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To Pot or Not to Pot: Understanding Technological Investment in Ceramics and Marine Mammal Oil Rendering in Kodiak, Alaska

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TO POT OR NOT TO POT: UNDERSTANDING TECHNOLOGICAL INVESTMENT IN CERAMICS AND MARINE MAMMAL OIL RENDERING IN KODIAK, ALASKA

by

Elizabeth Groat

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Archaeology and Cultural Resource Management

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ABSTRACT

To Pot or Not to Pot: Understanding Technological Investment in Ceramics and Marine Mammal Oil Rendering in Kodiak, Alaska

by

Elizabeth Groat, Master of Science

Utah State University, 2024

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Department: Sociology and Anthropology

Why do groups choose to use certain technologies, but not others? This is a complex issue, and the circumstances surrounding the adoption of ceramic technology are particularly complex. This study focuses on the Kodiak Archipelago, which, by the time pottery was adopted in 500 cal BP, was home to a large population of socially and economically complex hunter-gatherers. While ceramic technology existed on the mainland, it was ignored in Kodiak for centuries—and even after its adoption, pottery is found only in the southern parts of the islands. One explanation that has been proposed, which I refer to as the “oil-rendering hypothesis,” draws on the uneven distribution of whales and seals in the archipelago to suggest that pottery was adopted to facilitate an emerging southern specialization in marine mammal oil production. According to this hypothesis, therefore, it is worth investing in pottery instead of the traditional alternative, self-rendering in a seal stomach container, only if one wants to render surplus amounts of oil.

This study used an experimental, behavioral ecology-based approach to interrogate the plausibility of this hypothesis. By experimentally reconstructing both pottery and self-rendering technology, I derived the necessary information to evaluate them as Mutually Competitive Technologies, a concept from technological investment thinking that maps well onto the oil-rendering hypothesis. The results yielded insight into the characteristics and manufacture of Kodiak pottery, addressed the merits of pottery technology relative to the existing alternatives, and spoke to the relationship between pottery use and economic intensification in complex hunter-gatherer societies.

(180 pages)

PUBLIC ABSTRACT

To Pot or Not to Pot: Understanding Technological Investment in Ceramics and Marine Mammal Oil Rendering in Kodiak, Alaska

Elizabeth Groat

Why do groups choose to use certain technologies, but not others? This study focuses on an especially confusing instance of this question: the adoption of pottery in Kodiak, Alaska. This event was strange for two reasons. First, by AD 1500, when Alutiiq ancestors in the Kodiak Archipelago began making pottery, their neighbors on the mainland had already been doing it for centuries—so why did they wait so long? Second, pottery is also only found in the south of the islands—so why did some people use it, but not others? Whale and seal are more abundant in southern Kodiak, so one potential explanation is that the pottery was made because southern villages were starting to render larger amounts of marine mammal oil. I reconstructed the pottery of Kodiak to try to understand whether this hypothesis makes sense. Are Alutiiq pots actually a better way to mass-produce marine mammal oil than other traditional rendering methods? What conditions should favor the use of pottery? This study lays out what I've learned about Kodiak pottery and what this tells us about what was going on in the region, as well as the implications for our understanding of pottery use in general.

ACKNOWLEDGMENTS

This project had a lot of moving parts and involved many people and organizations. First, I need to thank the Alutiiq Museum and Archaeological Repository (AMAR), in particular Amy Steffian, Molly Odell, Patrick Saltonstall, Dehrich Schmidt-Chaya, and Amanda Lancaster. Molly and Patrick especially provided considerable logistical, personal, and moral support—I don't know what I would've done without you.

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For my funding, I thank the Alaska Anthropological Association, the USU College of Humanities and Social Sciences, the USU Student Involvement and Leadership Center, and the USU School of Graduate Studies. I also thank FenAnn Shen of USU's Core Microscopy Facility, Kimberly Watts UU's Materials Characterization Lab, Kelly Bradbury and the USU Rock Prep Lab, and Judson Finley and the USU Archaeometry and Geoarchaeology Lab, as well as Molly Cannon at the USU Museum of Anthropology, Christopher Kanyusik at the USU Eastern Ceramic Studio, Ross Israelson of USU's experimental farm, and the folks at Cache Valley Meats and Custom Cutting.

Last, my loving and supportive husband, who has kept me fed, listened to my meltdowns, and finally nudged me over the finish line. Thank you for believing in me.

Elizabeth Groat

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CHAPTER I. INTRODUCTION

Humanity's technologies form the interface between us and our environment; as such, they reflect aspects of both our environment and ourselves. One of the greatest shifts in the history of archaeology has been the conceptualization of artifacts *as* technologies, valuing them for their functional aspects rather than as purely aesthetic objects. Ancient tools carry information about both the ways they shaped their users' daily lives, and the circumstances that led to their use and development. What materials were available? How difficult was the tool to make? What need was it made to satisfy, and why was that a priority for the makers? Seen through this lens, the absence of a given technology becomes as telling as its presence.

The study of archaeological pottery provides a typical case study of this larger reorientation. While ceramics were once largely admired (or not) for their artistry, or prized for their chronologically diagnostic characteristics, scholars have since discovered the wealth of functional, technological information they hold (e.g. Arnold 1988; Simms et al. 1997). Countless decisions must be made, consciously or unconsciously, in the fashioning of a ceramic vessel, concerning topics such as materials selection and processing, construction and shaping methods, decoration techniques, and drying and firing strategies (Sillar and Tite 2000). All these choices hinge on an additional, hidden decision: whether to even begin. The very presence or absence of pottery in a culture, once considered easy to predict (Mason 1966), is in fact a very complex matter, with many intriguing variations (Arnold 1988; Eerkens and Lipo 2014).

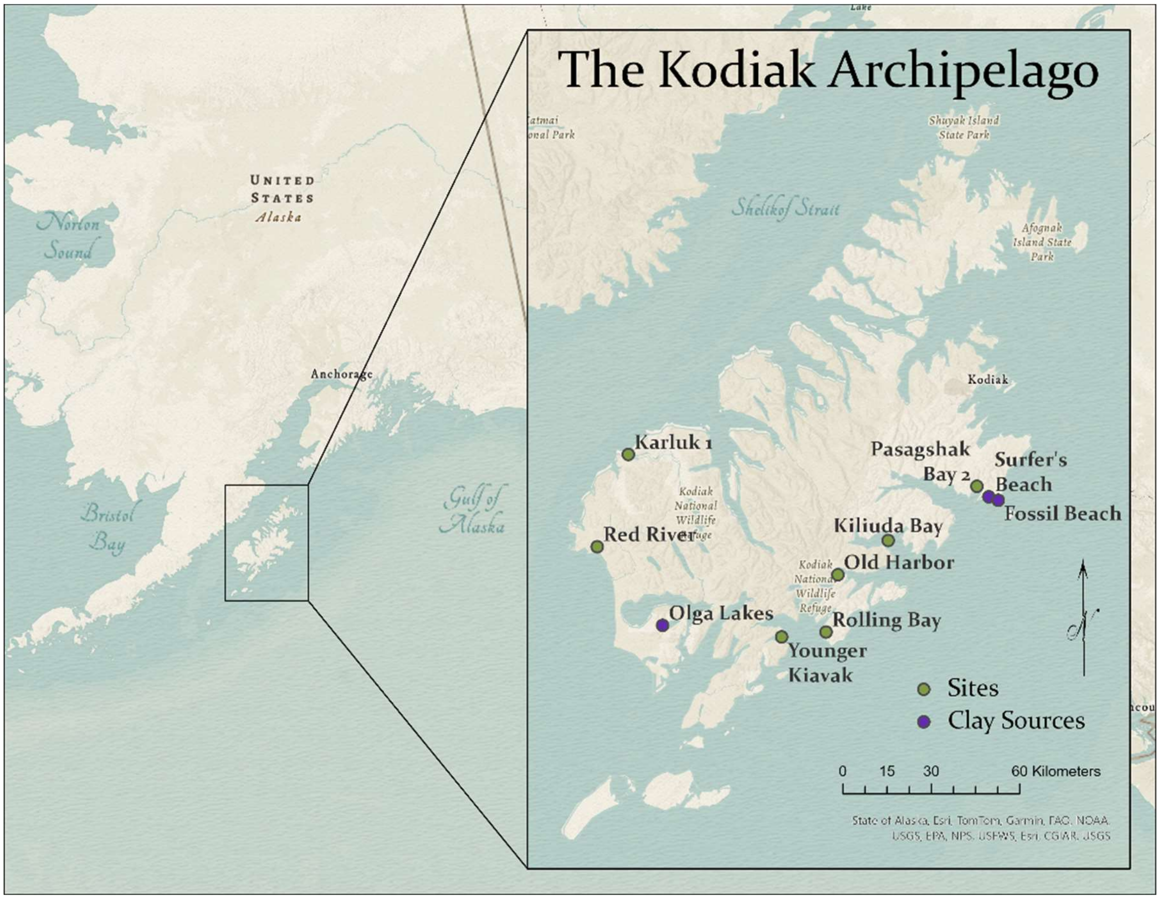

Figure 1. Map showing the position of the Kodiak Archipelago and points of interest mentioned in this thesis. NAD83 Alaska Albers projection. All maps in this paper use basemaps from ESRI.

This study focuses on one particularly puzzling instance of pottery adoption—and non-adoption—that of the Kodiak Archipelago, a group of islands in the Gulf of Alaska (Figure 1). The ancestors of the modern-day Alutiiq[1] people lived on these islands for thousands of years, maintaining contact with groups on the mainland (Saltonstall et al. 2021; Steffian et al. 2015)—and, for several hundreds of those years, their mainland

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[1] Alutiiq (adjectival, single noun), or Alutiit (plural noun), is the self-descriptor (or autonnym) most commonly used by those native to Kodiak and Prince William Sound. The traditional, pre-contact name for this culture/language group is Sugpiaq/Sugpiat. Today, however, most members of this group self-identify as Alutiiq/Alutiit, a "nativized" version of the Russian label "Aleut," in recognition of the role Russian culture plays in contemporary Alutiiq identity (DeHaas 2012). The Alutiit are not to be confused with the Indigenous residents of the Aleutian Islands, a culturally and linguistically distinct group known as the Unangax̂.

neighbors were making pottery (Dumond 1969). There are even a couple of sites on Kodiak Island where some of this mainland pottery has been found (the blue-green triangles in Figure 2), indicating that they must have been aware of the technology (Admiraal, Lucquin, von Tersch, et al. 2020:Figure 6). Apparently, it did not catch on, as it was not until centuries later (ca. AD 1500) that pottery appeared in significant quantities in the Kodiak Archipelago. Even then, pottery was concentrated in the south of the islands (Figure 2)—whatever made some Alutiiq ancestors change their minds and start using ceramic technology, not all of them were convinced.

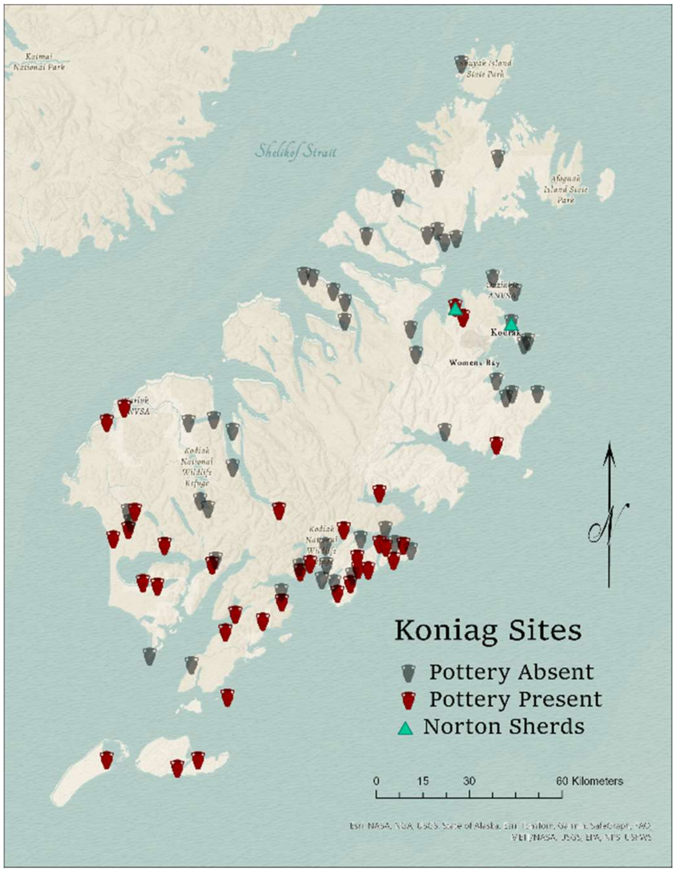

Figure 2. Map of Koniag tradition sites showing pottery distribution. Sites with mainland pottery (Crag Point and Monashka Bay) are indicated with triangles. Crag Point is also the northernmost local pottery site. Archaeological data from Admiraal et al. 2020; NAD83 UTM Zone 5N projection.

Comparatively few studies have been done on the ceramic tradition of Kodiak, for several reasons. Aside from the fact that the study of Kodiak in general has been a rather niche topic, pottery was only made there for a few hundred years, and not within living memory. As a result, few people realize that pottery was ever made on Kodiak, even among its current residents. The vessels are also exactly the sort of "ugly" pottery that many archaeologists find uninspiring—like most of the contemporaneous pottery found in Alaska (and like much pottery made by hunter-gatherers, for that matter), the pots on Kodiak are the color of mud, made from a coarse mixture of clay and gravel. They are fashioned into simple, "crude" shapes, with thick walls and little-to-no decoration.

However, this lack of scholarly attention is undeserved. Kodiak offers a compelling case study of the levels of social complexity and artistic achievement possible for hunter-gatherers in resource-rich marine settings, smashing stereotypes long held about hunter-gatherer societies (Clark 1968; Fitzhugh 1996; Knecht 1995). Occurring as it did during the Koniag tradition, the last cultural period before Russian contact (AD 1763, see Saltonstall et al. 2021), the appearance of pottery in Kodiak coincides with the peak of Alutiiq ancestors' precontact population growth, and the culmination of a wide array of related trends (Steffian et al. 2016). The curious circumstances surrounding pottery adoption in the region provide a way to dig further into the details of these developments. Koniag pottery also offers a new data point in the budding study of hunter-gatherer ceramics (e.g. Anderson et al. 2017; Eerkens and Lipo 2014; Jordan and Gibbs 2019). The very characteristics that make such pottery traditions less aesthetically enticing—utilitarian design, sparsity of stylistic features—make them ideal for studying the functional aspects of pottery production and use.

The pottery of Kodiak presents a distinctive opportunity for study, in that every aspect of its adoption appears to have occurred through deliberate decision-making, rather than being restricted by factors beyond the makers' control. The proximity of ceramic technology on the Alaska Peninsula indicates that the residents of Kodiak were not hindered by a lack of technological advancement. They had the opportunity to adopt pottery, but they chose not to for an extended period. Further, even when pottery was adopted by some, many still chose not to make, or even to use ceramic vessels—villages in the north of the archipelago could have easily traded for pottery manufactured in the south, but (with the possible exceptions of Pasagshak Bay and Crag Point, Figures 1 and 2) no such vessels are found. The result is a natural experiment in which differing segments of a given culture group, living in the same region, make different technological choices. The cultural florescence that occurred alongside ceramic adoption on Kodiak presents a rich soup of potential factors that might have made pottery more desirable—but which among them would have applied only to certain parts of the archipelago? Somewhere behind the unadorned and crumbling sherds found in the Kodiak mud lies a fascinating story, and one that is well worth uncovering.

The Hypothesis

Thus far, one main hypothesis has been put forward that could account for both the timing and spatial distribution of pottery adoption on Kodiak, an idea that I refer to as the oil-rendering hypothesis. This hypothesis is founded upon Richard Knecht's (1995:321, 375) observation of a difference in resource availability between northern and southern Kodiak: marine mammals. While whale and seal are central to Native lifeways throughout the region, their migration routes make both more abundant in the south, particularly on the southeast coast of Kodiak (Admiraal, Lucquin, von Tersch, et al. 2020). Given pottery's distinctive property of being able to withstand direct heating in a fire, Knecht supposed that the pots might have been chiefly used to render the blubber from these marine mammals into oil (a staple in the coastal Alaskan diet).

Ben Fitzhugh (1996, 2001) further developed this hypothesis, suggesting that pottery was adopted to facilitate an intensification in marine mammal oil production. Bearing in mind the social context of pottery adoption on Kodiak, in particular the growing levels of social inequality, Fitzhugh theorizes that newly powerful chiefs in the southern region of the archipelago could have led a movement to specialize in the mass-production of marine mammal oil. He suggests that the resulting surplus could then have been traded with those in the north of the archipelago, who might have focused more on fish. In its developed form, then, the oil-rendering hypothesis casts pottery as an integral facet of the increasing complexity of Alutiiq society.

Certain factors in the archaeological record support the plausibility of this hypothesis. For instance, Admiraal and colleagues (2020) performed lipid analysis on pots from several Koniag tradition sites. They found that, while pots found at riverine sites show chiefly fish residue (presumably reflecting those settlements' focus on salmon), those found in coastal settings were used for marine mammal processing. They also show that sites containing whale bone that has not been fashioned into tools (and therefore is less likely to have been transported far) cluster in similar areas to where pottery is found (Admiraal, Lucquin, von Tersch, et al. 2020:Figure 7). This supports the idea that whaling was practiced more intensively in the pottery-bearing region of Kodiak than elsewhere.

Certain historic and ethnographic evidence also aligns with the oil-rendering hypothesis. While contemporary coastal Alaskans report that a single seal can yield up to 6 gal of oil (Haynes and Wolfe 1999), an early-contact account suggests that a good whale catch could yield up to 50 barrels (Black 1977). These quantities are consistent with the idea that regular whaling would have produced a surplus of oil, and that large pots (such as those found on Kodiak) would have facilitated processing. Additionally, after European contact, the Alutiit quickly began using metal kettles to heat-render marine mammal blubber into oil (Black 1977; Heizer 1949), so it is plausible that the large pots produced late in the region's pre-contact history may have been used similarly.

All this suggests that the oil-rendering hypothesis is worth investigating further, and one way to do this is to break down the assumptions that underlie it. To begin with, it is important to remember that people were rendering marine mammal oil on Kodiak long before pottery was adopted, and that Alutiiq ancestors residing in non-pottery-bearing areas would have continued producing oil after its adoption. Heat-rendering in pottery may have made sense as a strategy for intensified oil production, but it was not so far superior to the traditional oil-rendering methods as to be worthwhile for everyone.

