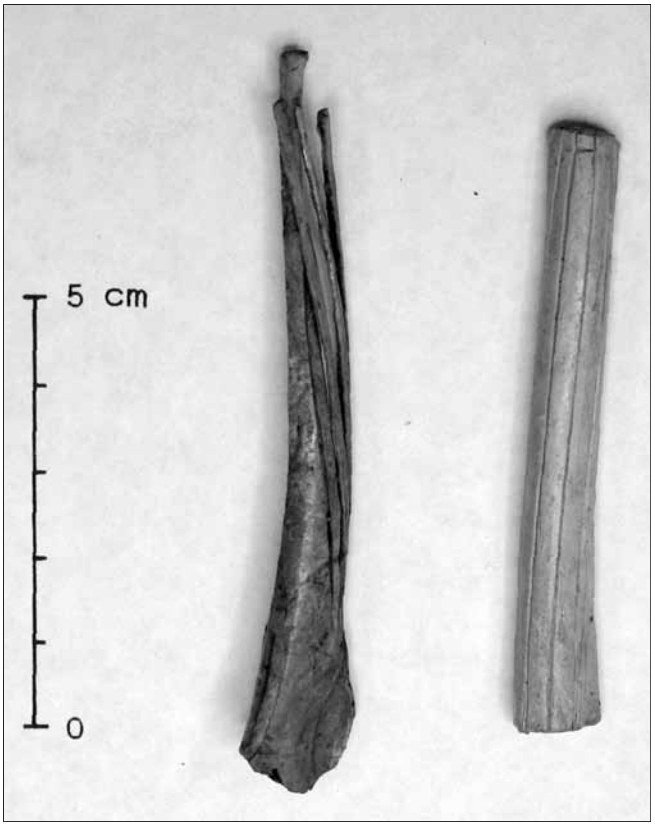

Figure 5. Sections of bird long bone shafts with needle blanks or preforms in stages of manufacture: a) needle blanks not yet snapped from proximal end of shaft, Ipiutak, Pt. Hope (1-1941-5304; H66); and b) needle blanks on tubular section which has been cut from shaft, Crag Point, Kodiak Island (UA86-202-790).

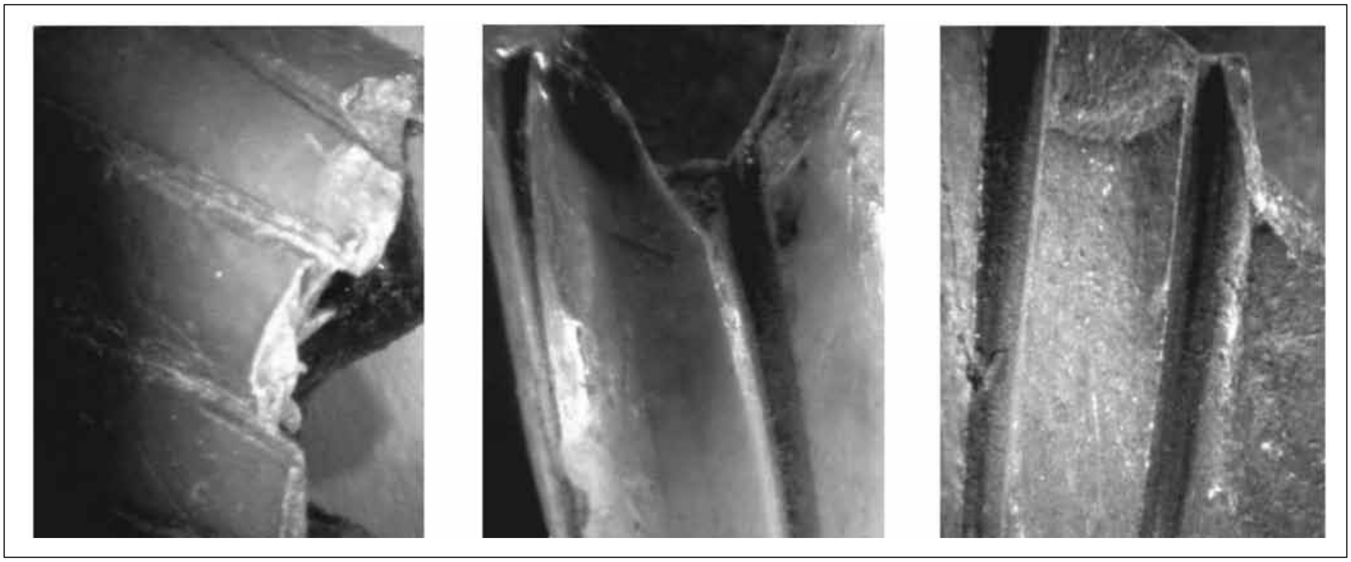

Figure 6. Grooves (~1 mm in width) with distinct shoulders, a characteristic of metal bits.

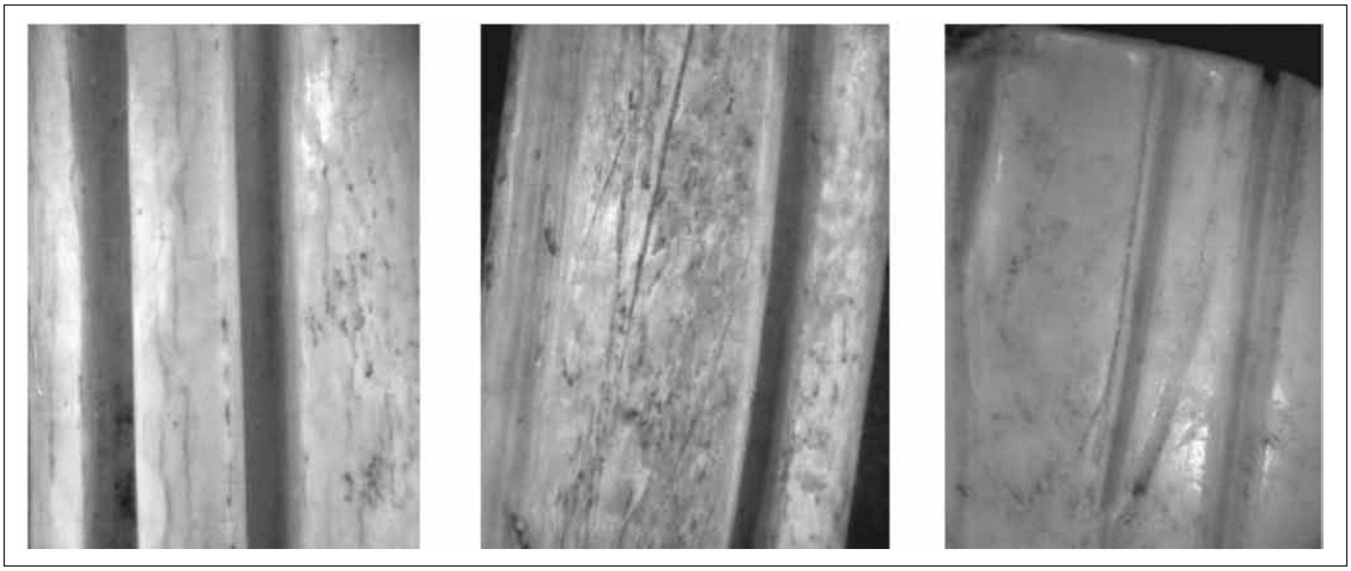

Figure 7. Grooves (~1 mm in width) with indistinct shoulders, a characteristic of lithic bits.

nishes or coatings on the cores, microscopic examination of groove shoulders on the uncoated Ipiutak goose cores were sharper in general than the Aleutian albatross cores, and groove wall angles were in general more consistent and had less stepping than Aleutian cores. This appears, as observed by Gusev and Zhilin, to be due in part to the ability of iron to hold a sharp edge, while a lithic edge develops microscopic concoidal fractures that dull the cutting angle. The fractured edge produces striations and stepping, which give the impression of rounded shoulders and more scooped grooves in general. The overall width of material used to create a groove is less significant than the angle of the cutting edge, especially when grooving thin material such as bird bone.