To rephrase, then, this hypothesis states that pottery was adopted by people who needed to render *more* oil than they had been doing previously, and more than their northern neighbors were doing. This scenario aligns with a concept from technological investment thinking known as Mutually Competitive Technologies (MCTs), which refers to cases wherein either of two technologies may be preferable, depending on how much one uses them (Bettinger 2009). There is an intuitive logic to it—a needle will suffice to mend a small tear, but if you intend to take up quilting, it may be worth investing in a sewing machine. These intuitive choices, however, are based at least in part on more objective factors, namely a) the expense and b) the efficiency of the two technologies in question. In this instance, for the oil-rendering hypothesis to hold water, pottery must be "expensive" enough, in comparison to the competing method, that it is not worth making a pot unless you want to render a surplus of oil. At the same time, heat-rendering in a pot must be efficient enough that, after a certain amount of use, its efficiency makes up for the additional time spent making the pot in the first place.

The Experiment

This study attempts to test the plausibility of the oil-rendering hypothesis by evaluating whether pottery and the leading alternative (I examine the practice of self-rendering using a seal stomach container) qualify as MCTs, using a simple model discussed in the next chapter. To this end, I experimentally derive a range of values estimating the manufacturing time (expense) and return rate (efficiency) for each technology. I do this by reconstructing each technology to the best of my ability, both in its manufacturing and in its use. These experiments were informed by numerous sources, including the existing literature, examination of extant archaeological ceramics, laboratory analysis, and conversation with Alutiiq Elders and other knowledgeable individuals.

Once these experimental values are obtained, I evaluate them against the requirements of the model for MCTs. Where applicable, I then calculate the threshold level of oil-production one would have to reach to make pottery preferable to seal stomach containers. For the results of this study to support the oil-rendering hypothesis, not only must pottery and seal stomachs qualify as mutually competitive oil-rendering technologies, but the threshold value must be plausible—not so high that one would not expect to reach it even in the course of mass-production, but not so low that an average family producing oil only for their own subsistence would reach it as well.

This study does not aim to provide direct evidence for or against the oil-rendering hypothesis in general, or Fitzhugh's formulation in particular. If the results align with the specific expectations generated by applying the concept of MCTs to the oil-rendering hypothesis, they will show that pottery would have been useful for producing surplus amounts of marine mammal oil, but they will not establish whether this production actually occurred, or what those surpluses might have been used for. In addition to trade, possible uses for large amounts of oil include storage and feasting. Conversely, if the results do not align with the model's expectations, it will not rule out the possibility that other factors not included in the model conspired to make pottery desirable as an oil-rendering technology.

The results will, however, provide additional information about the place of pottery in the suite of food processing technologies available to Alutiiq ancestors, and to coastal hunter-gatherers in general. This information will furnish further context against which to evaluate hypotheses about pottery adoption on Kodiak, in the Arctic, and beyond. Experiments like these are important because they keep archaeologists accountable, grounding our ideas in the realities of human experience. It is my hope that this modest contribution will help to do just that.

CHAPTER II. THEORETICAL BACKGROUND

This project is situated at the intersection of several questions about human behavior: Why do humans choose to adopt or ignore a technology, and why do they choose one over another? Why do people, and particularly hunter-gatherers, use pottery? How do social factors influence these decisions? To address these questions, I draw on two main lines of scholarship: ceramic studies, and technological investment thinking.

Pottery Adoption

Ceramic technology holds a special fascination for archaeologists. This is due in part to the durability of ceramic sherds compared to many other crafts, and particularly other container technologies, such as basketry. Another key factor is the plasticity of clay, which makes possible an extraordinarily wide variety of forms and allows the end product to be closely tailored to its intended use (Eerkens and Bettinger 2001). This means that ceramic artifacts have the potential to convey an unusually high amount of specific information about the users' needs, tastes, and even motor habits (Arnold 1988; Sillar and Tite 2000). At the same time, creating a ceramic vessel is a highly complex task, requiring considerable practice, skill, and understanding of one's materials to reliably produce a polished product that is durable enough to survive firing and use. The adoption of ceramic technology is thus no small undertaking.

So, what makes a group decide to make pottery, or not? As with many archaeological questions, the study of this topic has largely consisted of disproving our own assumptions. During the nineteenth century, for instance, it was thought that sedentism constituted a necessary precondition for ceramic adoption (Arnold 1988;

Mason 1966). It was thought that pottery existed mainly to process cereal grains in an agricultural setting. Pottery has also been associated with economies of scale, with scholars suggesting that pottery must be produced in large quantities to be worthwhile (e.g. Brown 1985; Steward 1965).

However, all of these associations have proved to be far from universal. In recent decades, we have learned that some of the earliest pottery ever to be discovered, the Jomon tradition of Japan, was created by hunter-gatherers and frequently used to process animal products, particularly aquatic ones (Craig et al. 2013; Horiuchi et al. 2015; Yoshida et al. 2013). There is even considerable ethnographic evidence of pottery being made, used, and transported by residentially mobile groups in the Arctic (Anderson 2019; Reid 1989:172). Pots are also often made in small quantities, at a household level, rather than being produced for trade (e.g. Eerkens et al. 2002).

While anthropologists have become more cautious about applying absolute constraints to investment in ceramic technology, certain factors have been observed that limit or modify its feasibility and utility. On a basic level, one must have access to clay, as well as fuel for firing. Dean Arnold (1988) has also proposed climate as a key limiting factor—a temperate, dry climate is much more conducive to drying clay properly prior to firing than a cold, damp one. Karen Harry and colleagues (2009) have experimentally confirmed the difficulties involved in drying clay in cold and wet environments, as well offering insights into the impact that such difficulties can have on the manufacturing process and final product. And, while a degree of mobility is clearly not prohibitive of pottery production and use, mobility levels do appear to impact various aspects of investment in ceramic technology, with greater sedentism tending to correspond to increased investment (Iizuka et al. 2022; Simms et al. 1997).

Researchers have yet to reach a consensus on what led to the earliest adoptions of pottery by hunter-gatherers, with hypotheses tending to fall into two categories: a) that pottery offers some key benefit to subsistence, and b) that its role had chiefly to do with feasting and/or ceremonialism (Hayden 2019). The details of the former type of hypothesis, which shares some characteristics with what Rice (2015:10) calls the "culinary hypothesis," vary regionally. Examples of potential benefits include processing seeds in the Great Basin (Eerkens 2001) and the extraction/retention of oils (such as bone grease) in the Arctic (Reid 1989).

The second type of explanation, which Rice (2015:10–11) calls the "aggrandizer-feasting hypothesis," casts ceramic technology as having a chiefly social significance. In this model, pottery is used to assert social status, through its aesthetic appeal and by facilitating conspicuous consumption. Chronologically, the emergence of pottery in Eurasia in the Upper Paleolithic/Mesolithic coincides roughly with the development of increased social complexity and feasting (Hayden 2019). A number of case-studies also show evidence of pottery being first used for special occasions (such as feasts and other ceremonies), and to prepare prestige foods (Boyd et al. 2019; Uchiyama 2019), which in the Arctic often means oil (Hayden 2019). While this model emphasizes the social dimension of pottery use, its applications may lean on functional considerations as well, suggesting that pottery is the most effective technology for preparing some feasting foods, or simply that large pots facilitate cooking for and serving large groups.

While more attention is being given to hunter-gatherer ceramics than in the past, it remains a relatively poorly understood topic (Eerkens et al. 2002; Eerkens and Lipo 2014; Harry and Frink 2009; Simms et al. 1997), and the case of Arctic pottery is particularly perplexing. Ceramic technology appeared in Siberia by around 14,000 BP (some time after the first human settlement of the area) and was widely adopted, despite the difficulties presented by the climate and the mobile lifestyle typical to the region (Hayden 2019; Jordan and Gibbs 2019). Circumpolar potters also face challenges around the seasonality of Arctic life. Winter conditions (frozen clay, precipitation) would have precluded pottery manufacture, relegating the activity to the busy summer months, the season of peak subsistence activity (Harry and Frink 2009; Jordan and Gibbs 2019). It seems that pottery must have been a very valuable technology to merit such time investment during this crucial season. However, it is difficult to parse such behavior without a clear idea of the costs and benefits involved. Technological investment thinking offers a way to grapple with these factors.

Technological Investment Thinking

Technological investment thinking is rooted in the broader theoretical paradigm of Human Behavioral Ecology (HBE). HBE is based on the idea that human behavior often impacts reproductive fitness and can therefore be subject to natural selection, even when not conditioned by genetics (Smith and Winterhalder 1992). This implies that, over time, humans should gravitate toward behaviors that maximize the reproductive fitness of the individuals who practice them, in the context of the environment—physical and social—in which those behaviors developed. These ideas form the basis for a wide range of models that seek to determine which behaviors would have been optimal for past humans, which offers one frame of reference for determining which behaviors they likely engaged in (Cannon and Broughton 2010; Smith and Winterhalder 1992). As reproductive fitness is a complex concept, these models generally examine it through a proxy, most commonly the optimization of subsistence activities (Zeanah and Simms 1999)—to pass on anything, one must be able to feed oneself and one's offspring effectively.

Technological investment thinking uses this concept of optimization to understand people's choices about which tools and processes to employ to achieve their goals. Sometimes the choices in question are as broad as whether to invest in a "formal" tool, such as a biface, or to make do with "expedient" tools, such as modified flakes and scrapers (Bright et al. 2002). Technological investment models can also be used to examine more fine-grained issues, however, such as the decision to invest in an improved version of an existing technology, or the decision to replace one technology with another that accomplishes the same task (e.g. Bettinger et al. 2006; Ugan et al. 2003). Conversely, they can also be used to make arguments about when a given technology is *not* worth employing (e.g. Byers et al. 2014). This last point is especially important to keep in mind when studying hunter-gatherer societies, as it pushes against the common assumption that if a group does not use a given technology, they must not have the knowledge to do so.

Technological investment work shares HBE's focus on subsistence, largely examining technologies used to procure and/or process food resources. Such technologies are considered the most directly linked to fitness, and they also have the most easily quantifiable returns. As is typical of HBE, the models involve making predictions about a decision variable (in this case, whether to use a given technology) by looking at the relationship between a currency (generally either time or energy expended) and a goal (often measured in caloric return, or in the quantity of the relevant resource processed). In the case of technological investment, however, there is another key factor, namely the significance of the task that the technology performs to the users' daily lives. This may be shaped by a number of factors (Bright et al. 2002), but the most basic way to look at it is simply by measuring the amount of time devoted to that task. These three factors together form the basis for the model that I use in this thesis.

The Model

To assess the plausibility of the oil-rendering hypothesis as an explanation for the distribution of Koniag pottery, I have chosen a simple technological investment model (see Bettinger 2009:Chapter 4). In its most basic form, this model defines the value of a technology in terms of two variables: manufacturing time, the time expended to create the tool, or the expense, given as m; and rate of return, the amount of the relevant resource processed per time, or the efficiency, given as r:

$$r / m$$

Note that both variables are properties inherent to the technology in question. In this basic formulation, any given technology can be compared visually to another by plotting a point for each on a graph, with m on the x-axis and r on the y-axis, and drawing lines from the origin to each point (Figure 3). Whichever line falls above the other (that is, whichever has the greater slope, or the greater ratio of r / m) is thus considered the superior technology.

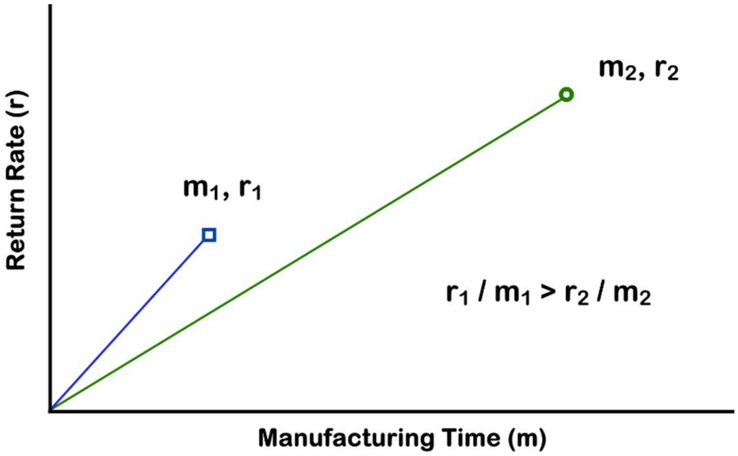

Figure 3. Comparison of two technologies based on the ratio of their return rates (r) to their manufacturing times (m). Technology 1 has a greater ratio and therefore a greater slope, making it preferable.

However, this formulation does not adequately describe all possible scenarios. In some cases, two technologies may be mutually competitive, meaning that neither is inherently superior to the other. Instead, the choice between them depends on a third variable, concerning the behavioral context of the technologies: the amount of time the user spends processing the relevant resource (given as s). This variable is introduced into the equation as follows:

$$r / (m + s)$$

This is conventionally visualized by plotting the technology based on its r- and m-values, as in Figure 3, and then by plotting an x-intercept at “negative s,” or at “s” distance to the left of the y-axis. In this way, the overall slope (and thus utility) of a technology changes as the s-value is adjusted. To compare two technologies in this way, one plots them both according to their r- and m-values and draws lines from the selected s-value to the points corresponding to each technology (the blue and green lines in Figure 4), once again looking for the line with the higher slope. If one draws a line connecting the points for the two technologies (the red line in Figure 4), and that line intersects the x-axis to the left of the y-axis, then they qualify as MCTs. The point at which this line intersects the x-axis constitutes the threshold s-value at which the two technologies are equally useful (or, for which their slopes are equal).

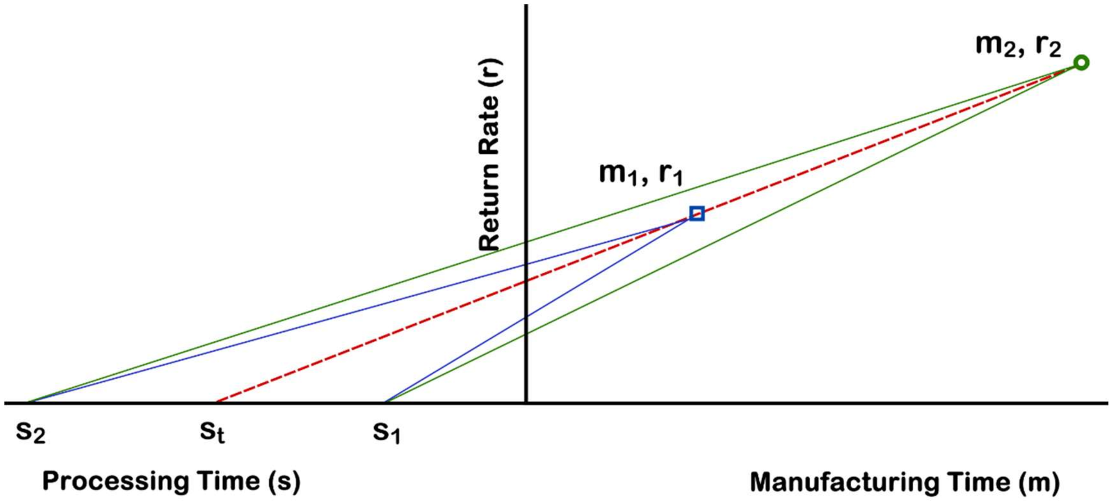

Figure 4. Illustration of MCTs evaluated at different values of s. At s_2, technology 2 has the greater slope, whereas at s_1, technology 1 has the greater slope. At s_t, the threshold value of s, the two technologies are of equal slope, and thus of equal utility.

Mathematically speaking, for this case to apply, three conditions must be met. First, one technology (technology 2) must have a higher manufacturing time than the other (technology 1):

$$m_2 > m_1$$

Second, for the high-cost technology 2 to be competitive, it must also offer a higher rate of return than technology 1:

$$\text{if } m_2 > m_1, \text{ then } r_2 > r_1$$

Third, for the less efficient technology 1 to be competitive, it must show at least as high a ratio of return rate to manufacturing time as technology 2:

$$\text{if } r_1 < r_2 \text{, then } r_1 / m_1 \geq r_2 / m_2$$

In graphical terms, technology 1's slope drawn from the origin must be at least as high as that of the more expensive technology 2. If this is not the case, then the line drawn between the points corresponding to the two technologies will fall to the right of the y-axis (Figure 5), resulting in an invalid s-value. In this scenario, technology 2 is always preferable to technology 1.

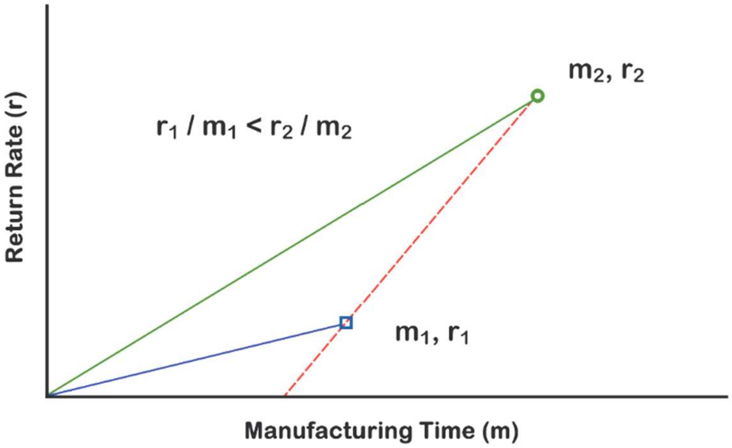

Figure 5. Illustration of two technologies that meet the first two requirements for MCTs, but not the third.

When all three conditions are met, however, there is a threshold value of s that marks the turning point at which it becomes more efficient to set aside one of these technologies in favor of the other. For s-values below the threshold, the lower-cost option is preferable, whereas for those above it, it becomes worthwhile to invest in the higher-cost technology. This value is calculated mathematically by setting the utility expressions for each technology equal to each other, then solving for s:

$$r_1 / (m_1 + s) = r_2 / (m_2 + s)$$

$$s = (r_1 m_2 - r_2 m_1) / (r_1 - r_2)$$

As previously discussed, the principles of this model are implied in the structure of the oil-rendering hypothesis. The higher abundance of whale and seal in the south of the archipelago is used to infer that the people there spent more time rendering oil—or, in other words, that the s-value for this activity was higher in that area. The argument implies that said s-value was high enough to cross the necessary threshold to justify investment in pottery (referred to below as “p”), which is assumed to be a higher-cost, higher reward technology than the alternative methods (e.g. self-rendering, referred to below as “alt”). By testing the oil-rendering hypothesis against this model, therefore, I will be evaluating it based on its own implied logical and theoretical framework.

For the results to support the oil-rendering hypothesis, a) it must take longer to make a pot than the alternative equipment ($m_p > m_{alt}$); b) a pot must be able to process more blubber/time than the alternative method ($r_p > r_{alt}$); c) the ratio of return rate to manufacturing time for the alternative must be at least as high as for pottery ($r_{alt} / m_{alt} \geq r_p / m_p$); and d) the level of oil production (s) at which pottery becomes preferable must be a plausible quantity for pottery-using communities, but higher than expected for others.

If a) or c) is not fulfilled, pottery is clearly superior by this metric, leaving the question of why it was not adopted throughout the archipelago. If b) is not fulfilled, it indicates that pottery is clearly inferior for this task, raising the question of why it was adopted at all. Last, if a) through c) are fulfilled, but not d), it indicates that, while pottery and the alternative technology qualify as MCTs, this concept does not explain the phenomenon of pottery adoption on Kodiak. In this last scenario, an implausibly low s-value would indicate that everyone would have been rendering enough oil to make pottery worthwhile, whereas an implausibly high value would mean that nobody was.

Caveats: Active vs. Passive Time. Typically, technological investment models deal only with “active time,” the time spent actively engaged in performing a task, which therefore cannot be spent on other activities (Bright et al. 2002; Ugan et al. 2003). However, some of the main differences between pottery and stomach containers have to do with “passive time,” time spent waiting for various natural processes to take their course, during which the maker/user may attend to other tasks. This distinction impacts the manufacture of both technologies (both must be left to dry for substantial periods), but it is particularly important when it comes to the rendering process. Self-rendering in a stomach container requires some active time to set up, but the rendering itself takes place during passive time, whereas heat-rendering requires more active attention throughout the process. For this reason, I generate estimates for both the active time and the “gross” (total, including both active and passive) time involved in the manufacture and use of both technologies.

Caveats: Interpreting s. There is yet another wrinkle to consider: to what period do the s-values apply? In other words, by what point does the user need to reach the threshold level of processing time for it to become worthwhile to invest in pottery? If one considers the lifetime of the individual, nearly any threshold might be met eventually. On the other hand, if one uses the amount of time spent processing blubber in one sitting, thresholds above a certain level may never be met regardless of what technology is used. The two most logical candidates in this case are one year/harvesting season, or the lifetime of the container.

There are difficulties with either metric. Since marine mammal hunting and processing are somewhat seasonal activities, the year/harvesting season seems intuitively to be the most meaningful unit for decision making. Realistically, however, the oil rendered in a given stomach container would likely have been fermented and stored in the same container, to be dispensed as needed. The same may have held true for pots as well, though it is by no means certain. In this circumstance, the number of times the container in question can be used in a year depends on its storage capacity and on how quickly the oil inside is consumed, which does not necessarily reflect the overall level of oil production—a household would presumably have multiple stomach containers in use simultaneously.

Considering the amount of use over the lifetime of the vessel appears at first to be a reasonable solution. This metric is best suited to technologies that may be manufactured on the spot, used as many times as they are wanted, and then discarded. In other words, it works when the amount of use a tool receives in its lifetime is limited *by the user's behavior,* rather than by the characteristics of the tool itself. These technologies, however, would both have been used repeatedly from year to year, until they lost functionality. Marine mammal oil is a crucial, persistent subsistence need—and, as will become clear in later chapters, a given seal carries far more blubber than will fit in its stomach, so it makes sense to save stomachs from previous seasons when possible. In this situation, the s-value would be met or not based on the technology's durability rather than the users' behavior, which is counter to the purpose of the model.

One way of coping with the issue of using multiple containers simultaneously would be to adjust the manufacturing time, processing time, and yield of each technology according to the number of containers that might have been used in a given year. This approach introduces another level of assumptions about past human behavior, however, when changes in this behavior are exactly what the study attempts to understand and predict. Additionally, it is not immediately clear whether one should include the time spent manufacturing containers in previous seasons that are being re-used in the current season.

The issue is essentially one of capacity limitations, a peculiar characteristic of container technologies that this model does not fully address. As such, while acknowledging these conceptual difficulties, I focus my discussion on interpreting the threshold values in terms of yearly consumption. While this metric may not fully reflect the ways in which these technologies would have been used, it remains the most meaningful reading in terms of human behavior. It also aligns best with the example given in the introduction to Bettinger's (2009) exposition of the model, that of a hapless fisherman who must quickly make a new harpoon head in order to lay in a store of fish for the winter. The practical impacts of capacity issues will be discussed in the concluding chapter, separately from the results of the model.

CHAPTER III. THE KODIAK ARCHIPELAGO

Humans have lived in the Kodiak archipelago for at least ~7500 years. Archaeologists divide the region's precontact habitation into three main cultural periods, or traditions (Table 1). The Ocean Bay tradition was characterized by a small population of seasonally mobile hunter-gatherers who relied largely on marine mammals (Saltonstall et al. 2021). This period was followed by the Kachemak and Koniag traditions, both of which were characterized by increases in population levels, sedentism, economic intensification, and social inequality. It is during the Koniag tradition that pottery appears, marking the beginning of what is sometimes called the "Developed Koniag" (AD 1500 – 1763) (Admiraal, Lucquin, von Tersch, et al. 2020; Clark 1998; Saltonstall et al. 2021).

Date Range	**Cultural Tradition**	**Alutiiq Name**
5500 BC – 2000 BC	Ocean Bay	*Cuumillat Pisurtat* (Early Ancestral Hunters)
2000 BC – AD 1300	Kachemak	*Cummillat Iqallugsusqat* (Early Ancestral Fishermen)
AD 1300 – AD 1763	Koniag	*Tuyunkut, Metqit-llu* (Chiefs and Slaves)

Table 1. Pre-contact cultural periods in the Kodiak Archipelago. Adapted from Saltonstall et al. 2021.

The oil-rendering hypothesis draws on elements in both the physical and social environment to explain pottery adoption in the Kodiak Archipelago. The spatial distribution of pottery adoption is attributed to differences in the physical environment of the northern and southern regions, whereas the timing is put down to the changing social environment of the Koniag tradition. I therefore begin by discussing each of these topics in turn, followed by a more in-depth look at what we know about traditional oil rendering on Kodiak, and finally an overview of the Koniag ceramic tradition and how it compares to pottery from elsewhere in Alaska.

Physical Environment

The Kodiak Archipelago has a very intricate coastline, rising quickly to mountainous island interiors, and it is extremely rich in both marine and littoral resources (Hood and Zimmerman 1987). Alutiiq ancestors employed a largely coastal settlement pattern, with some riverine settlements designed to exploit salmon (Knecht 1995; Steffian et al. 2015). Kodiak is located in the "Subarctic" region and thus experiences a milder range of temperatures than most of Alaska. The weather year-round is characterized by high winds and frequent precipitation, the latter occurring especially on the eastern side of the mountain range that bisects Kodiak Island (Hood and Zimmerman 1987). Travel around the archipelago and to the mainland is straightforward by kayak, but frequent winter storms tend to limit such activity (as well as any sea-based hunting) to the summer.

Subsistence. Prehistoric inhabitants did utilize some terrestrial resources—such as bear, birds, fur-bearers, berries, greens, and the starchy Kamchatka Lily root—but their subsistence was based predominantly around the archipelago's abundant marine and riverine resources (Knecht 1995). They probably hunted a range of marine mammal species: humpback, fin, sei, minke, and gray whales (perhaps focusing on humpback and fin); Pacific white-sided dolphins, Dall's porpoise, and Harbor porpoise; harbor and northern fur seals; and steller sea lions (Crowell 1994; Fitzhugh 1996; Knecht 1995). The migratory routes of grey whales, humpback whales, and fur seals in particular follow the

Alaska Current along the east coast of the Archipelago (Knecht 1995). Fish include several varieties of salmon, as well as halibut, Pacific cod, rock fishes, and herring.

Since whaling is so integral to the oil-rendering hypothesis, it is worth taking a moment to discuss Kodiak's distinctive whaling tradition. Rather than relying on large numbers of hunters to kill and retrieve the animals, as is common elsewhere in the region, Alutiiq whaling is based around the use of poisons by individual hunters to incapacitate the quarry. Whalers would coat their detachable harpoon heads with a concoction of grease (sometimes derived from the corpses of other skilled whalers) and natural toxins, and when on the hunt they would aim for a whale's flipper or tailfin (Crowell 1994; Heizer 1943; Holmberg 1985). The harpoon head remaining embedded in the whale's flesh, the poison would then paralyze this appendage, leading to the creature's death.

Retrieval rates were somewhat low, as they relied on a whale's carcass washing up on shore. At this point the meat and blubber would be divided between the village where it washed up and the whaler, whose identity was signaled by signature markings on the harpoon head (Crowell 1994; Heizer 1943; Holmberg 1985). Whalers formed a specialist class unto themselves and were respected and feared for their craft. Whaling knowledge was passed down from father to son, and whaling was the subject of a range of ritual practices (Crowell 1994; Desson 1995; Holmberg 1985).

Other Resources: A Note on Clay Distribution. Upon viewing the clustering of pottery-bearing sites in the south of Kodiak, one of the first questions that comes to mind is whether those living in non-pottery-bearing areas had access to clay. In fact, clay is common throughout the archipelago, deposited through extensive glacial activity. The archaeological record confirms that clay was available to northern Alutiiq ancestors:

starting during the Kachemak tradition, clay-lined pits appear in and around Alutiiq residences throughout the archipelago (Saltonstall 1996, 1997; Steffian 1992). These were likely used for storage and for cooking (perhaps using heated stones). Some of the first of these pits to be studied are on Afognak (the second largest island in the archipelago, directly north and east of Kodiak, Figures 1 and 2), where no pottery has yet been found. In some cases, clay-lined hearths have also been found (Saltonstall et al. 2021). These features make it clear that, not only did Alutiiq ancestors throughout the archipelago have access to clay, they were already accustomed to gathering, transporting, and manipulating it before any of them began to make pottery.

Even a village without easy access to clay could still have used pottery. Ethnographic accounts and sourcing analyses from mainland Alaska indicate that, while a variety of clay sources were available, potters were often willing to go out of their way to obtain higher quality clay from distant sources (Anderson 2019). It thus would not have been surprising for clay-poor villages to find a way to obtain clay, if they wanted to make pots. Alternatively, they could have obtained pots through trade—in fact, as no sourcing analysis has yet been done on Kodiak, it remains possible that some of the pottery that has already been found may have been furnished through trade. This makes the absence of pottery in the northern area of Kodiak all the more telling.

Other Resources: The Role of Firewood. Pottery manufacture also requires fuel for firing. Native lumber is not abundant on Kodiak: spruce did not colonize the islands until after AD 1000, during the transitional Kachemak, and spruce forests are largely limited to the northern third of the islands (Knecht 1995). Most Alutiiq ancestors relied on driftwood for building, perhaps supplemented by small quantities of local cottonwood.

The presence of spruce roots and spruce root baskets at some southerly locations (Steffian et al. 2015) suggests that these materials were sometimes traded between different parts of the archipelago, but it is difficult to judge the extent of this trade, given that such organic materials are not normally preserved.

However, Kodiak's archaeological record does not suggest a scarcity of lumber. Wood is used extensively in constructing residences, as well as in a variety of wooden artifacts, from tools to figurines, with particularly heavy use occurring during the Kachemak and Koniag traditions (Shaw 2008; Steffian et al. 2015). This extensive use of driftwood in building would have been made possible partly by the use of brush, which is much more common, for fuel and smaller manufacturing projects (Shaw 2008). The wood supply therefore seems to have been sufficient to fill and even exceed the needs of these communities. Fuel conservation likely still played a role in ancestral Alutiiq technological decisions, but it does not appear to have been a major limiting factor.

Social Environment

Kodiak's archaeological record changes so dramatically between the Ocean Bay and Koniag traditions that, at one time, scholars thought it represented a sudden migration and population replacement event (Clark 1998). However, as more Kachemak tradition settlements have been studied, the threads of cultural continuity have made themselves clear, leading to the current consensus of in situ development (Steffian et al. 2016, 2015). The archaeologist's challenge is now to comprehend the changes in ancestral Alutiiq culture as it developed from the small, mobile hunting bands of the Ocean Bay tradition to the densely populated, year-round villages of the Koniag tradition.

The social trends that culminate in the bustling Koniag period have their roots in the Kachemak tradition. This period is characterized by increasing sedentism, evidenced by the profusion of more permanent, single-family houses (Saltonstall et al. 2021; Steffian et al. 2015, 2016). Comparisons between the tool sets found at coastal vs. riverine sites, as well as other analyses of settlement strategy, suggest logistic mobility in the form of seasonal "fish camps" during salmon runs (Fitzhugh 2003; Steffian et al. 2015), a fixture of Kodiak life that still exists today. In the Transitional Kachemak, beginning around AD 1000, multi-room houses begin to appear. This period also shows increased evidence of trade with the mainland in the form of exotic materials, such as ivory, coal, antler, and obsidian.

Importantly, the Kachemak tradition also saw an intensification of fishing activities, as well as a marked increase in food storage features (Saltonstall et al. 2021; Steffian et al. 2006, 2015). These trends indicate the beginnings of surplus resource production for storage, used to insulate a household from the uncertainties of seasonal resource availability. It is not believed that true "over-production," resulting in surpluses large enough to be conducive to trade, occurred until the end of the Kachemak/beginning of the Koniag tradition (Fitzhugh 2003; Knecht 1995; Steffian et al. 2006), but these initial, subsistence-level surpluses surely paved the way for such later activities. Interestingly, this pattern of surplus production appears in the Early Kachemak tradition, predating some of the trends mentioned in the previous paragraph.

The Koniag tradition, which coincides with the onset of the Little Ice Age, is characterized by increasing social stratification (Admiraal, Lucquin, von Tersch, et al. 2020; Knecht 1995; Saltonstall et al. 2021; Steffian et al. 2015). Indicators of social status (such as labrets and other bodily adornments) proliferate, as do works of art (such as figurines and incised pebbles), many of which likely carry spiritual significance. The theme of residential complexity is further elaborated in this period (Figure 6), as homes designed to house extended families, as well as distinct neighborhoods, begin to emerge (Knecht and Jordan 1985; Steffian et al. 2016, 2015). These settlements formed true villages, which historical accounts indicate operated as self-contained political entities, each under its own chief. By the time of contact, slavery was also strongly in evidence, with slaves generally being acquired as prisoners during raids (Davydov 1977). Access to slave labor would have freed their owners up to participate in "trading and raiding" during the summer months (Fitzhugh 1996; Knecht 1995).

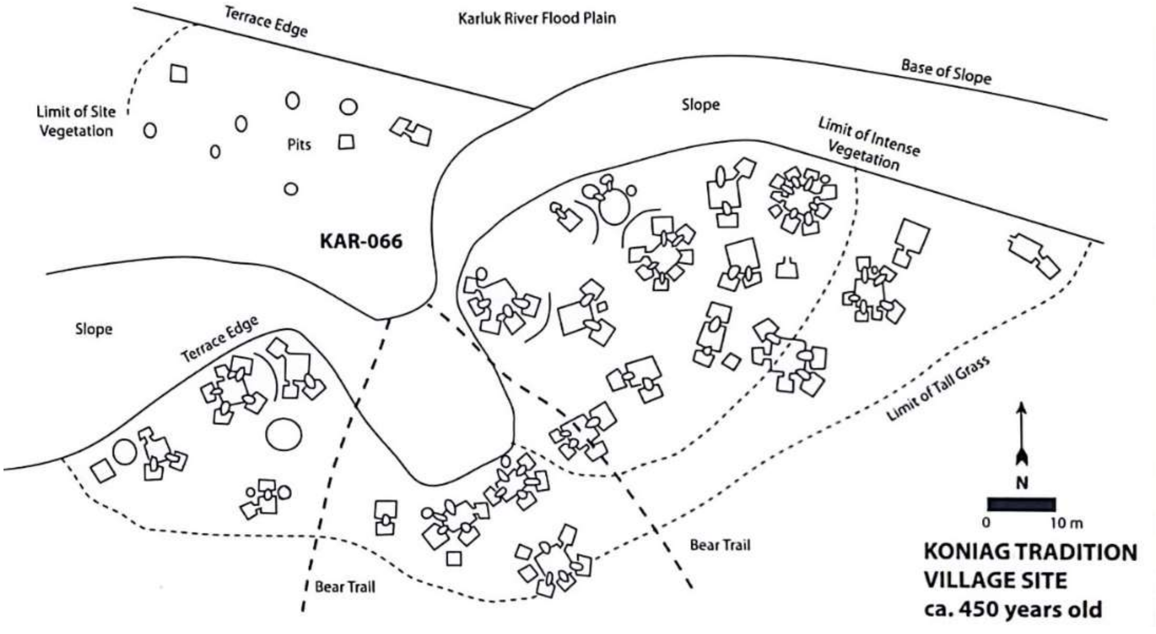

Figure 6. Map showing the layout of a Koniag tradition village on the Karluk River. Illustrated by Amy Steffian (Steffian et al. 2015:Figure 2.16).[2]

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This period also saw further intensification of marine resource exploitation and storage, likely spearheaded by the emerging leaders, one of whose functions was to organize labor within their villages (Steffian et al. 2016, 2015). This intensification may well have reached the point of true over-production (Fitzhugh 2003), as would be expected if people were intentionally producing surpluses to use in trade. One ethnographic account indicates that Alutiiq ancestors traded whale meat for furs to the Tanaina residents of Cook Inlet, who ostensibly did not know how to hunt whales themselves (Heizer 1943:436). If this account is accurate, it seems logical enough that they might have traded whale oil as well.

Such surpluses could also have played a role in facilitating winter feasts, the hosting of which constituted another chiefly function—and indeed, evidence of feasting and general ceremonialism increases dramatically during the Koniag tradition (Knecht 1995; Steffian et al. 2015). The appearance of pottery around the same time accords well with the feasting hypothesis of hunter-gatherer pottery adoption. However, the feasting hypothesis in and of itself does not address the spatial aspect of Kodiak's ceramic record, since presumably northern villages engaged in this activity as well.

Oil Rendering on Kodiak

Oil rendering would have been a crucial activity in the precontact Kodiak Archipelago. As is typical of coastal Alaska, fat was a crucial source of calories for Alutiiq ancestors (Knecht 1995). This fat could be obtained from marine mammal blubber, largely seal and whale (Haynes and Wolfe 1999). Blubber was integrated into the Kodiak diet in many ways, including using it to preserve other foods, mixing it with berries, and using it as a dipping sauce for dried seal or fish meat (Black 1977; Davydov 1977; Haynes and Wolfe

1999). Many of these dietary uses require rendering the fat into oil, which was also burned in lamps and used to waterproof skins for boats.

There is ethnographic, historic, and archaeological evidence of several methods of oil-rendering that have been employed across Alaska. Most of these involve self-rendering (blubber left to sit will eventually render on its own) in some kind of container, followed by preservation through fermentation. Examples of container technologies used for self-rendering include sealskin pokes, seal stomach containers, and bentwood boxes (Black 1977; Frink and Giordano 2015; Haynes and Wolfe 1999). Other possible methods include chewing fat to extract the oil and spitting the result into a container (Davydov 1977), rendering through indirect heating in a clay-lined pit or bentwood box, or impaling pieces of fat on sticks near a hearth and channeling the resulting oil into an adjacent clay-lined pit in the floor (Saltonstall et al. 2021).