REDUCTION SEQUENCE

Beyond groove characteristics, cores preserved at the Aleutian sites and the Crag Point site on Kodiak exhibit other differences in the reduction sequence from cores found at Ipiutak sites. For example, Aleutian cores were made with longitudinal grooving on the humeral shaft, followed by transverse cuts across the shaft below the flare of the deltoid crest, which separated the grooved shaft as an intact tubular piece (Fig. 8). This piece was then grooved deeper in a final step to separate individual needle blanks. The Ipiutak cores, however, were created by longitudinal grooves on the humeral shaft that extended toward epiphyses and cut completely through the shaft, defining one needle blank from the other before removal. Needle blanks were then removed from the core by snapping, somewhat like block matches (as shown in Fig. 5). No evidence of transverse cutting is seen consistently on Ipiutak shafts. However, the photograph of the core found at Nuvuk, at Point Barrow, dated to cal. AD 140–380, clearly shows transverse grooving (Jensen 2009). The number of longitudinal grooves on both Ipiutak and Aleutian cores suggests standardization in concept and spacing related to optimal widths of needles, diameter of the bone, and size of bit used for grooving.

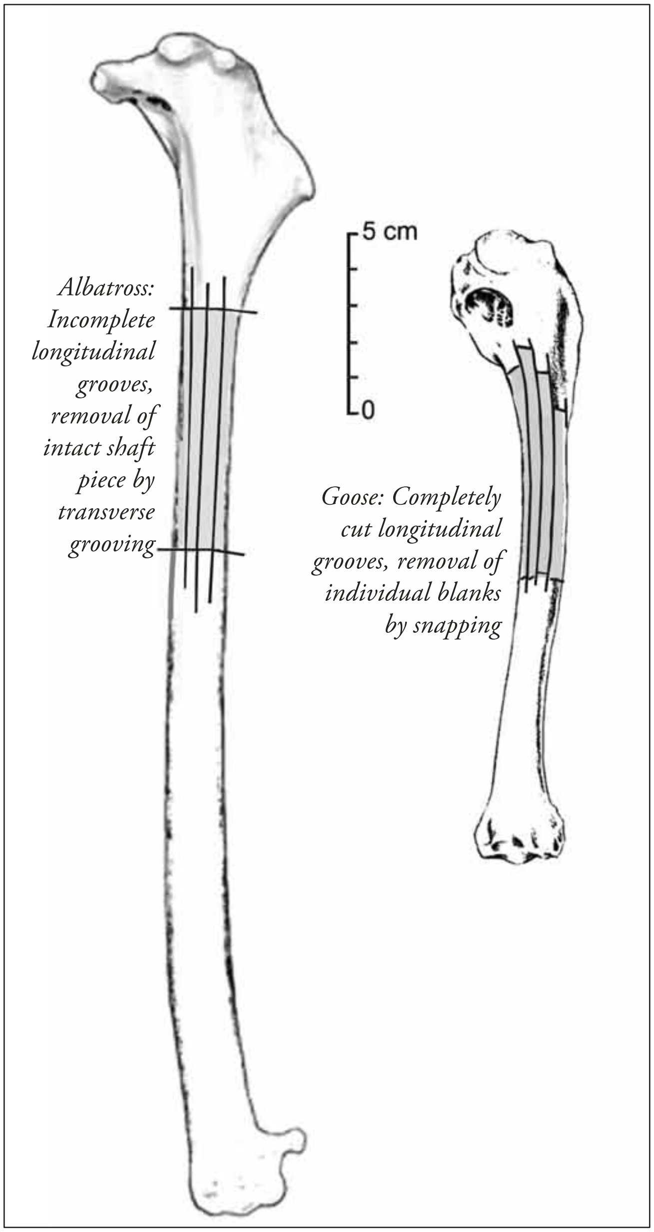

Figure 8. Albatross and goose humeri with typical placement of grooves near proximal ends and methods of needle blank removal (element drawings based on Gilbert et al. 1996 [1985]).

On heavier bone and ivory, as well as wood, nicks sometimes observed along the sides of grooves indicate that during reduction sequences the separation of linear blanks was accomplished by blows on the end of wedges placed into grooves or possibly by direct percussion (Gelvin-Reymiller et al. 2006; Knecht 1993; Margaris 2006; Semenov 1976 [1964]). Bird bone cores, however, do not exhibit nicks or any evidence that additional tools such as wedges were used in grooves to separate blanks; this action may have been unnecessary due to the thinness of the bone or the desire to retain smooth edges.

NEEDLE MEASUREMENTS

Needles that were measured in the sample were necessarily only those recognizable as made of bird bone. Needle sizes were consistent, measuring from about 1.5 mm to 2.5 mm in width and usually less than 1.5 mm in thickness. Most needles and needle blanks were less than 60 mm in length. The fineness of some needles is truly remarkable; the length and beveled tips of some of the eyed needles are similar to modern steel glovers' needles between sizes #1 and #2/0, commonly used for skin or leather sewing (Talbot 1943). Eyes in needles that were examined vary from nearly perfectly round to tiny slots parallel to the needle's length. The exactitude of the round needle eyes are reminiscent of engraved round holes in Ipiutak decorated surfaces and may have been accomplished with a metal-bitted drill, although jade bits were also recorded in the region by early observers (Belcher 1861).

SCRIBER HANDLES

Scriber handles are not numerous or perhaps preserve poorly for reasons unknown. The midshaft slots that run parallel to handle lengths were difficult to measure because of breakage (apparently a common breakage point) in all but one example, but midshaft slots were estimated to be about 15 to 20 mm in length.

Measures of scriber tip slots (similar to the chuck that accepts a drill or a collet that holds a bit in a Dremel or Foredom tool) average about 1.5 mm by 2.3 mm in width and depth and about 8 mm in length. This bit material could have been iron, perhaps commonly traded in a particular size, or could have been another material, such as ground squirrel teeth, bone—including bird bone needles which are approximately that size, or lithic spalls.