Figure 7. A seal stomach container, made by Alutiiq artisan Coral Chernoff, containing bear grease. The stopper, which seals the neck of the container, has a plughole from which to pour the contents.

I was privileged to discuss this topic with a group of Alutiiq Elders in January of 2023, facilitated by the Alutiiq Museum and Archaeological Repository (AMAR). The predominant traditional oil-rendering method they knew of was self-rendering in a container made from a seal stomach. I discussed the manufacture and use of these containers with the Elders and with Alutiiq artisan Coral Chernoff, who has experimented with the craft herself. The stomach is first cleaned, which includes washing it in seawater, and inflated for drying, the ends being tied off using sinew-thread. While it is drying, the muscular tissue adhering to the outside is scraped off. Once it has dried, strips of blubber are cut partway through (to help them render more quickly) and inserted through the esophageal opening. The container is made airtight by means of a wooden stopper (see Figure 7), and the blubber is left to self-render and ferment.

Pottery Adoption on Kodiak

Before addressing the particulars of pottery on Kodiak, I will go over the broader context of Alaskan pottery. As discussed in the previous chapter, Alaska's cold climate makes the popularity of ceramics in Alaska somewhat mysterious. However, whatever compelling advantage induced mainland Alaskans to make pots, the delay of pottery adoption on Kodiak indicates that Alutiiq ancestors did not find it quite so compelling. This further suggests that pots may have been used differently on Kodiak than in the rest of Alaska. Any contrast between Kodiak and mainland pottery is thus especially intriguing.

Alaskan Ceramic Traditions. Ceramic technology first appeared in Alaska in the Bering Strait region, approximately 2500 – 3500 BP (Anderson 2019), and was used variously in different times and places to make oil lamps, pots, or both (de Laguna 1940). Scholars unanimously recognize a shift in pottery traditions throughout Alaska, occurring around AD 1000/~1000 BP (Anderson 2019). The two pottery types are sometimes referred to as Paleoeskimo and Neoeskimo (Anderson 2019), but the earlier type is more often referred to as Norton tradition pottery (Figure 8), as it is solidly associated with the Norton cultural tradition (Dumond 2000; Griffin 1953; Oswalt 1955). The emergence of the later style (Figure 9) appears to be tied to the growing influence of the Thule tradition, so it is often called Thule tradition pottery (Admiraal, Lucquin, von Tersch, et al. 2020).

Frederica de Laguna (1940:64) describes all Alaskan pottery as having several shared characteristics:

> It is tempered with sand, gravel, or broken rock-fragments. Often organic matter, such as grass, animal hair, or small feathers, is added, or may be used without rock-temper. The mass of clay is modelled with the fingers and beaten into shape with a bone or wooden paddle. A small vessel can thus be made out of a single lump; a large pot requires patching. Sometimes blood or grease is mixed with the clay or smeared on the finished pot, though we do not know whether this was done also in prehistoric times. Methods of firing differ from place to place, perhaps depending on the amount of available fuel. The ware usually has a laminated structure, and tends to split off in flakes parallel to the surface. The colour varies from tan or gray, through reddish brown, to black.

Don Dumond (1969:20) also notes that, due to the inconsistent results achieved in firing across the board, color and hardness are universally variable throughout Alaskan ceramics, often even within a given vessel. Broadly speaking, however, Norton pottery is associated with relatively thin walls, the use of organic temper materials, laminar breaks, a range of vessel forms, and frequent use of stamped and other decoration (Admiraal, Lucquin, von Tersch, et al. 2020; Anderson 2019; Dumond 1969; Oswalt 1955).

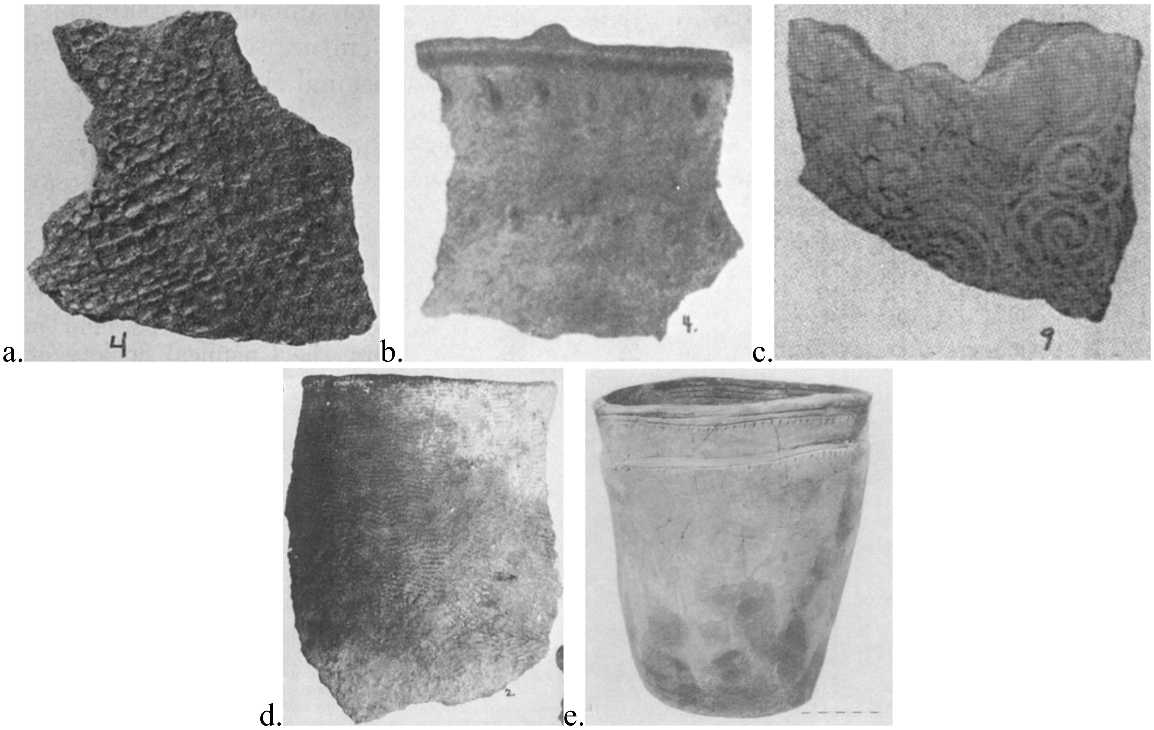

Figure 8. Samples of Norton pottery. a) Check-stamped, Norton Sound (Collins 1928:Figure 4.4)[3]; b) line-dot decorated, Hooper Bay (Oswalt 1952:Figure 9.4)[4]; c) curvilinear paddled (Oswalt 1955:Figure 16.9)[4]; d) short striations, Hooper Bay (Oswalt 1952:Figure 8.2)[4]; e) situla shaped, incised decoration, New Grayling (de Laguna 1939:Plate 19, Figure 2b) [4].

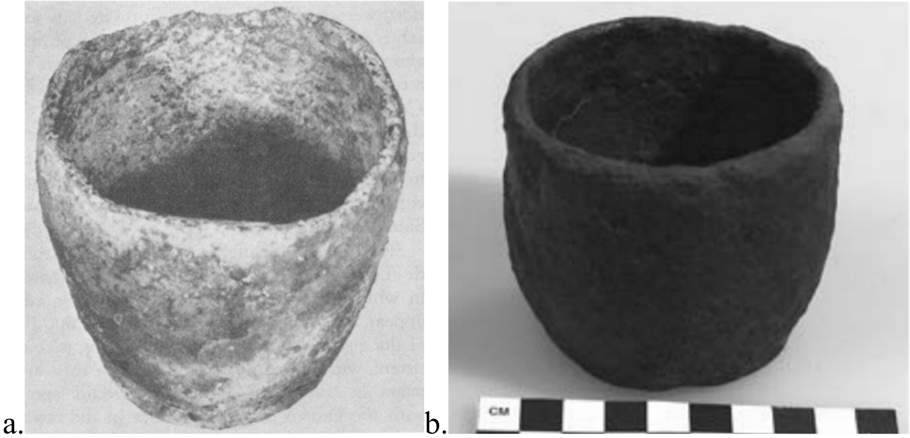

Figure 9. Two Thule tradition pots. These are from a) Nelson Island (Oswalt 1952:Figure 12)[4] and b) the Kuksokwim River region (Harry et al. 2009:Figure 1)[5]. Pot a is approximately 12.5 cm tall and 12.5 cm wide at the mouth.

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In the Thule tradition, on the other hand, vessel walls get noticeably thicker; temper is more consistently composed of coarse sand or gravel; breaks tend to be crumbly, rather than laminar; vessel forms are more consistently cylindrical; and, while a variety of decoration strategies have been observed, undecorated sherds become more common (Admiraal, Lucquin, von Tersch, et al. 2020; Anderson 2019; Dumond 1969). Interestingly, vessel walls gradually increase in thickness during the later Norton tradition, making the transition to the later wares less abrupt than might be supposed (Anderson 2019; Dumond 1969). This suggests that the thickening vessel walls served a practical purpose, rather than representing some kind of "degeneration" of the craft.

The pottery nearest to Kodiak is found in the Alaska Peninsula/southern Bristol Bay region. The earliest pottery in this area is of the Norton Check-Stamped type (Dumond 1969; Oswalt 1955), appearing on the Bering Sea coast of the peninsula by about 200 BC and on the Pacific coast/along the Shelikof Strait closer to AD 300 (Dumond 1969). This type exhibits wall thicknesses of 4 – 7 mm and evidence for the use of a paddle with the hand as an anvil (Griffin 1953; Oswalt 1955). The northern Alaska Peninsula transitioned to the later class of wares around AD 1000, with the southern portion following around AD 1200 (Dumond 1969). This shift was characterized by an increase in wall thickness (consistently >1 cm) and in the use of gravel and pebble temper (Dumond 1969).

Alaskan pottery seems mainly to have been used for cooking animal products, especially aquatic resources (Admiraal, Lucquin, Drieu, et al. 2020; Anderson et al. 2017). Liam Frink and Karen Harry draw on ethnographic evidence of culinary preferences, as well as the higher nutritional value of uncooked marine meats, to argue that pots facilitated a very specific culinary practice: partially cooking meat by dipping it quickly in boiling water (Frink and Harry 2008; Harry and Frink 2009; Harry et al. 2009). Some pots also exhibit handles, or holes drilled in the vessel walls, by means of which they could be suspended over a fire or an oil lamp for cooking (de Laguna 1940).

Shelby Anderson (2019), pointing out the wide mouths, thick walls, and flat bases characteristic of the later wares, suggests that the shift from Norton to Thule pottery may have been motivated by a growing preference for indirect heating (such as through heated stones) over direct heating. Experimentation has shown that indirect heating is the most effective way to maintain simmering temperatures over long periods of time (as would be needed to render oil), but it also suggests that Norton pottery would have performed this function just as well as later vessels (Butler 2022; Gjesfjeld 2019). On the other hand, low-fired pottery, such as is characteristic of the Thule tradition, may function best when placed next to a fire rather than in it (Reid 1989), so perhaps people were simply no longer taking the trouble to make pots well suited to direct heating.

Characteristics of Koniag Ceramics. There is limited research on the physical characteristics of traditional Alutiiq pottery, but the existing scholarship has yielded a few key insights. Pottery on Kodiak is made from grey glacial clay, often found in areas formerly occupied by glacial lakes (Saltonstall et al. 2021), and it exhibits a very coarse gravel temper, with no evidence of organic temper (Heizer 1949). Wall thicknesses hover around 1 cm (Clark 1968:447–448), and the only potentially decorative feature is the variety of rim styles. Interestingly, these rim styles appear to grow more complex and varied over the course of the ceramic period on Kodiak (Clark 1968).

Figure 10. Somewhat intact examples of Koniag tradition pots. a) Rolling Bay, 33 cm tall (Clark 1966:Figure 7)[6]; b) unknown provenience 31 cm high, 21.5 cm rim diameter, 25.5 cm shoulder diameter, 9 cm base diameter, upper wall height 12 cm (de Laguna 1939:Plate 19)[4]; c) Old Harbor (Miller 2023:Figure 4.5)[7]; d) Karluk 1, 25 cm diameter (Steffian et al. 2015:Figure 6.68).[2] All but b) are housed at AMAR.

With the possible exception of a higher firing temperature, which Robert Heizer (1949) speculated to be around 750˚C, what most distinguishes the pottery of Kodiak

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[7] Photographed by Ian Provencal during the excavation of the Ing'yuk Village Site (KOD-114); excavation conducted by the Old Harbor Archaeological History Project. Reproduced with permission.

from the mainland Thule tradition is the vessel forms. The pots are unusually large, measuring as much as a foot across at the mouth, and are able to hold multiple gallons of liquid (Saltonstall et al. 2021). They exhibit a distinctive “biconical” shape (Clark 1968; de Laguna 1939) not seen elsewhere in Alaskan ceramics (Dumond 1969:Figure 3), with lower walls flaring out from a small, flat base to a broader shoulder, and then either proceeding straight up (Figure 10a) or angling in toward the rim (Figure 10b). There is no clear evidence of any other vessel forms, with the possible exception of a fragmentary, “globular” vessel (Figure 10d) found at Karluk 1 (Steffian et al. 2015).

A few clues about the manufacture of these vessels can be discerned from the archaeological record. In line with de Laguna’s (1940:64) general remarks about Alaskan pottery construction, these pots show no evidence of coiling (though no radiographic studies have been done). They do however show evidence of being shaped using the paddle-and-anvil technique (Heizer 1949). The degree of surface smoothing varies, but some attempt has generally been made (Clark 1968; Heizer 1949). I am unaware of any direct evidence of firing techniques used on Kodiak. No potential kilns—technically defined as an apparatus that separates the fuel from the vessels to be fired (Rye 1981)—have been found, which suggests the use of open-firing techniques. This is consistent with the overall infrequency of kiln use in the precontact Americas (Rice 2015:24).

It is difficult to draw conclusions about pottery tools, given that many of these would likely have been made of wood or other organic materials which are not well preserved at most sites in the area. One particular site, Karluk 1 (located in the southwest region of Kodiak Island, see Figure 1), exhibits extraordinary preservation of organic materials and furnishes much of our understanding of the perishable material culture of

Kodiak (Steffian et al. 2015). Apart from the vessel pictured in Figure 10d, no pottery has been found there, but the assemblage is still informative—the variety of wooden artifacts present suggests that a basic set of clay-shaping tools could be easily derived from existing items. The collection also contains many tools that have been repaired and/or repurposed (Steffian et al. 2015), so the need to modify existing equipment slightly would not have been a great obstacle.

The main clues to these pots' usage lie in their form and in the residue that coats them. First, the wide mouths seem designed to allow easy access to the contents, suggesting that their main use was some kind of cooking—storage and transportation vessels are more likely to be made with constricted necks. This could also make them conducive to indirect heating (Anderson 2019). There is evidence that Alutiiq ancestors used a variety of containers, such as bentwood boxes, for indirect heating using heated stones (Steffian et al. 2015). This indicates that indirect heating, while a familiar technique, did not require the use of pottery.

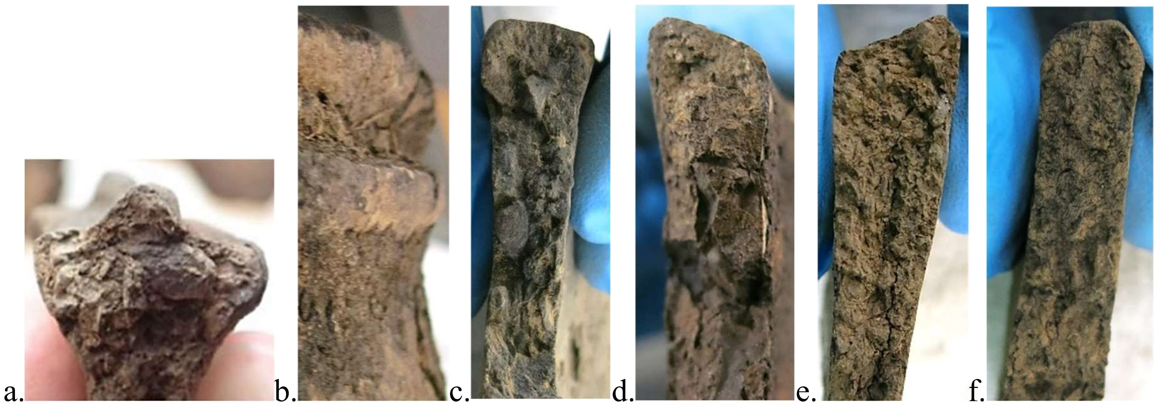

Figure 11. Selected Koniag rim shapes. a) AM711.615, Kumluk Site, Old Harbor (Saltonstall et al. 2021)[8]; b) and c) AM106, Rolling Bay; d) AM596.872, Younger Kiavak; e) and f) AM503.249, Red River.

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[8] Reproduced with permission from AMAR; all subsequent photographs of pottery from Kodiak were taken by the author.

A variety of rim styles have also been observed (Clark 1968; Saltonstall et al. 2021), including one “ridged” type (Figure 11a) which could have accommodated a lid if the pot was used for storage. No ceramic pot lids have been recovered, but pot coverings could easily have been made from wood or some other perishable material. Another rim style, which Heizer (1949) called “double-beveled” (Figure 11b), effectively creates a groove around the outer edge, potentially allowing for a skin covering to be stretched across the opening of the pot and secured with sinew-thread or twine.

The second clue is that the ceramics recovered from Kodiak tend to exhibit thick coatings of animal fat (Heizer 1949). Such coatings are consistent with repeated use in processing animal products, an interpretation that is supported by Admiraal and colleagues’ (2020) findings of marine mammal and fish signatures in the residue. It is important to note that Alaskan vessel interiors are ethnographically known to be coated with animal fat as part of the manufacturing process (Anderson 2019; Harry et al. 2009), raising the question of whether these residues were deposited during manufacture or use—or both. However, experimentation has shown that any such coatings applied pre-firing would burn off subsequently (Admiraal, Lucquin, Drieu, et al. 2020), and in many cases the residues found are thick enough to suggest accumulation over time.

CHAPTER IV. METHODS

This project consisted of three main phases: initial information-gathering, preliminary reconstructions, and final experiments. In addition to the background research discussed in chapter 2 (including the conversation with Alutiiq Elders), the information-gathering phase included research on extant sherds housed at the Alutiiq Museum and Archaeological Repository (AMAR). I was able to study sherds from four of their collections in person, after which several sherds were loaned to USU for laboratory analysis. Between these two endeavors, I was able to greatly improve my understanding of Koniag pottery and to tailor my reconstruction efforts accordingly. Equipped with this information, and having made several practice pots during the preliminary reconstruction phase, I then dove into the experimental portion of the study, through which I derived the manufacturing times and return rates used to inform my conclusions. In this chapter I will detail my methodology for the in-person museum research, the laboratory tests I conducted on the loaned sherds, the final experiments, and the analysis of the experimental data.