Modern arctic ground squirrel (*Spermophilus parryii*) incisors average from 1.7 to 2.0 mm in width and from 2.5 to 2.8 mm in thickness, tapering at the tip. This is slightly larger than bit slot sizes, although teeth vary in size. Teeth are curved and hollow along the first quarter to third of the root and solid toward the tip. Based on a limited number of teeth examined, upper incisors measure approximately 30 mm in length and lowers approximately 40 mm, with usable solid curved tip material about 10 to 15 mm in length.

Sizing of slots for bits may be related to other unknown factors. Larger slotted or split handles were not measured in this study due to time constraints, although a cursory look at slot dimensions indicates some similarities to scriber handles. The data gathered here does not allow conclusions to be drawn about handles used in grooving bird bone. Further examination of larger slotted handles, as well as experimentation, might add clarity.

IDENTIFICATION OF SPECIES

Identifying species of goose versus albatross was straightforward because the morphological differences between the Anserini tribe and *Phoebastria* genus are pronounced. Distinctions between *Chen caerulescens* and *C. canagica* as well as between members of the *Chen* genus and *Branta* genus are much more subtle, but several characteristic differences were apparent, at least in the comparative specimens available for this study (two to three specimens for each of five goose species). Variability, of course, may be greater if more specimens were assessed. There are distinct size ranges that separate the species; for example, black brant and cackling geese have noticeably smaller humeri than snow and emperor geese, and greater Canada geese humeri are noticeably large. Distinctions are present on the proximal humerus: for example the proximal margin of the humeral head appears less pointed in greater Canada geese than in snow geese, and the distance between the deltoid and bicipital crest attachment points on the diaphysis is greater in greater Canada geese than in snow geese. There also appear to be differences in the morphology of the mesial crest and the average size of the pneumatic fossa in the various species. Other distinctions on the distal portion of humeri include the shape of the attachment point of the anterior ligament, which is almost vertical on Canada geese and tilted on snow geese. While these distinctions render a definitive identification of particular goose species less certain on artifacts on which diagnostic morphology is partially or completely missing, the identification to Anserini tribe is certain.

DISCUSSION

This initial look at the presence of grooved bird bone cores at Alaska sites indicates continuity of use through time as well as broad geographic range for this use of bird humeri. At these sites, the proximal articulation of humeri with a portion of the shaft intact were also crafted as awls (the shaft beveled to a point) or bodkins, which are large pointed tools similar to awls but often with large eyes, and are found at sites with cores. Perhaps sets of bones were part of the well-rounded seamstress or seamster's tool kit. These uses of the humerus for needle- and awl-making were typical, though a number of albatross humeri from Amchitka were cut transversely and have no longitudinal grooving present, possibly for use as bone tubes, beads, or fishhooks, or perhaps they were in an early stage of reduction.

Characteristics such as hardness, strength, flexibility, thickness, or relative smoothness of the interior medullary surface may be responsible for the frequent use of bird bone in needle manufacture. Bird bone morphology, particularly the broadened proximal articulations of humeri that encourage ease of handling during reduction by grooving (but which is not exclusive to avian species) might also be a factor. Preference by many cultures for complete use of an animal may be an additional factor, exemplified by bird bone drinking tubes, needle "keepsafes" or feather procurement in addition to needle or awl manufacture (Serjeantson 2009). The sharpness and hardness (edge-holding ability) of a bit was a critical variable in successful needle manufacture, as was the moisture content or state of the bone being worked and whether lubricants were used, as noted in experimental results by Gusev and Zhilin (2002). Soaking of material before working was commonly recorded by early ethnographers. Types of lithic materials with different fracture characteristics and hardness would leave different traces on various organic materials, as would iron. Studies of use-wear patterns on organic material and experimental tool-making give valuable insights into grooving techniques, especially when microscopic observations are also recorded (cf. LeMoine 1989, 1994; Margaris 2006).

Relevant to the discussion of handles used in the grooving process, LeMoine (1994) points out that microscopic examination is best combined with other sources of information to understand tool manufacture and use, which guards against the acceptance of assumptions about tools, manufacturing processes, and tool usage. The decorative treatment and slotting of scriber handles, which are generally less than 1 cm in diameter, required considerable effort; we speculate that midshaft slots may have facilitated wrapping with leather for added comfort, similar to neoprene or rubberized sections added to modern-day pencils and pens. Alternatively, the mid-shaft slots may have been used for affixing the handle to a longer shaft meant for drilling. In addition, the design of handles may represent an instance of skeuomorphism, or replication in bone or ivory based on original designs in wood or metal (cf. Sherrat 2006).

In terms of seasonality, migrations of snow geese from Japan and Siberia to nesting grounds in Alaska were recorded in the mid-1900s (Austin 1949). A large migration over the Brooks Range and Kotzebue Sound en route to Wrangel Island has also been recorded, for which Tukuto Lake may have been a resting place. The season of occupation for Tukuto Lake may have been at the optimal time for capturing geese. This time would have been during spring or early summer concentrations (May/June) or during fall migration (August/September). Whether a resident population was available for capture in drives during the molt in midsummer is unknown. Geese migration coincides with caribou migration, which has been suggested as the purpose for the Tukuto Lake site and may have influenced Ipiutak site locations (Burch 1972; Gerlach 1989; Moss and Bowers 2007).

The symbolism of goose species or waterfowl that relates to women and the female role of needlework may also play a part in material chosen for needle making. Ethnographic records suggest that geese and water birds in general figure prominently in mythology and cosmology, may have affected their visibility in the archaeological record. Tales connected to geese include subjects such as motherhood and female tasks in general, including sewing and distinctions between materials from the land, sea, and air (Borgoras 1902; McGhee 1977; Nelson 1983[1899]; Pearce 1987). Geese in particular represented connections to migration, childbirth, and the female role in needlework, including stitching of clothing (including bird skin/ and feather clothing) and household items (Laugrand and Oosten 2005; Pearce 1987). Geese figure in Alaska Native creation myths, in which Raven attempts to keep a migrating goose as a wife (Lantis 1938:160–161; Nelson 1983 [1899]:462). In Siberia, birds in general are associated with connections between worlds and facilitate shamanic travels (Balzer 1996).

Other factors encouraging the use of particular waterbird species for needle making were related to differences in cosmology or ritual treatment of spirits. Proscription of the use of needles by women during certain times, a widespread practice in circumpolar regions, or requirements of giving offerings of needles when certain furbearing animals were caught (Ellanna and Sherrod 2004; Gubser 1965; Mannermaa 2008; Rasmussen 1929; Van Deusen 1997) may be related to associations between land and water or water birds. Apparently some of these requirements extended into historic times; the use of iron, as well as the use of "sharp or pointed instruments [needles and awls]" during certain hunting seasons, for example the beluga hunting season in Norton Sound, was forbidden (Nelson 1983 [1899]:438). In addition, intriguing connections between Siberian shamanism and symbolic bird humeri, crafted of iron and attached to shaman's coats (Balzer 1996:306), support the idea that the wing itself and its association with flight were of significance.

Parts of birds had symbolic meaning and special uses in Alutiiq society; albatross feathers were used as amulets and their beaks were used by warriors as pincers to extract arrows from wounds (Jochelson 2002 [1933]). Ethnographic accounts record the hunting of these birds not only for food but also for purposes of gathering quills, bones, and whole bird skins for clothing; procurement may have been opportunistic and nearly year-round in this region. Auks and cormorants were formerly hunted extensively in the North Pacific, and some smaller shaft fragments used for needle manufacture at Kodiak and Aleutian sites were likely from cormorants (Jochelson 2002 [1925]). Ethnographic information tells us birds were taken from boats and on land by using darts, bolas, traps, snares, and nets as well as by bow and arrow with special bird projectile tips and by organized drives (Jochelson 2002 [1933]; Ray 1964; Nelson 1983 [1899]). Jochelson (2002 [1933]) recorded cormorants on most Aleutian Islands being hunted in January on land while birds were sitting on nests. Albatrosses would have been hunted from boats, since these birds' habits rarely brought them to land.

According to Black and Liapunova (1988:56–57), Unangan or Aleut people had "a strict division of labor" with men working bone, metal, and wood, and women working primarily skins and fibers. However, needles, most commonly made of bird bone, were made by women.

This division of labor and material use by sex suggests that we might not see the use of iron for grooving in needle manufacture, even though it may have been regularly used by men for other purposes.

Skill was probably a factor in needle manufacture because dexterity in placing grooves on a curved surface likely required practice. Differences in skill (from beginners with reduced manual dexterity to the aged with less visual acuity) might be recorded in grooves, but these differences would not change the overall effect of a bit's characteristic signatures (cf. Milne 2005; Weedman 2002). Jochelson (2002 [1925]:79–83) discussed Aleut manufacturing techniques and the skill required in choosing material as well as in the execution of tasks. Referring to ivory and bone, he stated material must be of the same "density" throughout the piece in order for implements to maintain straightness; grooves and scoring were used to mitigate anticipated warping or curvature in linear tools resulting from "unfitness of material" and "lack of skill of the maker."

Studies of the technological processes within societies and research that examines processes of change in manufacturing techniques sometimes note causal factors such as chance, individual choice, cultural expectations, necessity, or combinations of these factors. Change detectable in artifactual data can be linked to factors such as population movements or trade, increases or restrictions in the supply of raw materials, the introduction of novel techniques, ideas, and materials, or innovation. Arctic and subarctic environments, often considered hostile for human habitation, encouraged ingenuity (Arutiunov 1988; Buijs 1997; McCartney and Veltre 1999). A possible example of technological changes facilitated through the use of introduced material is toggling harpoon manufacture in the Bering Strait region which, according to Semenov (1976 [1964]) and Gusev and Zhilin (2002), was substantially enhanced by the use of iron bits for shaping the deeply undercut grooves of line slots and other features. Although the timing and magnitude of significance of the introduction of iron in the Bering Strait may be debated, detectable changes in grooves and accompanying techniques used in the reduction of organic materials can be used as indicators of contact or trade, innovation, or changes in cultural processes.

The form in which iron would have been traded and made available, whether as rods, flat "blades," disks, etc., is another question difficult to answer without the recovery of artifacts of iron, which unfortunately readily degrade over time. However, Gusev and Zhilin (2002:142), based on their own and other Siberian archaeologists' analyses and on limited finds of iron artifacts, conclude that iron bits were about 1 mm thick and approximately 5 to 30 mm in length. The brief examination of our small sample of scriber handles that may have been fitted with iron bits and needle cores that may have been grooved with iron bits concurs with Gusev and Zhilin's description of probable bit size (see Table 3). One could logically surmise that iron was an extremely important material for numerous reasons, including its novelty, edge and point holding properties, ability to be resharpened, and general resilience in contrast to lithic material.

The postulated introduction of iron in the Bering Strait region may have been followed by the cessation of bone needle core production, since iron needles could have replaced bone ones. This cessation and replacement of bone needle manufacture does not appear to have been the case until much later, although it is possible that iron technology at the time of its introduction did not produce needles with traits superior to bone. In addition, iron may have been available only to a very small percentage of people due to sociopolitical dynamics or distance from Asian production. Iron bits for grooving, if available to women, may have sped up the process of bone needle production, or alternatively, shifted production to a different member of a group. However, changes in techniques and materials are much more complex than simple adoption of new processes or materials. For example, as noted by Margaris (2006), manufacture of bone tools on Kodiak Island using traditional techniques continued (scoring and snapping methods), with metal replacing lithics, but not necessarily with the adoption of new crafting techniques such as sawing with metal. In any case, the introduction of iron could have caused shifts in "operational sequences" or "cascades" in technological processes (Lemonnier 1992; Schiffer 2005). By about AD 900–1100, the scale of iron production in Asia was much greater, and later still, the introduction of steel needles is noted by several researchers as important to northern cultures in general (Buijs 1997; Gelegdorj et al. 2007; Nelson 1983 [1899]).

According to paleoenvironmental data, warming of temperatures occurred roughly during the BC/AD temporal juncture, a time also associated with the initial occupations of several archaeological sites in Alaska with material cultures and settlement patterns defined as Old Bering Sea, Punuk, Okvik, and Ipiutak (Mason and Gerlach 1995). These sites have been described as having Asiatic connections, and efforts to understand temporal relationships between these sites and cultural designations are ongoing (Bronshtein 2006 [1986]; Dumond 2001a; Giddings 1967; Mason 2006; Morrison 1988). Early research exploring the introduction of iron indicated this material may have been traded out of the Manchurian region during the second century BC (Chard 1960; Collins 1961) and is thought to have been a part of the material culture of groups expanding north along the Bering Sea coast during warming trends. This is corroborated by the rare presence of iron at Chukotka sites such as Uelen and Ekven (Gusev and Zhilin 2002) and at later sites such as Sivuqaq on St. Lawrence Island (Collins 1961).

Sherratt (2006), Sinor (1998), and others discuss the likelihood of a metallurgic center in central Siberia between 4000 and 3500 BP. Technology was based on bronze casting, but sophisticated iron casting techniques were developed by the second century BC in Mongolia for such items as chariot wheel hubs. North of Mongolia, a chance discovery in 1999 in the Barun-Khul Valley on the western shore of Lake Baikal suggests iron smelting technology, indicated by iron slag and wood charcoal deposits, was developed by approximately 2000 ^{14}C yrs BP (Kozhevnikov et al. 2001). In later centuries, craftsmen developed high-temperature metallurgical techniques by using coal rather than wood-fired forges (Gelegdorj et al. 2007). Mason (1998) suggests another pathway for the introduction of iron to eastern Bering Strait populations via smelting centers in Korea and Japan, traded northward along the Kamchatka Peninsula and to East Cape on the Chukota Peninsula. Recent work by Park and Gordon (2007) on Korean bronze technology suggests high-quality forged iron was produced in Korea by AD 300, associated with Chinese technological and political influence. Others also suggest that iron was traded along already established obsidian trade routes (Bowers 2009).