Museum Research

The first step of this project was examining archaeological pottery held at AMAR. This research was conducted during three working days over the course of one week in January of 2023. The main objective was to establish overall vessel dimensions, as well as gleaning any possible insight into manufacturing methods, to inform my reconstruction efforts.

Figure 12. Map showing locations of collections studied. NAD83 Alaska Albers projection.

Collection #	Location/Site	Owner	*n*	Sherds Loaned for Destructive Analysis
AM50	Rolling Bay	BLM	*1*	
AM106	Rolling Bay	OHNC	*40*	
AM503	Red River	USFWS	*22*	AM503.263, AM503.264
AM596	Younger Kiavak	USFWS	*21*	AM596.360, AM596.374
AM821	Kiliuda Bay	AMAR	*4*	AM821.026, AM821.303, AM821.304
AM1012	Old Harbor	OHNC	*1*	

Table 2. Breakdown of the pottery sample examined. “OHNC” refers to the Old Harbor Native Corporation. 89 total specimens examined.

Sample. I examined sherds from four collections, originating in different locations around Kodiak: AM821, Kiliuda Bay; AM596, Younger Kiavak; AM106, Rolling Bay;

and AM503, Red River, as well as two more complete individual specimens from AM50 and AM1012 (Figure 10a, c; Figure 12; Table 2). The Younger Kiavak and Rolling Bay collections included sherds from the same sites examined by Clark (1968). The Red River collection is from a riverine site, enabling the comparison of riverine and coastal samples.

In the interest of time, data collection was mainly limited to sherds with clear structural elements (bases, shoulders, and rims). Certain specimens in the Rolling Bay collection, as well as the more complete individual specimens, were examined to a more limited extent to avoid disturbing and potentially damaging them.

Tools. I used a Canon Power Shot G15 and a DinoLite Pro AM4113T digital USB microscope to visually document the sherds. Qualitative visual assessments were made using a tabletop LED magnification lens. Quantitative information was collected using a soft measuring tape, digital plastic-tipped calipers, and an angle ruler.

Data Collected. I recorded a variety of quantitative and qualitative variables for each sherd (Table 3), though many were not applicable to every specimen. The variables recorded were selected to best capture the dimensions of the original vessels, and to glean as much information as possible about manufacturing methods. Diameters of incomplete curves (rims, shoulders, and bases) were assessed after the fact based on tracings and photographs. Qualitative variables concerning surface finish and temper characteristics were recorded using arbitrary categorizations, developed in the course of the examination based on the range of variation observed in the sample (illustrated in Figures 13 – 17).

Certain circumstances made some data difficult to record. For instance, wall thicknesses were not taken when one of the surfaces was completely absent, or when the wall had split/fractured. Additionally, in some cases, it was unclear which wall in a shoulder fragment was the upper and which was the lower. For this reason, and to achieve a larger sample size, analysis focused on the overall minimum and maximum wall measurements of each sherd. Often, the actual surface of the sherd was somewhat obscured, by cooking residue or other buildup, or because it had eroded away. Whenever possible, unaffected portions of the surface were described.

QUANTITATIVE		**QUALITATIVE**	
Measurement	**Vessel Part**	**Characteristic**	**Variable**
Diameter	Base	Surface Finish	Interior
	Shoulder		Exterior
	Rim	Manufacturing Marks	Interior
Angle	Base		Exterior
	Shoulder	Color	Interior
Height	Lower Wall		Exterior
	Upper Wall		Profile
Thickness	Base – Maximum	Temper	Type
	Base – Minimum		Size
	Wall – Maximum		Density
	Wall – Minimum		Uniformity
	Lower Wall – Maximum	Rim	Type
	Lower Wall – Minimum		
	Upper Wall – Maximum		
	Upper Wall – Minimum		

Table 3. List of variables that were recorded for the pottery sample.

As many high-quality images as possible were captured for further examination. Photos were taken to capture all surfaces, profiles, and the curves of each sherd. DinoLite images were obtained for sherds with special features, such as manufacturing marks.

a.

b.

c.

d.

e.

f.

g.

Figure 13. Scale used to evaluate surface finish. a) AM596.0343, eroded; b) AM596.0955, very smooth; c) AM106.54, smooth; d) AM106.09, intermediate; e) AM596.0927, rough; f) AM596.0891, very rough; g) AM596.0332, obscured by buildup.

Figure 14. Scale used to evaluate temper size. a) AM503.260, small; b) AM503.248, medium; c) AM821.350, large; d) AM821.299, extra-large (scale in cm).

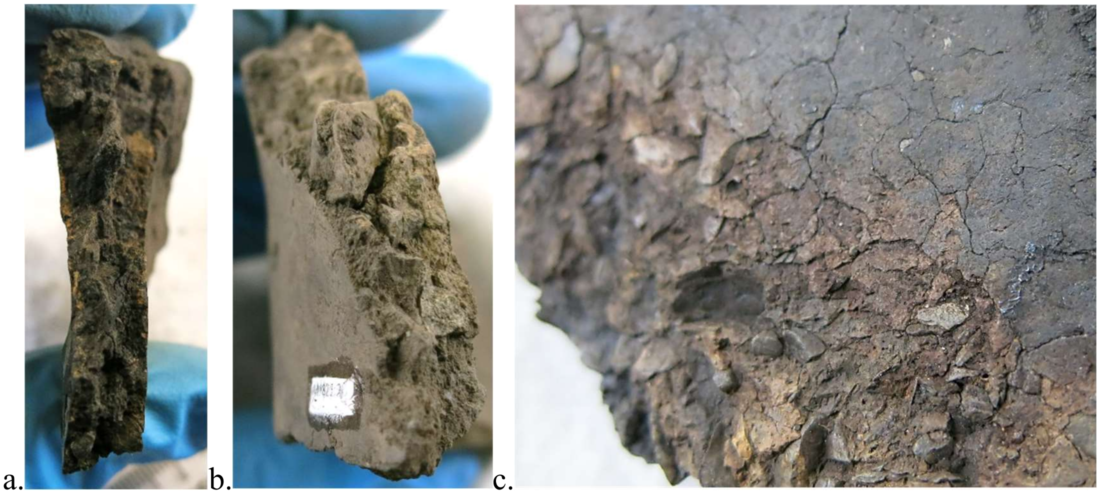


Figure 15. Scale used to evaluate temper density. a) AM106.54, low; b) AM821.030, medium; c) AM596.0173, high.

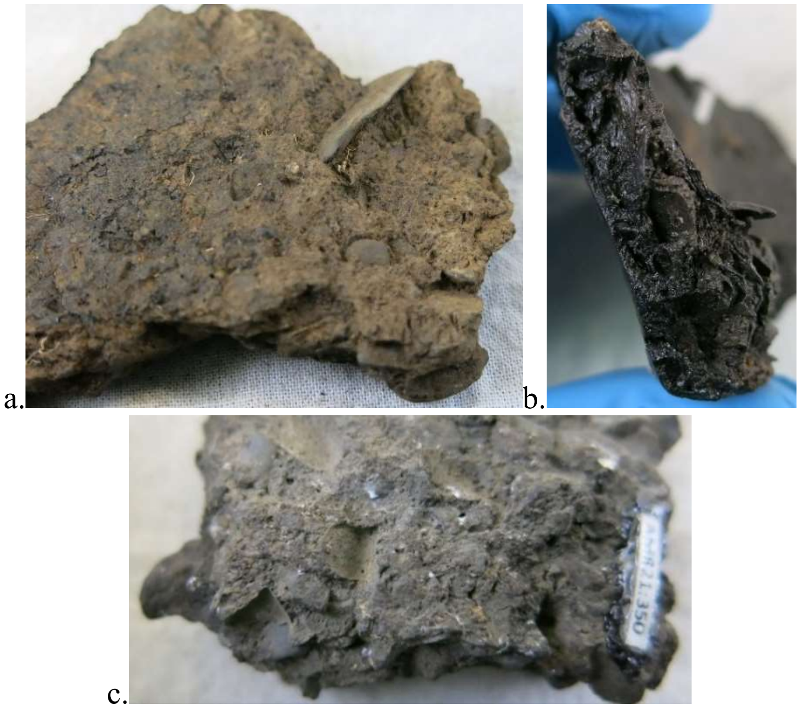


Figure 16. Scale used to evaluate temper uniformity. a) AM106.51, low; b) AM596.0955, medium; c) AM821.350 high.

Figure 17. Examples of temper types observed. a) AM106.49, pebbles and gravel; b) AM106.26, red stone; c) AM596.1164, thin and flaky d) AM503.257, sand and gravel.

Laboratory Analyses

AMAR and USFWS graciously authorized the loan of several sherds from their collections to be shipped to USU for use in laboratory analyses. These analyses were aimed at estimating the temperature to which the archaeological sherds were fired, thus establishing a target firing temperature for the reconstruction efforts. A set of controls were also made from Kodiak clay and fired to a range of known temperatures. The controls were intended to establish expected results for a range of temperatures, thus creating a scale against which the archaeological sherds could be measured. After the final experiments took place, samples from the pot fired in Kodiak were also examined using two of the three tests (the DSC/TGA was out of order).

The samples were subjected to Scanning Electron Microscopy (SEM), Differential Scanning Calorimetry/Thermo-Gravimetric Analysis (DSC/TGA), and X-Ray Diffraction (XRD). All three are often used to estimate firing temperatures of archaeological ceramics, especially in conjunction with each other (e.g. Annamalai et al. 2014; Palanivel and Kumar 2011; Rodrigues et al. 2015; Trindade et al. 2009; Velraj et al. 2015). SEM and XRD provide insight into the clay's microstructure, which changes as it is heated and the clay minerals decompose. Thermal analysis, on the other hand, operates by heating a sample and identifying evidence of chemical reactions—if a non-reversible reaction occurs in a sample at a certain temperature, it indicates that the sample has not previously been heated to that temperature (Rice 2015:377–382).

Major sources of error for all analyses include contamination, which can influence compositional analyses and obscure the original clay structure in images; natural variation in the composition of the clay matrix, which can cause the results for a given sample to misrepresent the overall clay body; and post-depositional changes in the archaeological sherds, in this case including rehydration and the impacts of repeated freezing and thawing (Reid 1989), which may obscure the effects of the pot's initial firing and makes the archaeological samples less comparable to the controls (Drebushchak et al. 2005; Rice 2015:273–275). Additionally, the temperature variations inherent to open firings mean that different parts of a given vessel may have very different maximum temperatures (Rye 1981), such that to obtain a full understanding, one would need to test samples from different parts of each vessel. Intra-sample variability and contamination can impact the results of SEM and thermal analysis most strongly, as both tests only represent a tiny portion of each specimen.

Sample Selection. The collections sampled were selected based on two considerations: geographic diversity (including the desire to inspect both riverine and coastal pottery) and ease of obtaining permissions for destructive analysis. This resulted in the selection of sherds from three collections: AM821, Kiliuda Bay; AM596, Younger Kiavak; and AM503, Red River (see Figure 12, Table 2). As the Kiliuda Bay collection is owned by AMAR, permissions were easily obtained. The other collections were selected to provide geographic diversity while only needing to obtain permission from one additional collection owner (USFWS). Kiliuda Bay and Younger Kiavak are both located along the southeast coast of Kodiak Island, in prime whaling territory. They are also relatively distant from each other, with Kiliuda Bay being located toward the northern end of the main cluster of pottery-bearing sites and Kiavak being closer to the southern tip of Kodiak Island. Red River, located to the west, is one of only a few pottery collections from a riverine site.

The specimens requested for destructive analysis were selected mainly based on the lack of structural information present: wall fragments were targeted, particularly those missing one or both surfaces, to minimize the destruction of valuable information. An effort was also made to select larger sherds where possible to decrease the impact of destructive sampling. Seven total sherds were authorized for destructive analysis, two each from AM596 and AM503, and three from AM821 (see Table 2).

Preparing Controls. Using donated clay samples from two sources on Kodiak Island (see Figure 1), one from Olga Lakes (OL) and one from Surfer's Beach (SB), a set of tiles were formed (some 5 cm x 5 cm to be powdered for destructive analysis, some ~0.5 in x 0.5 in for SEM). For each clay source, one tile was left unfired, and the others were fired at 100°C intervals from 500 – 1100°C using small electric test kilns. This temperature range was chosen because 500°C is usually the lowest firing temperature that can trigger decomposition of clay minerals and thus produce true ceramic, whereas 1000°C is the highest firing temperature achievable without a kiln (Rye 1981). The tiles were marked to indicate the clay source and the temperature to which they had been fired.

As these controls were prepared in a pottery studio rather than a laboratory environment, some level of contamination with dust from other materials is probable. However, steps were taken to minimize this contamination. The clay was rolled out between layers of clean plastic, all tools and surfaces were wiped with a damp sponge, and hands were washed before beginning and when changing between clay sources.

Scanning Electron Microscopy (SEM). The seven sherds and 14 control samples (from both sources for temperatures 500 – 1100°C) were examined under the USU Core Microscopy Facility's field-emission scanning electron microscope (FEI Quanta FEG

650), to directly observe the clay's crystal structure. The raw clay was not examined due to concerns that it might disintegrate in the vacuum. Elemental analyses were also obtained for five of the sherds (AM821.026, AM821.304, 503.264, AM596.360, and AM596.374) and for one control sample from each clay source, using the instrument's energy dispersive X-ray spectrometer (EDS). Images were taken of one point per sample at a variety of magnification levels: x25k, x10k, x5k, and x1k. In a few cases, images at x50k magnification were taken, but resolution suffers at this level, particularly in the instrument's low-vacuum mode. Magnification levels were selected on the advice of the SEM operator to best take advantage of the instrument's capabilities.

To prepare samples from the archaeological sherds, I broke pieces off each sherd with a blunt chisel and hammer and wiped the fragments with alcohol/Kim wipes. The SEM operator further prepared the samples (cutting, sanding the bottom, blowing nitrogen, and wiping with alcohol). The sherds were then coated with 10 nm of alumina and examined in high vacuum mode (starting at 8.99 e^{-5} torr). The controls were initially examined uncoated under the microscope's low vacuum mode (starting at 0.53 torr). A selection of the controls (SB 600°C – 900°C) were later coated and re-examined, together with a sample from the pot fired in Kodiak. All samples were imaged using the Concentric Backscatter detector (CBS); those examined in high vacuum mode were also imaged using the Everhart-Thornley Detector (ETD), while those examined in low vacuum mode were also imaged using the Large Field Detector (LFD).

Differential Scanning Calorimetry/Thermogravimetric Analysis (DSC/TGA). Next, thermal analysis was performed using the TA Instruments Discovery SDT 650 at the University of Utah's Materials Characterization Lab (MCL). Differential Scanning

Calorimetry (or DSC, which is very similar to differential thermal analysis, or DTA) measures a sample's change in temperature as it is heated, compared to an inert standard (in this case an empty crucible), thus identifying any exothermic and endothermic chemical reactions that occur. Thermogravimetric analysis (TGA), which was run simultaneously, tracks the changes in the sample's mass as it is heated (Rice 2015:380–381). Thermal methods are most useful in obtaining estimates for the upper end of the firing range, as they indicate that the sample was at least not fired past a certain point (Giordana et al. 2004). Each sample was heated at 20°C/min up to 1200°C (upper temperature selected to exceed the highest plausible firing temperature for the sherds, ~1000°C) under a nitrogen flow (lab standard). Due to the time and expense involved in this test, only 15 samples were examined: the seven archaeological sherds, and controls from both clay sources fired to 0°C, 600°C, 800°C, and 1000°C.

Powdered samples were prepared by breaking chunks off each sherd or tile with a chisel and hammer and crushing using a porcelain mortar and pestle. All tools were wiped with Kim wipes and alcohol between samples. Some error may have been introduced by the presence of non-clay inclusions in the samples, which were not thoroughly ground and sieved for this analysis, as well as the range of starting sample masses, some of which significantly exceeded the lab's recommended sample mass of 10 mg. It should also be noted that the standard heating rate for thermal analysis is 10°C/min (Giordana et al. 2004; Palanivel and Kumar 2011; Rodrigues et al. 2015; Trindade et al. 2009; but see Singh and Sharma 2016). Using a faster heating rate increased the number of samples I was able to test, but it could also have obscured the timing of the chemical reactions involved.

X-Ray Diffraction (XRD). Powder samples from each of the seven sherds and twelve controls (from both sources, fired to 0°C, and 600 – 1000°C) were also run through a Bruker D2 Phaser XRD, also at the MCL. The following settings were used: upper discriminator: 0.25 V, lower discriminator: 0.19 V (lab standard for samples including iron); 2θ range: 5 – 75° (following Rodrigues et al. 2015); step increment: 0.02°, and step time: 0.5 sec (lab standard).

The samples for the controls and four of the sherds were taken from the vials of powder prepared for the thermal analyses, with large inclusions/unground clay chunks being removed using tweezers. However, producing the requisite flat surface using the archaeological samples during the first session proved quite challenging, due to the large amounts of inclusions and uncrushed ceramic material present in the samples. Therefore, before the second session, all the archaeological samples were sieved and reground, together with any larger chunks previously broken off but not used in the SEM analysis, to achieve a sufficient quantity of powder.

Unfortunately, XRD analysis does not always discriminate well between different firing temperatures in the 500 – 800/900°C range (the most likely temperature range for these sherds), as the clay minerals tend to be amorphous at this stage—the crystal structure of the clay has decomposed, and high-temperature minerals have not yet formed (Rice 2015:382; Rye 1981). However, some clay types can still yield useful information, and this analysis can still confirm whether the firing temperatures for the samples examined do indeed fall within the 500 – 900°C range.

Experiments

Prior to performing the final experiments, I constructed five practice pots and two bases, to get a feel for the types of hand-building methods most likely used in constructing traditional Alutiiq pottery. For these attempts, I worked under the guidance of Dan Murphy (USU Ceramics professor) and used a beginner-friendly clay. We also held a practice firing in Logan, Utah, in which we attempted (unsuccessfully) to fire three of these pots.

Due to a combination of logistical issues, it was not possible to perform any of the experiments involving animal products on location in Kodiak. However, all phases of the pottery-making process were performed and recorded at least once in Kodiak in August of 2023, with additional pottery construction being accomplished in Utah. The remaining experiments were completed in Utah and Washington, using pig fat and a portion of a cow's stomach as proxies for the analogous seal products.

The experiments were documented using a combination of voice and video recording. Most images and video taken in Kodiak were captured using a Canon EOS Rebel series camera; remaining footage and stills were taken using a computer or cell phone camera. Temperature readings were taken periodically during the firing and heat-rendering experiments using a handheld infrared thermometer (temp range: -50 – 1500°C).

Pottery Construction. The pottery construction techniques used during both the preliminary reconstructions and the final experiments were informed by the existing scholarship, supplemented by Dan Murphy's practical expertise. As suggested by the research on Alaskan pottery (de Laguna 1940; Dumond 1969), and Kodiak pottery in particular (Clark 1968; Heizer 1949), the body of the pot was not formed from coils, but rather using patches of clay. Formal rectangular slabs were considered, but in contemporary studio practice these are formed using a cutting wire, an anachronistic method that works poorly with coarse-tempered clay. It thus seemed more accurate, as well as quicker, to use smaller, less intensively shaped patches, a method that has been called "morsel building" (Rice 2015:137–138).

The base was either formed inverted around an interior (or convex) mold of truncated conical shape (see Figure 18) or built free-standing. After the base had dried somewhat, it was turned (and the mold removed, if applicable), and an upper wall was attached in patches. Coils were used sparingly, to reinforce the interior of the base and shoulder, to serve as the base for the rim, and sometimes to even out the shoulder edge before attaching the upper wall. Once formed, the vessel was shaped using a wooden paddle and an anvil stone, left to dry to leather-hard, and scraped to refine the shape. The surface was then finished by water-smoothing, slipping, and/or burnishing.

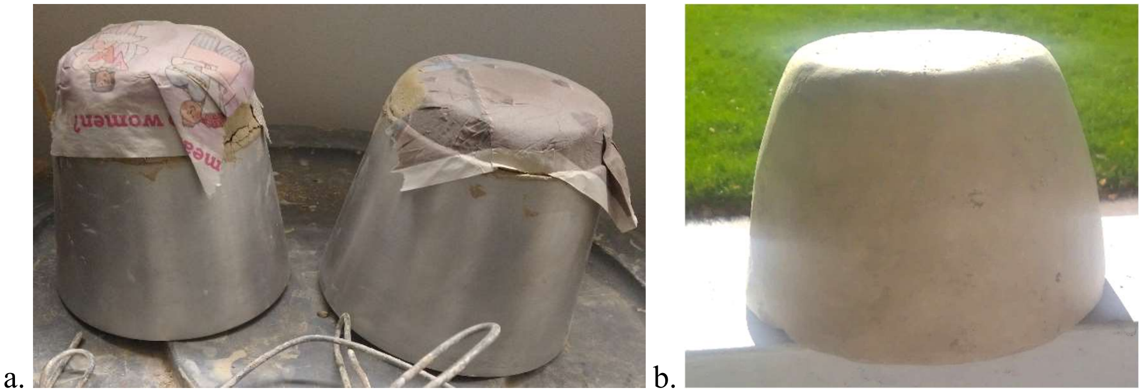


Figure 18. Molds used for a) practice pots and b) pots made from Kodiak clay.

I am not aware of any direct evidence supporting the use of either internal (convex) or external (concave) molds on Kodiak. There is some ethnographic evidence for the use of convex molds, made from either basketry or birch bark, in Alaskan pottery, as well as archaeological evidence in the form of fiber impressions on vessel interiors (Anderson 2019), but no such impressions have been observed on Koniag pottery. However, my experiences working with the Kodiak clay confirm that large pots would have been difficult to achieve without some kind of support. The two molds used in the preliminary reconstruction phase were fashioned from appropriately shaped pieces of ceramic studio equipment, known as “jigger jollies” (Figure 18a). During this phase, I also constructed a small freestanding base (Figure 18b), which I then used as a mold when making pots from the Kodiak clay. While this mold was smaller than the jigger jollies, I was nonetheless able to achieve larger finished vessels using it than I was through freestanding base construction.

Tools used in the final experiments were limited to a) the mold; b) wooden scrapers and paddles; c) stones, some used as anvils and some for burnishing; d) a metal needle tool, used for scoring; and e) thin plastic bags, used as a parting agent between the mold and the base. While the metal needle-tool is somewhat anachronistic, Alutiiq ancestors certainly had access to very serviceable (and sharp) bone needles that could have served the same function. There is less clear-cut justification for use of plastic bags, but if a mold was used, it would have been accompanied by some parting agent—dry sand is known to be used in other parts of the world (Rye 1981).

In total, I constructed six bases of Kodiak clay (Figure 19), four of which had upper walls added, three of which became complete pots, and two of which were fired. The construction of the first pot (pot A) took place in Utah prior to the trip to Kodiak and was not recorded. This pot was constructed using my handmade mold, using clay from

Olga Lakes and Surfer's Beach in Kodiak (Figure 1), supplemented by a sample from a deposit of grey glacial clay from Owen Beach in Washington. The clays were dried, powdered, mixed, slaked (mixed with water to produce a slurry), and dried to a workable moisture content, after which I kneaded in tempering materials collected from Fossil Beach (Figure 1) during my first trip to Kodiak (sand and gravel from the beach itself, and chunks of siltstone scraped from an outcrop). The clays and tempering materials were weighed dry and the proportion of temper to clay calculated. Pot A was later brought to Kodiak and used in the firing experiment.

Figure 19. Bases and pots constructed with Kodiak clay. a) Pot A, b) base B, c) pot C, d) pot D, e) pot F. Pots C and D were constructed freestanding and are smaller than pots A and F. No images were captured of base E.

Base B (molded) and pots C and D (freestanding) were constructed in Kodiak, made from clay and temper (sand and gravel) that I personally collected from Surfer's Beach. Base B and Pot C both cracked catastrophically while drying, and their clay was ultimately mixed with additional temper and used to construct the remaining vessels. Unfortunately, both A and D broke in transit back to Utah, necessitating the construction of another vessel in Logan to be used in the rendering experiment. This resulted in another failed base (E), which was then slaked and used in the final pot (F). Both E and F were made using my handmade mold.

Figure 20. Fire pit dug for experimental firing, with pots C, A, and D arranged alongside. The firing experiment was conducted on August 18, 2023 at Surfer's Beach.

Firing. The methods used in both the practice and final firings were informed by instruction from Andy Ward (2020), an archaeologist who specializes in studying, practicing, and teaching the reconstruction of ancient southwestern pottery. In both cases, a firepit was dug and lined with stones, and an initial, "primary" fire was built in the pit with the pots placed around it to preheat (see Figure 20). The primary fire was then allowed to burn down to coals. After a considerable period of preheating the pots by placing them near and/or suspending them over the primary fire, the pots were placed directly over the coals, balanced on stones to avoid direct contact with the fuel.

In the practice firing, we proceeded directly to building the main, or “secondary” fire: after placing a few pre-prepared “cover sherds” around the pots to shield them from the heat, we piled sticks in a conical arrangement around them, inserted dried grass around the base of the cone, and lit the grass (Figure 21a). Shortly after the secondary fire was lit, however, the pots began to spall, a process that occurs when the water present in the clay is heated too rapidly and expands forcibly, resulting in large flakes popping off the pot’s surface. While much of the water present in clay evaporates as the piece dries at room temperature, there is also the “chemical water,” which is chemically bonded to the clay and can only be released at higher temperatures (Rye 1981). Since the practice pots had been drying for weeks in a heated pottery studio, the issue must have arisen through rapid heating of the chemical water.

Figure 21. Fuel arrangements used in a) the practice firing (6/17, Logan) and b) the final firing (8/18, Surfer’s Beach, Kodiak).

To avoid this problem in the final firing, the pot was left positioned directly over the coals for some time and rotated periodically. This process ensured that each part of the pot spent some time at approximately 100°C, to allow the trapped chemical water to escape safely. The secondary fire was then built up slowly around the pot/cover sherds (Figure 21b), and fuel was gradually added until the target temperature (~700˚C) was surpassed. The fire was then allowed to burn down naturally for a while before being dismantled to allow the pot to begin to cool.

There are numerous variations on open firing methods. Many aspects of the process can be manipulated, such as the fuels used, the number of vessels fired and their arrangement, and the depth and disposition of the firing depression, if any (Rice 2015; Rye 1981). Ethnographic accounts of Alaskan pottery reflect a range of distinctive firing strategies, such as soaking the fuel with oil, or placing a pot at the edge of a cookfire on several successive occasions before eventually firing it (Anderson 2019). I am aware of only one other kiln-free firing method having been attempted on pieces made from Kodiak clay: namely, burying the ceramic pieces in sand and building a bonfire on top, with the finished pieces being retrieved the next day after the fire has burnt out (Susan Baker, personal communication, 2023). In this instance, the pieces did not reach the temperature needed to decompose the clay minerals and become true ceramic. For this reason, I elected to use an above-ground firing strategy.

Heat-Rendering. Pot F was used to complete the heat-rendering experiment, which took place in Washington state in January of 2024. I used a direct heating method, for three reasons. First, direct heating has fewer moving parts than indirect heating, as stones need not be carried between the fire and the pot. Second, direct heating takes fuller advantage of the unique characteristics of ceramic technology. Third, while indirect heating is useful for maintaining the proper temperatures for rendering (Gjesfjeld 2019), oil tends to adhere to the heating stones as they are repeatedly inserted and removed, leading to oil loss (Boyd et al. 2019)—as well as, presumably, some very slippery stones. For these reasons, I felt that testing direct heating methods would make the best case for pottery as an oil-rendering technology, though indirect heating is also very plausible.

The fat was first cut into strips and scored, according to the description given in the Elders Session, and placed in the pot. The store-bought pig fat included intramuscular fat and had significant amounts of meat still adhering, which had to be removed before the fat could be prepared. However, as blubber naturally occurs in a thick layer uninterrupted by muscle tissue, the de-fleshing time was not counted toward the processing time estimates.

At this point, I started a small fire and placed the pot in it. I placed the pot on a relatively flat cover sherd to balance it, but alternative approaches could have involved the use of a griddle stone, letting the fire burn down to coals and settling the pot on stones placed in the coals, or placing the pot directly on or near the coals (Reid 1989). I stirred the pot periodically with a wooden spoon. I also cut and added further strips of fat as the pot's contents decreased in volume. When the fat seemed to have rendered the maximum amount of oil, I dismantled the fire and, after some time, used oven mitts to remove the pot. I discovered after the fact that oil had been leaking through a crack in the bottom of the pot and burning off during the experiment, making a reliable measurement of the amount of oil produced impossible.

Stomach Container Manufacturing and Use. I obtained a portion of a cow's abomasum (the final stomach compartment) from a butcher in Logan. This was trimmed of fat, rinsed, and sanitized in a dilute solution of ammonia to simulate urine, a traditional cleaning agent in the region (Davydov 1977; Holmberg 1985). As my stomach portion did not have a constricted neck, I was unable to inflate it effectively, so I stuffed it with paper before hanging it to dry. I then removed the paper, prepared strips of fat as described above, and inserted them into the stomach portion. When it was full, I used more sinew to attach a stopper fashioned from modern materials and placed the result in a sealed bin in a concrete storage shed (Figure 22b).

This process has many shortcomings: aside from the stomach portion being from a different animal, which impacted the vessel's shape, volume, and potentially its durability, the temperature and humidity in Utah were very different than they would be in Kodiak. Some small pieces of paper also adhered to the inside of the stomach, which may have compromised the integrity of the rendering environment. Ultimately, the container decayed, and I was unable to produce any self-rendered oil. In fact, I have no confirmation that pig fat can be self-rendered—unlike seal oil, which is stable in a liquid state, lard rapidly solidifies at room temperature.

Interpretation

As discussed in chapter 2, the technological investment model is intended to pertain only to "active" time, time spent engaged in the activity in question. However, given that the bulk of the self-rendering process consists of "passive" time, waiting for the blubber to render, I thought it important to evaluate these technologies in terms of "gross" time (including active and passive time) as well as in terms of active time alone. I was able to record the passive time involved in my firing and heat-rendering experiments with a degree of precision. The amounts of passive time needed for pots and stomachs to dry and for self-rendered fat to be usable were estimated roughly, however, as I found that these periods may often be determined as much by the maker's schedule as by the amount of time that is strictly required.

As mentioned above, I was unable to record a reliable quantity of oil produced in either rendering experiment. When determining return rates, therefore, I used the weight of fat that was processed, rather than the quantity of resulting oil. This substitution relies on the assumption that a pound of blubber produces approximately the same amount of oil regardless of what rendering method is used. To test this assumption properly would require further experimentation with actual seal products. If there is a difference, heat-rendering likely produces less oil per pound of blubber than self-rendering, especially if not carefully attended, as fat may cook off or burn if temperatures are too high.

In estimating the passive time involved in self-rendering, I was guided by the statement of an Elder who had self-rendered seal oil once using glass jars—he said that the rendering itself took "a few hours." I did not attempt to estimate the time needed to ferment the oil, as fermentation is a preservation technique that may be performed on oil rendered using either method (Haynes and Wolfe 1999). I did not include time needed to transport the clay, as a pot might be constructed at or near the clay source used. I also did not consider the time required to make the tools used in any of these tasks. The variety of wooden artifacts observed at Karluk 1 suggests that Alutiiq ancestors had access to items that would have served reasonably well as pottery tools (Steffian et al. 2015), and each decision to make a new tool becomes a separate instance of technological investment.

After the experiments were completed, I reviewed the footage and noted the timestamps of when key events took place and when various activities began and ended. The resulting lengths of time were then categorized (e.g. “inactive,” “materials processing,” “primary fire,” etc.). I then combined various subsets of these chunks of time to generate a range of possible times it might take to complete a given activity. In the case of pottery manufacture, it was necessary to compare the results for vessels B – F to determine an overall manufacturing time (see Appendix B for details).

In addition to the distinction of “gross” vs. “active” time mentioned above, the final interpretation uses “liberal” vs. “conservative” time estimates. The conservative estimate includes only those activities most essential to the task at hand, excluding things like time spent evaluating the situation, setting up the work area, and general “futzing” (it is assumed that an experienced individual could complete these tasks with less hesitation than I exhibited). The conservative estimate also does not include the time spent setting up a fire pit or hearth, gathering fuel, and starting a fire. This is based on the probability that Alutiiq households would always have had a fire burning (Coral Chernoff, in conversation, August 2023), as well as a stockpile of fuel and kindling from which they could easily draw fuel. This interpretation is debatable when it comes to firing pottery, which would have taken place outside the home, but might have been done nearby (in which case the fuel stockpile would still be accessible) or at a special-use campsite (in which case the campfire could be used as the primary fire). In any case, as will be demonstrated, the precise amount of time spent in firing pottery is not crucial to the observed relationships and the conclusions I draw from them.

The liberal estimate, on the other hand, includes all periods during the recording in which I was engaged in activity pertaining to the task at hand, excluding periods of inactivity and "documentation" (e.g. note-taking, temperature readings, camera setup, etc.). During the preparation of the cow stomach, this time estimate does not include time spent trying to sort out the stomach from the intestines, as I assume that Alutiiq ancestors would know their way around a seal's (or, in this case, a cow's) digestive system better than I do.

Return rates (the weight of the fat processed divided by the processing time) are given in lbs/hour and were calculated for a range of possible container volumes. I extrapolated the appropriate weights of fat for different volumes based on the amounts used in the heat-rendering experiment. Fat weights for different stomach volumes were based on the amount of unrendered fat needed to fill the pot before it was put on the fire. Fat weights for different volumes of pot were based on the total amount of fat processed in the heat-rendering experiment, to account for the possibility of adding more blubber to the pot as rendering progresses, something that is not feasible with self-rendering. I then calculated modified processing times for the different fat weights using the time-per-pound that I spent a) cutting the fat into strips and b) stirring/rendering it.

While the measurements of the pot in which I performed the rendering experiment (which holds 1.5 – 2 L) were considerably smaller than those that my museum research suggested for a typical Koniag pot, I was also able to measure the volume of one of the practice pots, whose measurements were more consistent with the museum results. I used this value (5.5 – 6 L) to generate a "low yield" estimate. For the "high yield" estimate, I calculated an approximate functional volume for a pot based on the high end of the dimensions observed in the museum sherds, which came to about 18 L.

The volumes used for the stomach container were informed by comparing pictures of my own attempt with images of a seal stomach container I observed in Kodiak (Figure 22). I determined that the two probably had similar capacities, with the seal stomach container probably holding somewhat more than my reconstructed version. I thus calculated return rates for the amount of fat that I was able to fit into my stomach (which I estimated held ~1.75 L) for the Low Yield estimate, and for a stomach holding 3 L for the High Yield estimate.

Figure 22. Containers made from a) a seal's stomach, by Coral Chernoff, and b) a portion of a cow's abomasum, which I constructed in the course of these experiments.

CHAPTER V. RESULTS

The results from this project fall into two main categories: those based on observations of archaeological sherds, and those derived from experimentation. The former are of interest in and of themselves to those who wish to learn more about traditional Alutiiq pottery. As such, I have provided figures and tables summarizing the museum data in Appendix A. In this chapter, I will focus on those results which most directly informed the final experiments. I will then discuss the final m- and r-values obtained for both technologies and their implications, up to and including calculating a threshold s-value where applicable. While this chapter includes additional information intended to contextualize these s-values, I have left the evaluation of their plausibility for chapter 6.

Vessel Characteristics: Quantitative

Dimension	**Element**	***n***	**Min**	**Mean**	**Max**	**Mode(s)**
Diameter (cm)	Base	*5*	8.15	11.55	14	–
	Shoulder	*18*	16.3	23.14	32	20 – 22, 26 – 28
	Rim	*27*	16	22.87	37	20-25
Height (cm)	Upper Wall	*4*	11.5	14.38	18	–
	Lower Wall	*2*	20	20.6	21.2	–
Angle (°)	Base	*5*	75.45	106.21	135	100 – 120
	Shoulder	*19*	140.9	155.13	169.5	150 – 155, 160 – 165

Table 4. Summary statistics for the dimensions observed in the pottery sample. 89 total specimens examined. The *n* column indicates the number of specimens for which the given variable could be measured.

The quantitative characteristics I relied on most in my reconstructions were, first, the vessels' overall dimensions (Table 4), and second, their thicknesses (Table 5). Rim and shoulder fragments were much more common than base fragments, so less data was available about base diameters and thicknesses. Wall heights were difficult to observe as well—only a few sherds were intact from rim to shoulder, and the only full lower walls available in the sample were those of the two more complete vessels.

Element	**Measurement**	***n***	**Min**	**Mean**	**Max**	**Mode(s)**
Wall (mm)	Min Thickness	*68*	6.53	9.50	15.7	9 – 10
	Max Thickness	*68*	8.15	12.66	18.31	11 – 12, 13 – 14
Base (mm)	Min Thickness	*4*	18	21.92	29	18 – 20
	Max Thickness	*4*	23.13	25.08	29	22 – 24

Table 5. Summary statistics for the base and wall thicknesses observed in the pottery sample.

Vessel Characteristics: Qualitative

The qualitative variables I tracked most closely were surface finish (interior and exterior) and temper characteristics (size, density, uniformity, and type). See Figures 13 – 17 for illustrations of the scales on which I evaluated these variables.