Regardless of the pathway by which traded metal artifacts reached distant Alaska locations throughout the centuries, remote populations were affected by material supplies and technological advances within regional economic systems. Clearly, new materials such as iron broadened available technological choices for Late Holocene prehistoric craftspeople, despite distance from centers of industry.

The thorough treatment of the subject of the use of needles themselves aside from their manufacture from bone cores is beyond the scope of this paper. We acknowledge the critical nature of needles and clothing within northern cultures (cf. Chaussonnet 1988), but for purposes of conjecture and because the topic is inextricably related to needles (or at least very small, sharp, pointed implements), we explore the idea that needles produced from waterfowl wing bones may have also been used in tattooing. Krutak (1998) found the placement of tattoo marks had a variety of meanings and purposes, some of which were indications of sex, age, status, clan affiliation, and hunting merit or other attribute. Tattoo marks, sometimes stitched into skin using needles that pulled pigmented threads, suggested to Krutak a detailed understanding of points on the body similar to those used in Asian acupuncture, which led him to conclude that tattooing was also used for prevention or cure of physical ailments (see Lo [2002] for a discussion of the transition of bone and stone to metal in acupuncture needle material). Bloodletting was also commonly performed in northern cultures as a curative method using "small lancets of stone or iron" (Nelson 1983 [1899]:309). Were so-called engraving tool handles used for this purpose? Recording on the skin the endurance of pain has significance in many cultures, and women, the wielders of needles, were commonly the tattooists (Krutak 2007). Perhaps sharp bird bone needles, in addition to the role of clothing construction, were integral to prehistoric tattooing or other curative processes.

CONCLUSION

Needle production shows variation in grooving technology over time and space and records the use of different bit materials. In general, the northern sites from which bird bone was examined date to more recent times than do the Aleutian, Kodiak, and St. Lawrence Island sites; in this study, the sites span approximately 2,100 years. Differences appear to reflect the use of iron at Ipiutak sites and stone at Aleutian and Kodiak sites. Radiocarbon dating suggests metal may have been available at least by AD 400. Most Aleutian sites date to several centuries prior to this time, and grooves reflect the use of stone bits. Some cores have been subjected to post-depositional effects or other processes that make identifying bit material with certainty more difficult. Though bit material used in needle manufacture appears to be discernible in many instances, the character of the handle of the grooving tool is undetectable. Our understanding of prehistoric technologies will improve with further study of existing collections, as well as with the discovery of additional tools or iron objects.

We have identified the properties that make bird bone inherently advantageous for needle use, although these advantages may decrease over time as the needle ages and becomes brittle. Luckily for archaeologists, these properties encouraged the continuous production and the regular discard of needles and needle production waste into the archaeological record. However, the source bone of many needles, especially the most delicate, is often unknown. More work is required on characteristics of bird bone relative to small mammal bone with similar cortical thickness in regard to needles and their manufacture. Bone of small mammals, such as fox and hare, terrestrial birds and other waterfowl could be shaped as needles and subjected to stress testing to compare elasticity, tensile, and flexural strengths.

Our research indicates bone needles were crafted from several avian species, primarily snow geese and Canada geese at Ipiutak sites in northwestern Alaska. Early accounts of spring snow geese migrations following routes north along the upper Koyukuk and the upper Kobuk drainages suggest that Tukuto Lake, where the Croxton site is located, was along a regular flyway. Bone and other materials from large seabirds formed part of the material culture base for human inhabitants of the Aleutians and Kodiak Island, where needle cores were made from albatrosses (*Phoebastria* genus, formerly *Diomedea*); two species were noted as historically numerous, the Laysan (*Phoebastria immutabilis*) and black-footed (*Phoebastria nigripes*) albatrosses.

Ethnographic accounts reveal migratory waterfowl in northern cultures were integrated into mythology and symbolism in interesting ways. The use of bird wing bones shows remarkable continuity in needle manufacture, a technological process often associated with women. Obviously, needles were critical for survival in arctic and subarctic cultures and have a variety of uses, some of which may have been related to curative and decorative processes. The use of introduced iron to produce bone needles or to fashion complex tools in innovative ways may reflect a shift in social processes. Material acquisition systems necessary to obtain iron, as opposed to stone, may have differed in significant ways. Continuation in the use of humeri or ulnae from particular bird species for needles, however, indicates stability of functional, symbolic, or other factors.

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REFERENCES

Alpenfels, Ethel J.
1955 The Anthropology and Social Significance of the Human Hand. *Artificial Limbs* 2(2):4–21.

Arutiunov, Sergei A.
1988 Chukchi: Warriors and Traders of Chukotka. In *Crossroads of Continents: Cultures of Siberia and Alaska,* edited by W. Fitzhugh and A. Crowell, pp. 39–42. Smithsonian Institution Press, Washington, D.C.

Austin, Oliver L. Jr.
1949 *Waterfowl of Japan*. General Headquarters Supreme Command for the Allied Powers, Tokyo, Natural Resources Section Report 118:1–106.

Balzer, Majorie M.
1996 Flights of the Sacred: Symbolism and Theory in Siberian Shamanism. *American Anthropologist* 98(2):305–318.

Bandi, Hans-Georg
1969 *Eskimo Prehistory.* University of Alaska Press, Fairbanks.

Belcher, Edward
1861 On the Manufacture of Works of Art by the Esquimaux. *Transactions of the Ethnological Society of London* 1:129–146.

Bernath, Balázs, Bence Suhai, Balázs Gerics, Gábor Csorba, Mihály Gasparik, and Gábor Horvath
2004 Testing the Biomechanical Optimality of the Wall Thickness of Limb Bones in the Red Fox (*Vulpes vulpes*). *Journal of Biomechanics* 37:1561–1572.

BirdLife International
2011 Laysan Albatross *Phoebastria immutabilis*, http://www.birdlife.org/datazone/speciesfactsheet.php?id=3958, accessed January 2011.

Black, Lydia, and Rosa G. Liapunova

1988 Aleut: Islanders of the North Pacific. In *Crossroads of Continents: Cultures of Siberia and Alaska,* edited by W. Fitzhugh and A. Crowell, pp. 52–57. Smithsonian Institution Press, Washington, D.C.

Bogoras, Waldemar

1902 Folklore of Northeastern Asia as Compared with that of Northwestern America. *American Anthropologist* 4:577–683.

Bovy, Kristine

2002 Differential Avian Skeletal Part Distribution: Explaining the Abundance of Wings. *Journal of Archaeological Science* 29:965–978.

Bowers, Peter M.

2006 Update on the Deering Archaeological Program. *Alaska Anthropological Association Newsletter* 32(1):13–20.

2009 *The Archaeology of Deering, Alaska: Final Report on the Deering Village Safe Water Archaeological Program*, edited by Peter M. Bowers. Report prepared by Northern Land Use Research, Inc., for the Native Village of Deering, the City of Deering, Alaska Department of Environmental Conservation Village Safe Water Office, and Alaska State Historic Preservation Office. Fairbanks.

Bronshtein, Mikhail

2006 Variability in Ancient Eskimo Graphic Designs: On the Problem of the Ethnic and Cultural History of the Bering Sea from the 1st Millennium BC to the 1st Millennium AD. Appendix 1. *Alaska Journal of Anthropology* 4(1–2):162–178.

Buijs, Cunera

1997 Ecology and the Principles of Polar Clothing. In *Braving the Cold: Continuity and Change in Arctic Clothing*, edited by C. Buijs and J. Oosten, pp. 11–33. CNWS Publications, Leiden University Press, Leiden, The Netherlands.

Burch, Ernst S.

1972 The Caribou/Wild Reindeer as a Human Resource. *American Antiquity* 37(3):339–368.

Chard, Chester

1960 The Neolithic in Northern Asia: A Culture Area Approach. *Anthropologica* new series 2(1):1–9.

Chaussonnet, Valerie

1988 Needles and Animals: Women's Magic. In *Crossroads of the Continents: Cultures of Siberia and Alaska,* edited by W. Fitzhugh and A. Crowell, pp. 209–226. Smithsonian Institution Press, Washington, D.C.

Clark, Donald W.

1977 Hahanudan Lake: An Ipiutak-Related Occupation of Western Interior Alaska. Archaeological Survey of Canada, Mercury Series No. 71. National Museums of Canada, Ottawa.

1984 Prehistory of the Western Subarctic. In *Handbook of North American Indians,* vol. 6, *Subarctic*, edited by June Helm, pp. 107–129. Smithsonian Institution Press, Washington, D.C.

Collins, Henry B.

1937a Culture Migration and Contacts in the Bering Sea Region. *American Anthropologist* 39(3):375–384.

1937b Archaeology of St. Lawrence Island, Alaska. *Smithsonian Miscellaneous Collections* 96(1). Smithsonian Institution, Washington, D.C.

1961 Eskimo Cultures. In *Encyclopedia of World Art,* 5:1–28. McGraw-Hill, New York.

Cubo, J., and A. Casinos

2000 Mechanical Properties and Chemical Composition of Avian Long Bones. *European Journal of Morphology* 38(2):112–121.

Desautels, Roger J., Albert J. McCurdy, James D. Flynn, and Robert R. Ellis

1971 Archaeological Report, Amchitka Island, Alaska, 1969–1970. U.S. Atomic Energy Commission Report TID-25481. Holmes and Narver, Las Vegas.

Dumond, Don E.

2001a Toward a (Yet) Newer View of the (Pre)History of the Aleutians. In *Archaeology in the Aleut Zone of Alaska: Some Recent Research,* edited by Don E. Dumond, pp. 289–309. *University of Oregon Anthropological Papers* No. 58. Department of Anthropology, University of Oregon, Eugene.

2001b Words in Closing. In *Archaeology in the Bering Strait Region: Research on Two Continents*, edited by Don E. Dumond and Richard L. Bland, pp. 345–357. *University of Oregon Anthropological Papers* no. 59. Department of Anthropology, University of Oregon, Eugene.

Dumond, Don E., and R. L. Bland

1995 Holocene Prehistory of the Northernmost North Pacific. *Journal of World Prehistory* 9(4):401–451.

Ellanna, Linda J., and George K. Sherrod

2004 *From Hunters to Herders: The Transformation of Earth, Society and Heaven among the Inupiat of Beringia*, edited by R. Mason. Alaska Region, National Park Service, U.S. Department of the Interior, Anchorage.

Gál, Erika

2005 New Data on Bird Bone Artefacts from Hungary and Romania. In *From Hooves to Horns, from Mollusc to Mammoth: Manufacture and Use of Bone Artefacts from Prehistoric Times to the Present*, edited by H. Luik, A. M. Choyke, C. E. Batey and L. Lõugas. *Muinasaja Teadus* (Tallinn) 15:325–336. Online at http://www.capidava.ro/publicatii/ErikaGal_birdbone.pdf.

2007 The Role of Archaeo-Ornithology in Environmental and Animal History Studies. In *Archaeological and Cultural Heritage Preservation within the Light of New Technologies*, edited by E. Jerem, Z. Mester, and R. Benczes, EPOCH Books and Archaeolingua, Budapest. Online at http://public-repository.epoch-net.org/publications/BORITO/049-062.pdf

Geist, Otto W., and Froelich Rainey

1936 *Archaeological Excavations at Kukulik, St. Lawrence Island, Alaska*. U.S. Government Printing Office, Washington, D.C.

Gelegdorj, Eregzen, Amartuvshin Chunag, Robert B. Gordon, and Jang-Sik Park

2007 Transitions in Cast Iron Technology of the Nomads in Mongolia. *Journal of Archaeological Science* 34:1187–1196.

Gelvin-Reymiller, Carol, Joshua D. Reuther, Ben A. Potter, and Peter M. Bowers

2006 Technical Aspects of a Worked Proboscidean Tusk from the Inmachuk River, Seward Peninsula, Alaska. *Journal of Archaeological Science* 33(8):1088–1094.

Gerlach, S. Craig

1989 *Models of Caribou Exploitation, Butchery and Processing at the Croxton Site, Tukuto Lake, Alaska.* Unpublished Ph.D. dissertation, Department of Anthropology, Brown University, Providence.

Gerlach, S. Craig, and Edwin S. Hall, Jr.

1988 The Later Prehistory of Northern Alaska: The View from Tukuto Lake. In *The Late Prehistoric Development of Alaska's Native People*, edited by Robert D. Shaw, Roger K. Harrit, and Don E. Dumond, pp. 107–135. *Aurora Monograph Series* no. 4. Alaska Anthropological Association, Anchorage.

Gerlach, S. Craig, and Owen K. Mason

1992 Calibrated Radiocarbon Dates and Cultural Interaction in the Western Arctic. *Arctic Anthropology* 29(1):54–81.

Giddings, J. Louis, Jr.

1956 The Burin Spall Artifact. *Arctic* 9(4):229–237.

1967 *Ancient Men of the Arctic*. Alfred A. Knopf, New York.

Giddings, J. Louis, Jr., and Douglas D. Anderson

1986 Beach Ridge Archaeology of Cape Krusenstern: Eskimo and Pre-Eskimo Settlements around Kotzebue Sound, Alaska. *U.S. National Park Service Publications in Archeology* 20. U.S. National Park Service, Department of Interior, Washington, D.C.

Gilbert, B. Miles, Larry D. Martin, and Howard G. Savage

1996 [1985] *Avian Osteology*. Missouri Archaeological Society, Columbia.

Gubser, Nicholas J.

1965 *The Nunamiut Eskimos: Hunters of Caribou*. Yale University Press, New Haven.

Gusev, S. V., and M. G. Zhilin

2002 The Technology of Bone Working Among the Sea Mammal Hunting Cultures of Bering Strait. In *Archaeology in the Bering Strait Region,* pp. 139–151. University of Oregon Anthropological Papers no. 59. Department of Anthropology, University of Oregon, Eugene.