I observed a wide range of surface finishes (Figure 23), with "intermediate" and "rough" being the most common. Only a few sherds possessed a finely polished appearance ("very smooth"). Overall, the interior surfaces (when not obscured by cooking residue and other accretions) appeared to trend toward a smoother finish than the exterior surfaces.

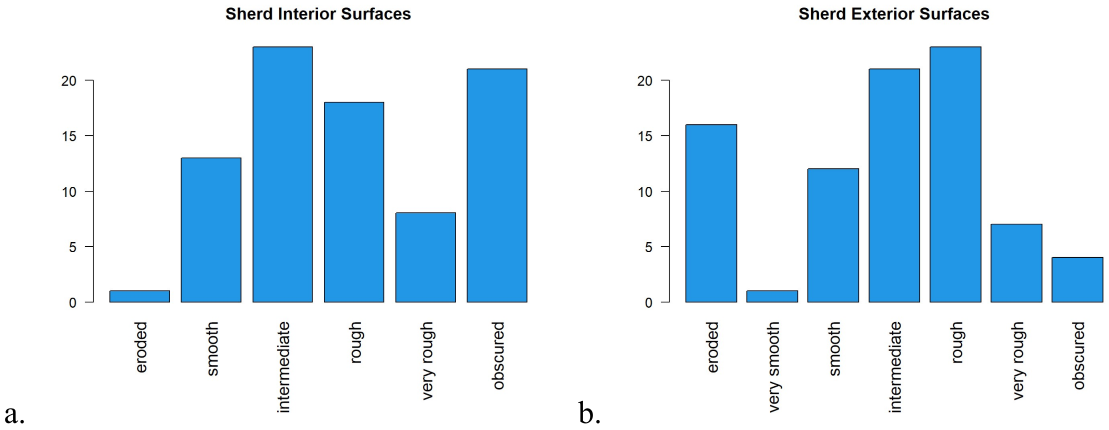


Figure 23. Bar charts illustrating variation in a) inner and b) outer surface finishes. Inner finish was recorded for 62 specimens, outer for 64.

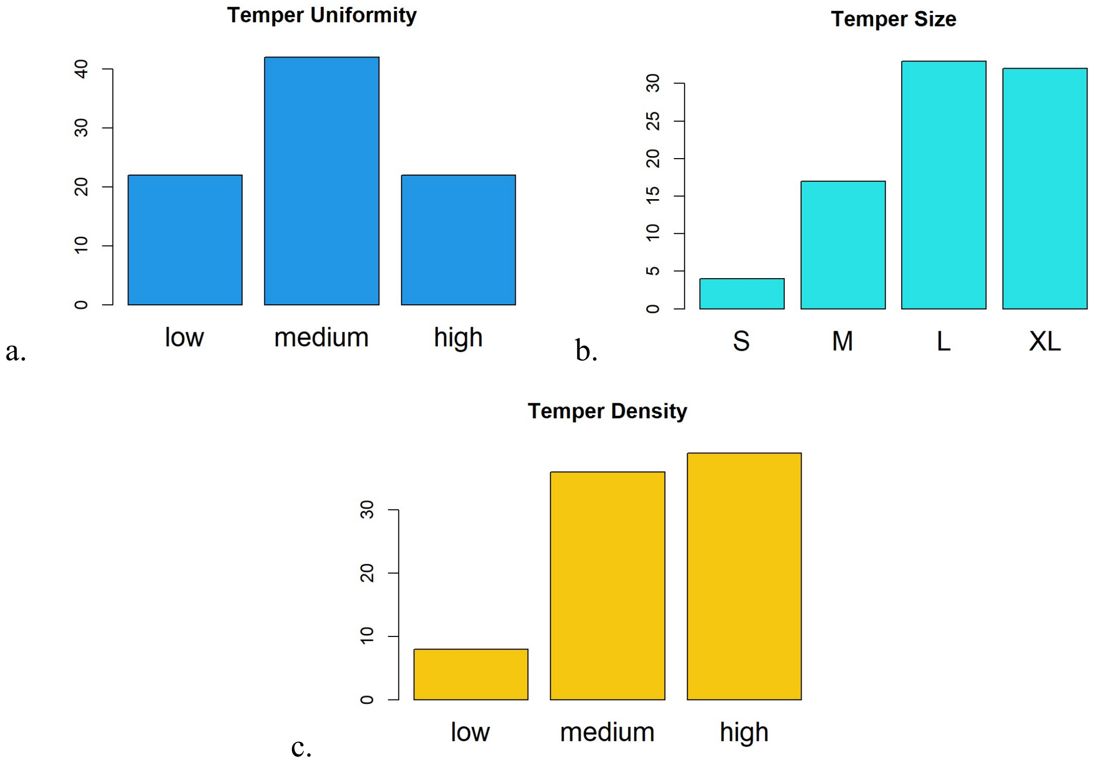


Figure 24. Bar charts illustrating observed temper characteristics. a) Uniformity and b) size were recorded for 86 specimens, while c) density was recorded for 83.

Temper was generally large (Figure 24b), often with a very high density (Figure 24c), and not very uniform in size (Figure 24a). The temper type results were especially interesting, as it was the variable that differed most strongly between collections (Figure 25). In fact, while “pebbles/gravel” was the most common type overall, the Rolling Bay, Red River, and Younger Kiavak collections each had their own distinctive tempering material. The red stone observed in some Rolling Bay sherds was of similar appearance to the siltstone I observed and collected from Fossil Beach (Figure 1).

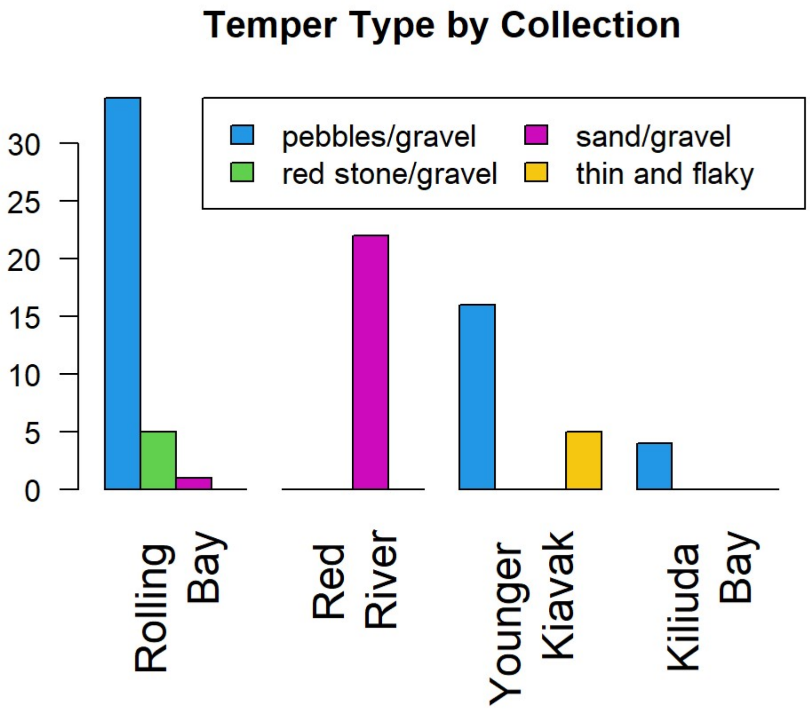


Figure 25. Temper types by collection. Temper type recorded for 87 specimens (all but the two more intact pots).

Firing Temperature

Due to time constraints, only preliminary interpretations of the laboratory results were attempted, based on comparing the images and plots to each other. However, as open firings constitute a very poorly controlled environment, with maximum temperatures reached varying by as much as 200°C in different parts of a single vessel (Rye 1981), only a rough estimation was needed to perform the firing experiment. The overall conclusion drawn from the results of the analysis was that the sherds were likely fired to somewhere between 600 and 800°C. A target temperature of 700°C was therefore chosen for use in the experimental firing.

SEM. A review of the SEM images for the controls revealed one main trend: the fusing/destruction of crystal structures as the temperature increased. The low temperature controls were characterized by “a sea of hexes” (Figure 26), presenting cluttered views abounding in small crystals, whereas the higher temperature controls appeared to have fewer free-floating crystals and larger overall crystal structures (see Figure 27). It was difficult, however, to codify the steps in this progression and to definitively match the sherds up with a specific stage.

The main upshot of the SEM results was to eliminate certain temperatures from consideration. In particular, the morphology of the controls fired to 1100°C differed dramatically from the other control samples and from the sherds examined. Very few crystalline structures were visible, limited largely to loose clusters of bar-like structures (Figure 28), and it was necessary to zoom in to x25k magnification to perceive them. The controls for 900°C and 1000°C exhibited larger, more cohesive plate structures than the other controls or the sherds, so these temperatures also were deemed unlikely. The 500°C controls (Figure 26), on the other hand, exhibited very few apparent larger formations, with the topography appearing to be composed of “mounds” of smaller crystals. As the sherds overall showed larger underlying structures (e.g. Figure 29), 500°C was also ruled out.

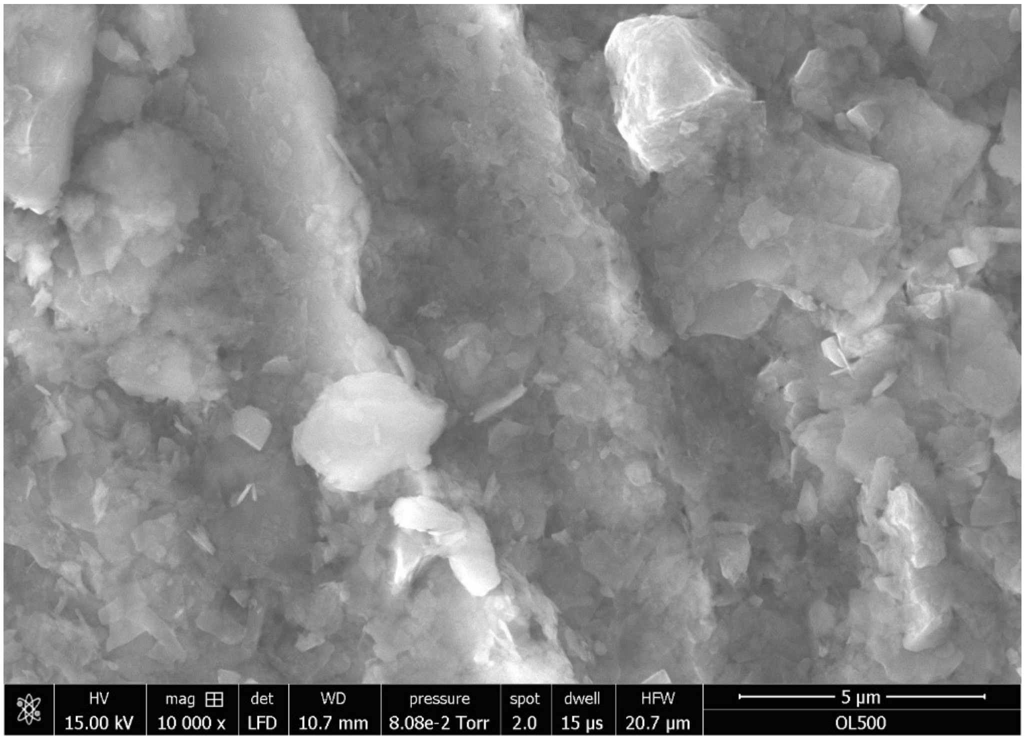


Figure 26. Clay sample from Olga Lakes fired to 500 °C, examined under x10k magnification.

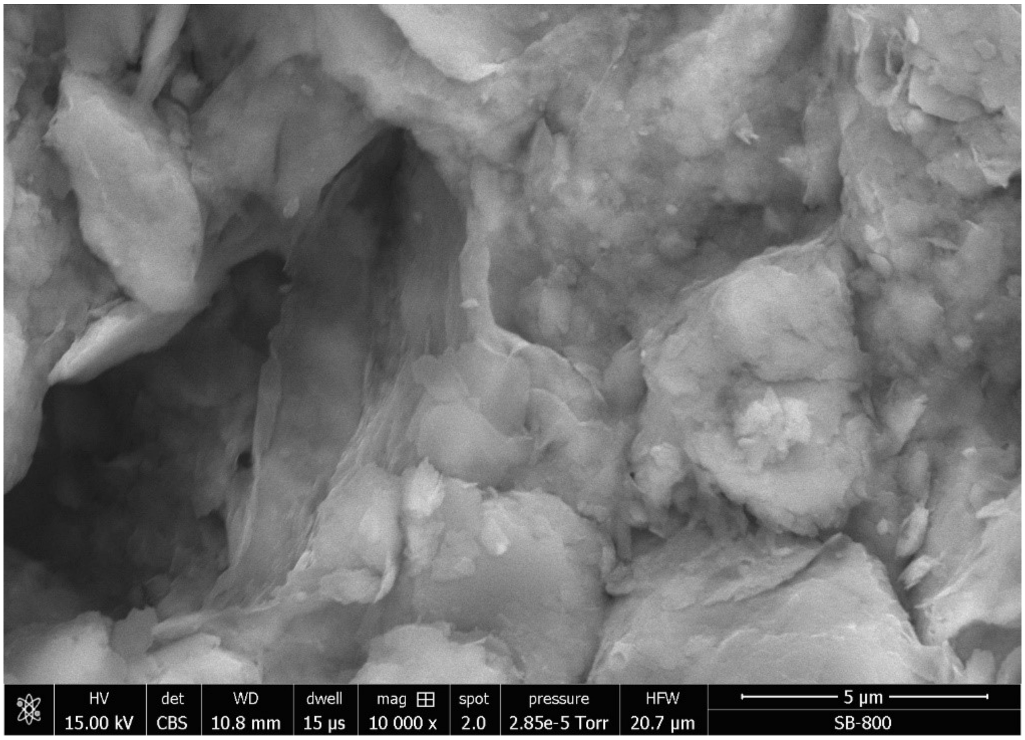


Figure 27. Clay sample from Surfer's Beach fired to 800 °C, examined under x10k magnification.

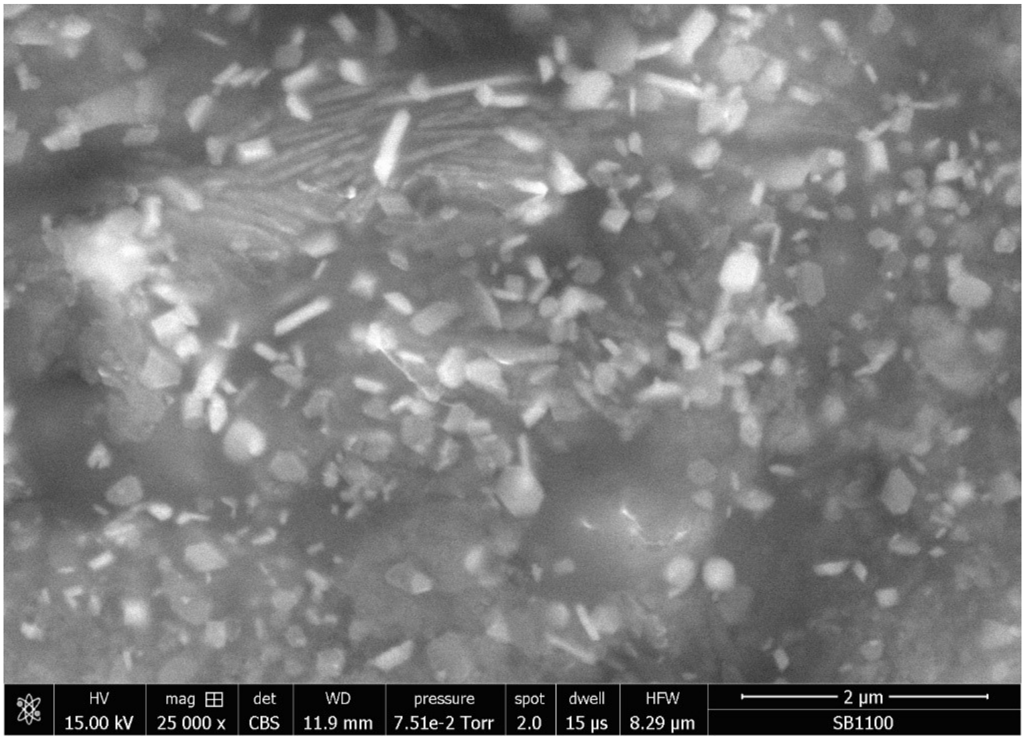


Figure 28. Clay sample from Surfer's Beach fired to 1100 °C, examined under x25k magnification.

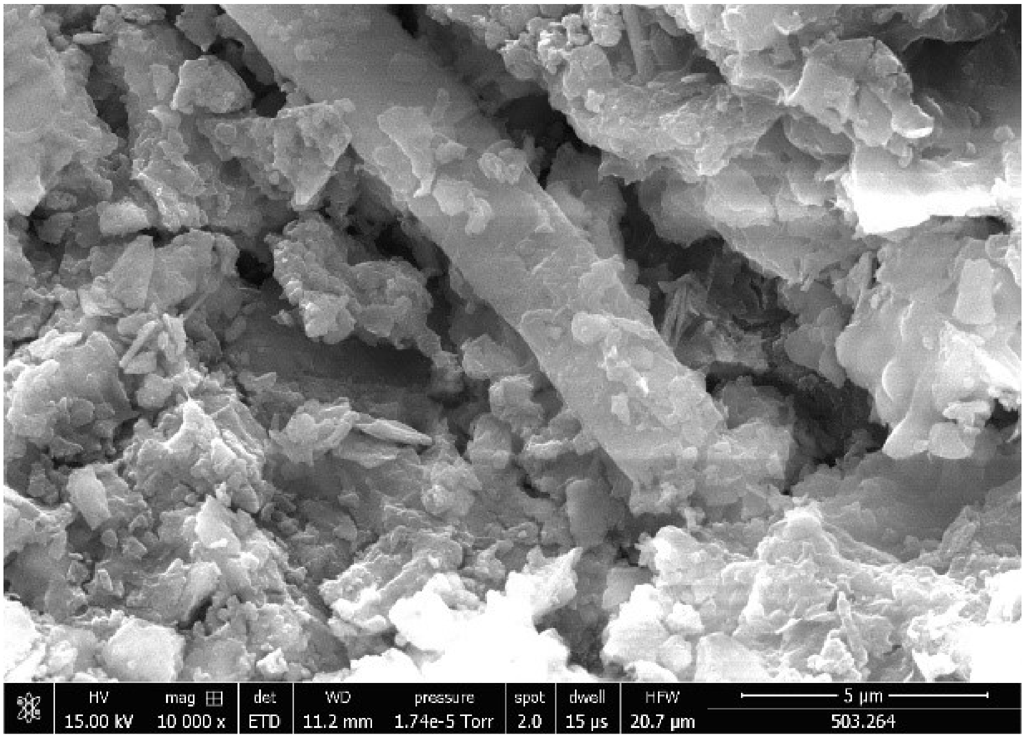


Figure 29. AM503.264, examined under x10k magnification.