Gusev, Sergey V., Andrey V. Zagoroulko, and Aleksey V. Porotov

1999 Sea Mammal Hunters of Chukotka, Bering Strait: Recent Archaeological Results and Problems. *World Archaeology* 30(3):354–369.

Hall, Edwin S., Jr.

1974 Archaeological Investigations in the Noatak River Valley, Summer 1973. In *The Environment of the Noatak River Basin Alaska: Results of the Center for Northern Studies Biological Survey of the Noatak River Valley, 1973*, edited by S. B. Young, pp. 460–523. Center for Northern Studies, Wolcott, VT.

Higgins, Jude

1999 Túnel: A Case Study of Avian Zooarchaeology and Taphonomy. *Journal of Archaeological Science* 26:1449–1457.

Hohman, W., C. Ankney, and D. Gordon

1992 Ecology and Management of Post-Breeding Waterfowl. In *Ecology and Management of Breeding Waterfowl*, edited by B. D. J. Batt, pp. 128–138. University of Minnesota Press, Minneapolis.

Holliday, Trenton W.
1998 The Ecological Context of Trapping among Recent Hunter-Gatherers: Implications for Subsistence in Terminal Pleistocene Europe. *Current Anthropology* 39(5):711–720.

Jensen, Anne M.
2009 *Nuvuk, Point Barrow, Alaska: The Thule Cemetery and Ipiutak Occupation*. Unpublished Ph.D. dissertation, Department of Anthropology, Bryn Mawr College, Bryn Mawr, PA.

Jochelson, Waldemar
2002 [1925] *Archaeological Investigations in the Aleutian Islands*. University of Utah Press, Salt Lake City.
2002 [1933] *History, Ethnology and Anthropology of the Aleut*. University of Utah Press, Salt Lake City.

Jordan, Richard H.
1992 A Maritime Paleoarctic Assemblage from Crag Point, Kodiak Island, Alaska. *Anthropological Papers of the University of Alaska* 24(1–2):127–140.

Klein, David R.
1966 Waterfowl in the Economy of the Eskimos on the Yukon–Kuskokwim Delta, Alaska. *Arctic* 19(4):319–335.

Knecht, H.
1993 Splits and Wedges: The Techniques and Technology of Early Aurignacian Antler Working. In *Before Lascaux*, edited by H. Knecht, A. Pike-Tay, and R. White, pp. 137–162. CRC Press, Boca Raton, FL.

Kozhevnikov, Nikolai O., Arthur V. Kharinsky, and Oleg K. Kozhevnikov
2001 An Accidental Geophysical Discovery of an Iron Age Archaeological Site on the Western Shore of Lake Baikal. *Journal of Applied Geophysics* 47:107–122.

Krutak, Lars
1998 *One Stitch at a Time.* M.A. thesis, Department of Anthropology, University of Alaska Fairbanks.
2007 *The Tattooing Arts of Tribal Women*. Bennett and Bloom, London.

Lantis, Margaret
1938 The Mythology of Kodiak Island, Alaska. *Folklore* 51(200):123–172.

Larsen, Helge
2001 Deering: A Men's House from Seward Peninsula, Alaska. *Publications of the National Museum Ethnographical Series,* vol. 19, edited by Martin Appelt. National Museum of Denmark, Copenhagen.

Larsen, Helge, and Froelich Rainey
1948 Ipiutak and the Arctic Whale Hunting Culture. *Anthropological Papers of the American Museum of Natural History* No. 42. New York.

Laugrand, Frédéric, and Jarich Oosten
2005 Connecting and Protecting: Lines and Belts in the Canadian Arctic. *Anthropological Papers of the University of Alaska* 4(1):133–147.

Lemonnier, Pierre
1992 Elements for an Anthropology of Technology. *Anthropological Papers of the Museum of Anthropology* no. 88*,* Ann Arbor, MI.

LeMoine, Genevieve M.
1989 Use Wear Analysis of Bone Tools. *ArchaeoZoologia* 3(1/2):211–224.
1994 Use Wear on Bone and Antler Tools from the Mackenzie Delta, Northwest Territories. *American Antiquity* 59(2):316–334.

Lo, Vivienne
2002 Spirit of Stone: Technical Considerations in the Treatment of the Jade Body. *Bulletin of the School of Oriental and African Studies* 65(1):99–128.

MacGregor, A. G.
1985 *Bone, Antler, Ivory and Horn: The Technology of Skeletal Materials Since the Roman Period*. Croom Helm, London.

Mannermaa, K.
2008 Birds and Burials at Ajvide (Gotland, Sweden) and Zvejnieki (Latvia) about 8000–3900 BP. *Journal of Anthropological Archaeology* 27:201–225.

Margaris, Amy V.
2006 *Alutiiq Engineering: The Mechanics and Design of Skeletal Technologies in Alaska's Kodiak Archipelago*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Arizona, Tucson.

Mason, Owen K.
2006 Ipiutak Remains Mysterious: A Focal Place Still Out of Focus. In *Dynamics of Northern Societies: Proceedings of the SILA/NABO Conference on Arctic and North Atlantic Archaeology*, edited by Jette Arneborg and Bjarne Grønnow, pp. 103–119. *Publications of the National Museum, Studies in Archaeology and History* Vol. 10. National Museum of Denmark, Copenhagen.

1998 The Contest Between the Ipiutak, Old Bering Sea, and Birnirk Polities and the Origin of Whaling during the First Millennium AD along Bering Strait. *Journal of Anthropological Archaeology* 17:240–325.

Mason, Owen K., and S. Craig Gerlach
1995 Chukchi Hot Spots, Paleo-Polynyas, and Caribou Crashes: Climatic and Ecological Dimensions of North Alaska Prehistory. *Arctic Anthropology* 32(1):101–130.

McAlister, G. B., and D. D. Moyle
1983 Some Mechanical Properties of Goose Femoral Cortical Bone. *Journal of Biomechanics* 16(8):577–789.

McCartney, Allen P.
1988 Maritime Adaptations in Southern Alaska. In *Proceedings of the International Symposium on Maritime Adaptations in the North Pacific*, edited by Hiroaki Okada, pp. 19–55. Abashiri, Hokkaido.

McCartney, Allen P., and Douglas Veltre
1999 Aleutian Island Prehistory: Exploring Insular Extremes. *World Archaeology* 30(3):505–515.

McCartney, Allen P., and D. Mack
1973 Iron Utilization by Thule Eskimos of Central Canada. *American Antiquity* 38:328–29.

McFee, R. D.
n.d. *The Feniak Lake Site: Resource Utilization by an Inland Ipiutak Group. A Faunal Analysis*. Manuscript. Northern Yukon Research, University of Toronto.

McGhee, Robert
1977 Ivory for the Sea Woman: The Symbolic Attributes of a Prehistoric Technology. *Canadian Journal of Archaeology* 1:141–149.

Milne, S. Brooke
2005 Palaeo-Eskimo Novice Flintknapping in the Eastern Canadian Arctic. *Journal of Field Archaeology* 30(3):329–345.

Milne, S. Brooke, and Sarah M. Donnelly
2004 Going to the Birds: Examining the Importance of Avian Resources to Pre-Dorset Subsistence Strategies on Southern Baffin Island. *Arctic Anthropology* 41(1):90–112.

Morrison, David A.
1988 *The Kugaluk Site and the Nuvorugmiut: The Archaeology and History of a Nineteenth-Century Mackenzie Inuit Society*. Mercury Series Paper no. 137. Canadian Museum of Civilization, National Museums of Canada, Ottawa.

Moss, Madonna L., and Peter M. Bowers
2007 Migratory Bird Harvest in Northwestern Alaska: A Zooarchaeological Analysis of Ipiutak and Thule Occupations from the Deering Archaeological District. *Arctic Anthropology* 44(1):37–50.

Nelson, Edward W.
1983 [1899] *The Eskimo about Bering Strait*. Smithsonian Institution Press, Washington, D.C.

Nicholson, Rebecca A.
1996 Bone Degradation, Burial Medium and Species Representation: Debunking the Myths, an Experiment Based Approach. *Journal of Archaeological Sciences* 23:513–533.

O'Leary, Matthew
2001 Volcanic Ash Stratigraphy for Adak Island, Central Aleutian Archipelago. In *Archaeology in the Aleut Zone of Alaska: Some Recent Research*, edited by Don E. Dumond, pp. 215–233. *University of Oregon Anthropological Papers* no. 58. Department of Anthropology, University of Oregon, Eugene.

Park, Jang-Sik, and Robert B. Gordon
2007 Traditions and Transitions in Korean Bronze Technology. *Journal of Archaeological Science* 34:1991–2002.

Pearce, Susan M.
1987 Ivory, Antler, Feather, and Wood: Material Culture and the Cosmology of the Cumberland Sound Inuit, Baffin Island, Canada. *The Canadian Journal of Native Studies* 7(2):307–321.

Rainey, Froelich
1941 The Ipiutak Culture at Point Hope Alaska. *American Anthropologist* 3(1):364–375.

Rasmussen, Knud
1929 *Intellectual Culture of the Iglulik Eskimo*. Report of the Fifth Thule Expedition 1921–1924, 7(1). Copenhagen.

Ray, Dorothy J.
1964 Nineteenth Century Settlement and Subsistence Patterns in Bering Strait. *Arctic Anthropology* 2(2):61–94.

Reanier, Richard E.
1992 *Refinements to K-means Clustering: Spatial Analysis of the Bateman Site, Arctic Alaska*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Washington, Seattle.

Reimer, P. J., M. G. L. Baillie, E. Bard, A. Bayliss, J. W. Beck, C. J. H. Bertrand, P. G. Blackwell, C. E. Buck, G. S. Burr, K. B. Cutler, P. E. Damon, R. L. Edwards, R. G. Fairbanks, M. Friedrich, T. P. Guilderson, A. G. Hogg, K. A. Hughen, B. Kromer, F. G. McCormac, S. W. Manning, C. B. Ramsey, R. W. Reimer, S. Remmele, J. R. Southon, M. Stuiver, S. Talamo, F. W. Taylor, J. van der Plicht, and C. E. Weyhenmeyer

2004 IntCal04 Terrestrial Radiocarbon Age Calibration, 26–0 kya BP. *Radiocarbon* 46:1029–1058.

Reuther, Joshua D.

2003 An Analysis of Radiocarbon Assays Produced by Three Laboratories: A Case Study on the Croxton Site, Locality J, Northern Alaska. Unpublished M.A. thesis, Department of Anthropology, University of Alaska Fairbanks.

Reuther, Joshua D., and S. Craig Gerlach

2005 Testing the "Dicarb Problem": A Case Study from North Alaska. *Radiocarbon* 47(3):359–366.

Ridgely, R. S., T. F. Allnutt, T. Brooks, D. K. McNicol, D. W. Mehlman, B. E. Young, and J. R. Zook

2007 *Digital Distribution Maps of the Birds of the Western Hemisphere*, version 3.0. Migratory Bird Program, Conservation International, Center for Applied Biodiversity Science, World Wildlife Fund–US and Environment Canada, WILDSPACE. NatureServe, Arlington, VA.

Rothe, Tom

2009 *Wildlife Notebook Series: Geese*. Revised and reprinted 1994, Alaska Department of Fish and Game. http://www.adfg.state.ak.us/pubs/notebook/bird/geese.php.

Serjeantson, Dale

2009 *Birds*. Cambridge University Press, New York.

Schiffer, Michael B.

2005 The Devil is in the Details: The Cascade Model of Invention Processes. *American Antiquity* 70(3):485–502.

Semenov, Sergei A.

1976 [1964] *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*. Translated by M. V. Thompson. Harper and Row, New York.

Sherratt, Andrew

2006 The Trans-Eurasian Exchange: The Prehistory of Chinese Relations with the West. In *Contact and Exchange in the Ancient World*, edited by V. H. Mair, pp. 30–61. University of Hawaii Press, Honolulu.

Sinor, Denis

1998 The Myth of Language and the Language of Myth. In *The Bronze Age and Early Iron Age Peoples of Eastern Central Asia*, vol. 2, edited by V. H. Mair, pp. 729–745. Institute for the Study of Man, Washington, D.C., and University of Pennsylvania Museum Publications, Philadelphia.

Stanford, Dennis J.

1976 *The Walakpa Site, Alaska: Its Place in the Birnirk and Thule Cultures*. Smithsonian Contributions to Anthropology no. 20. Smithsonian Institution Press, Washington, D.C.

Stuiver, Minze, Paula J. Reimer, and Ron W. Reimer

2005 CALIB 5.0. Program and documentation at http://calib.qub.ac.uk/calib/.

Suhai, Bence, Mihály Gasparik, Gábor Csorba, Balázs Gerics, and Gábor Horvath

2006 Wall Thickness of Gas- and Marrow-Filled Avian Long Bones: Measurements on Humeri, Femora, and Tibiotarsi in Crows (*Corvus corone cornix*) and Magpies (*Pica pica*). *Journal of Biomechanics* 39:1116–1128.

Talbot, Constance

1943 *The Complete Book of Sewing*. Greystone Press, New York.

Untracht, Oppi

1968 *Metal Techniques for Craftsmen: A Basic Manual for Craftsmen on the Methods of Forming and Decorating Metals.* Doubleday and Company, Garden City, NY.

Van Deusen, Kira

1997 Protection and Empowerment: Clothing Symbolism in the Amur River Region of the Russian Far East. In *Braving the Cold: Continuity and Change in Arctic Clothing*, edited by C. Buijs and J. Oosten, pp. 149–168. CNWS Publications, Leiden University Press, Leiden, The Netherlands.

Weedman, Kathryn J.

2002 On the Spur of the Moment: Effects of Age and Experience on Hafted Stone Scraper Morphology. *American Antiquity* 67(4):731–744.

Witthoft, John, and Frances Eyman

1969. Metallurgy of the Tlingit, Dene, and Eskimo. *Expedition* 11(3):12–23.