DSC/TGA. The DSC/TGA plots were very simple in appearance, and they largely seemed quite similar to one another. There was, however, one distinct difference: whereas the mass curve for every other sample began in the upper left-hand corner and snaked toward the lower right, indicating a continuous loss of mass, both controls for 1000°C exhibited a U-shaped curve, indicating loss and partial regaining of mass. This resulted in 1000°C being firmly ruled out as a possibility. Apart from this, however, there appeared to be greater differences between the controls and the sherds, and between samples of different starting masses, than between the different temperature controls.

XRD. The XRD results confirmed the results of the previous analyses, ruling out 1000°C as a possible firing temperature and making 900°C appear unlikely. This interpretation was based on the presence of peaks in the sherds that were absent in the controls starting at 900 or 1000°C. There was some indication, however, that the sherds from Kiliuda Bay may have been fired to a slightly higher firing temperature than those from Red River or Younger Kiavak, as some peaks were consistently missing from those sherds that were present in the sherds from the other collections.

Manufacturing Time

To address the plausibility of the oil-rendering hypothesis, the first question is whether pottery is a more “expensive” technology than a seal stomach container. As the currency expended in this model is time, this is assessed by determining which technology takes longer to manufacture. If this condition is not fulfilled, if pottery is actually “cheaper” (quicker) to make than stomach containers, it becomes difficult from a behavioral ecology standpoint to explain why it was not adopted sooner, and across the board.

This first condition was unambiguously fulfilled: pots take longer to make than stomach containers, whether one looks at the gross time involved or only the active time (Table 6). For a pot, one must collect the clay, add the temper, construct the base and upper wall, then refine the shape and finish the surface, all before allowing the clay to dry out thoroughly and firing it.

Type	Estimate	Yield	Pot (m_2)	Stomach (m_1)	$m_2 > m_1$
Gross Time	**Liberal**	**High**	153.5	48	TRUE
		Low	153.5	48	TRUE
	Conservative	**High**	83.3	12	TRUE
		Low	83.1	12	TRUE
Active Time	**Liberal**	**High**	12.4	2.2	TRUE
		Low	11.6	2.2	TRUE
	Conservative	**High**	4.7	0.7725	TRUE
		Low	4.5	0.7725	TRUE

Table 6. Summary of experimental results for manufacturing time.

A stomach, on the other hand, is collected while harvesting and butchering a seal, a task that is already being performed for other reasons. It can then be cleaned and prepared for drying in the time it takes to perform any given step of pottery construction, and a simple wooden stopper can be fashioned as quickly. Expanding the estimate to include drying time (the gross time) does not change this relationship—a large, thick-walled pot takes at least as long to dry as a thin, membranous organ container. The finding for the first condition thus supports the oil-rendering hypothesis.

Return Rate

The second requirement of the model is that heat-rendering using pottery must have a higher return rate than self-rendering in a seal stomach. If this condition is not fulfilled, then efficient oil-rendering becomes a less plausible motivation for pottery adoption.

The answer to this question comes down to active vs. passive time. The experiments suggested that the main expenditure of active time associated with both rendering technologies was the preparation of the blubber. If one considers only active time, therefore, the only additional processing for self-rendering consists of putting the fat in the container, sealing it with the stopper, and placing it wherever it needs to be while rendering. All this can be accomplished in a few minutes.

			Pot			**Stomach**		
Type	**Estimate**	**Yield**	**Processing Time (hrs)**	**Yield (lbs)**	***Return Rate***	**Processing Time (hrs)**	**Yield (lbs)**	***Return Rate***
Gross	**Liberal**	**High**	24.88	42.00	*1.69*	6.50	5.5	*0.85*
		Low	8.03	12.83	*1.60*	5.97	3.285	*0.55*
	Conservative	**High**	23.53	42.00	*1.79*	4.27	5.5	*1.29*
		Low	7.19	12.83	*1.79*	3.78	3.285	*0.87*
Active	**Liberal**	**High**	18.97	42.00	*2.21*	1.50	5.5	*3.66*
		Low	6.23	12.83	*2.06*	0.97	3.285	*3.39*
	Conservative	**High**	11.56	42.00	*3.63*	1.27	5.5	*4.32*
		Low	3.53	12.83	*3.63*	0.78	3.285	*4.24*

Table 7. Summary of experimental results for return rate, given in lbs/hr.

If one assumes that the cooking fire is already in place before one begins (as in the conservative estimate, see Table 7), the return rates for heat-rendering are close to those for self-rendering. However, filling, situating, and stirring a pot takes longer than filling, sealing, and situating a stomach container, so the stomach container will always have an edge. If one includes the time required to make a fire (as in the liberal estimate), the gap between the two technologies widens (Table 7, 8, Figure 30). Therefore, if only active time is considered, this data does not support pots and stomach containers as MCTs—rather, the stomach container should be universally preferable (Figure 30).

Type	**Estimate**	**Yield**	**r_2 (Pot)**	**r_1 (Stomach)**	**$r_2 > r_1$**	**Margin**
Gross	**Liberal**	**High**	1.69	0.85	TRUE	0.84
		Low	1.60	0.55	TRUE	1.05
	Conservative	**High**	1.79	1.29	TRUE	0.50
		Low	1.79	0.87	TRUE	0.92
Active	**Liberal**	**High**	2.21	3.66	FALSE	1.45
		Low	2.06	3.39	FALSE	1.33
	Conservative	**High**	3.63	4.32	FALSE	0.69
		Low	3.63	4.24	FALSE	0.61

Table 8. Comparison of return rates for both technologies.

If, on the other hand, passive time is included in the calculation, the tables are turned. If one considers the amount of time spent waiting for the blubber in a stomach container to self-render, the return rate for pottery becomes higher (see Tables 7, 8, Figure 31). Therefore, if the gross amount of time that it takes to produce oil is considered, the findings for the second condition also support the oil-rendering hypothesis.

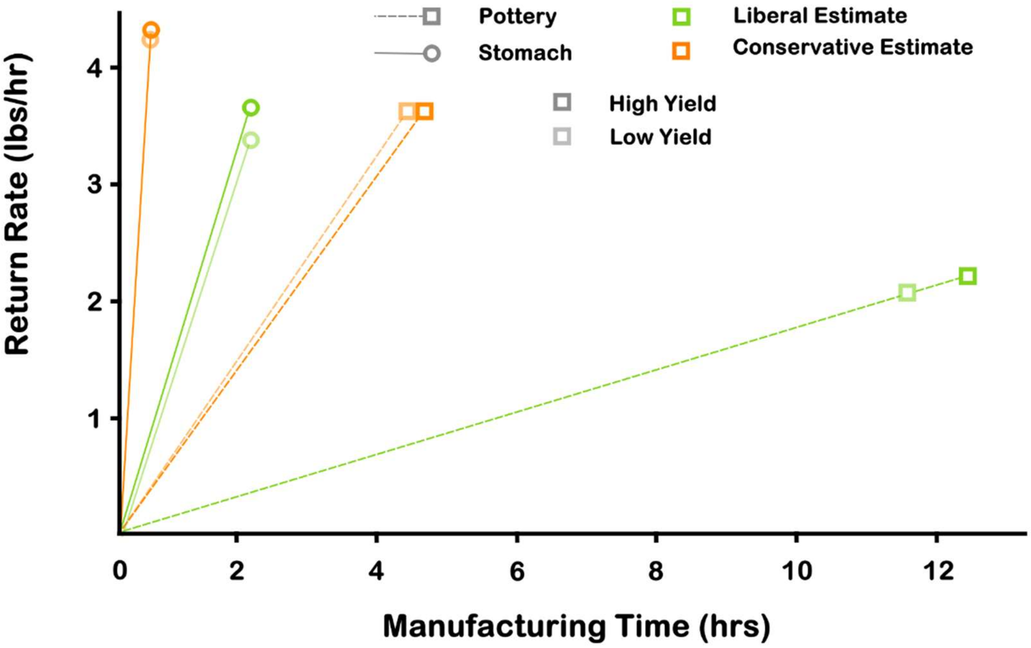


Figure 30. Graph of manufacturing times and return rates for active time only.

Mutually Competitive Technologies

The oil-rendering hypothesis relies implicitly on the idea that pottery may or may not be preferable to traditional oil-rendering technologies, depending on the behavioral context. Specifically, it posits that the need to render larger quantities of marine mammal oil triggered investment in ceramic technology. I have argued that this reasoning tacitly relies on the concept of Mutually Competitive Technologies (or MCTs), the special case wherein a more expensive but more efficient technology becomes a worthwhile investment only after one reaches a certain threshold of time spent processing the relevant resource. This scenario only applies in cases where the ratio of the cheaper technology's (technology 1's) return rate to its manufacturing time is greater than the same ratio for the more expensive technology (technology 2):

$$r_1/m_1 \geq r_2/m_2$$

If the more expensive technology 2 has a greater ratio of return rate to manufacturing time, then it will always be a worthwhile investment, meaning that technology 1, in this case stomach containers, would not be able to compete with it. If this were the case, additional factors would be required to explain why pottery was not adopted sooner, and throughout the Kodiak Archipelago.

As previously stated, the results considering only active time did not fulfil the model's second condition, so the relevant ratios are not given here. However, for the results that include passive time, the ratio of return rate to manufacturing time is higher for a stomach container than for a pot (Table 9, Figure 31). Thus, when the gross time spent is considered, pottery and stomach containers do indeed qualify as MCTs.

Estimate	**Yield**	**r_1 / m_1 (Stomach)**	**r_2 / m_2 (Pot)**	**$r_1 / m_1 > r_2 / m_2$**	**Margin**
Liberal	**High**	0.0176	0.0110	TRUE	0.0066
	Low	0.0115	0.0104	TRUE	0.0011
Conservative	**High**	0.1073	0.0214	TRUE	0.0858
	Low	0.0725	0.0215	TRUE	0.0510

Table 9. Comparison of r / m ratios for gross time for both technologies.

Table 9 also shows the margins by which each set of ratios differs. These margins are narrow, with the liberal/low yield scenario having the narrowest margin and thus being the most precarious result. Interestingly, this is also the scenario with the lowest return rate for both technologies (Tables 7, 8). Conversely, the estimate with the widest margin is for the conservative/high yield scenario, which also results in the highest return rates for each technology (Tables 7, 8). This indicates that, when each technology is at its best, so to speak, they are more clearly mutually competitive. On the other hand, when each is at its worst, the stomach container threatens to fall behind.

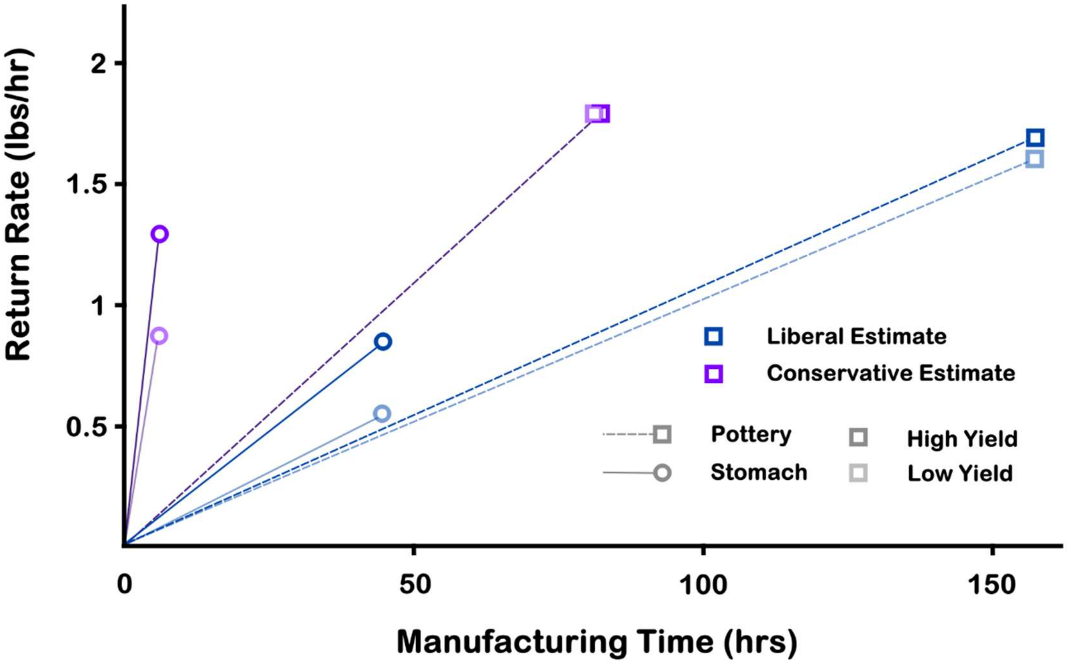


Figure 31. Graph of r/m ratios for gross time.

The Threshold Value of S

As discussed in chapter 2, since the two technologies qualify as MCTs, it is therefore possible to calculate a valid value for s, the amount of processing time at which the utilities of the two technologies—or the slopes, expressed as r / (m + s)—are equal (see Figure 4). I have calculated this value (Table 10, Figure 32), using the equation laid out in chapter 2. The results range widely, maintaining the same contrast between the liberal/low yield and the conservative/high yield scenarios. The threshold for the former (the least efficient scenario) is by far the lowest at ~7.5 hours, whereas the threshold for the latter (the most efficient case) is the highest, at 171.25 hours. The values for the other two cases fall between 50 and 60 hours.

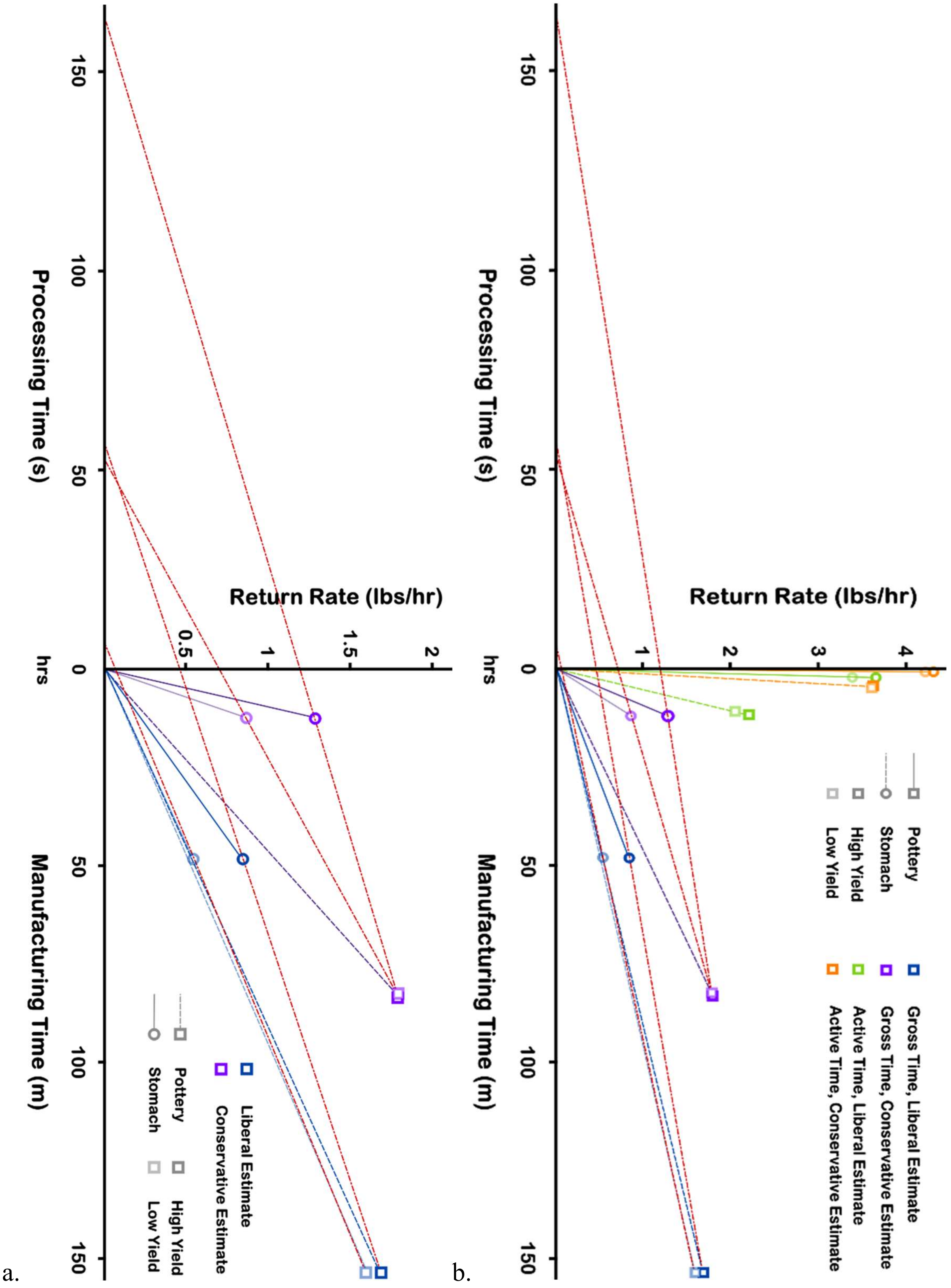


Figure 32. Graph of r/m ratios and thresholds for a) gross results and b) all results.

I have also provided two additional metrics to help contextualize these results. First, I have calculated the amount of fat that the s-value corresponds to for each of the technologies, by multiplying s by the appropriate return rate (Table 10). The results for pots range from ~12 to ~305 lbs of blubber, with the middle cases being ~100 lbs, whereas the results for stomachs range from ~4 to ~220 lbs, with the middle cases being ~50 lbs.

			Pot		Stomach	
Estimate	**Yield**	***s (hrs)***	**Fat (lbs)**	**# Seals**	**Fat (lbs)**	**# Seals**
Liberal	**High**	*57.93*	97.77	2 – 4	48.98	1 – 2
	Low	*7.48*	11.95	< 1	4.12	< 1
Conservative	**High**	*171.25*	305.71	7 – 11	220.44	5 – 8
	Low	*55.32*	98.76	2 – 4	48.14	1 – 2

Table 10. Results for the threshold values of s, with equivalent amounts of blubber and numbers of seals.

To provide additional context for the amounts of fat involved, I estimated the number of seals one would need to harvest to obtain such amounts of blubber. Based on interviews with Native Alaskan seal hunters, a single seal usually yields somewhere between 15 qt and 6 gal of oil (Haynes and Wolfe 1999). Assuming that seal oil has a similar density to olive oil (~7.6 lbs/gal) (United States Department of Agriculture 2012), a single seal should usually yield somewhere in the range of 28.5 – 45.6 lbs of oil. Based on this I determined that, for either technology, the threshold could be met with only part of one seal for the liberal/low yield case; with ~1 – 4 seals for the middle cases; and with ~5 – 10 seals for the conservative/high yield scenario.

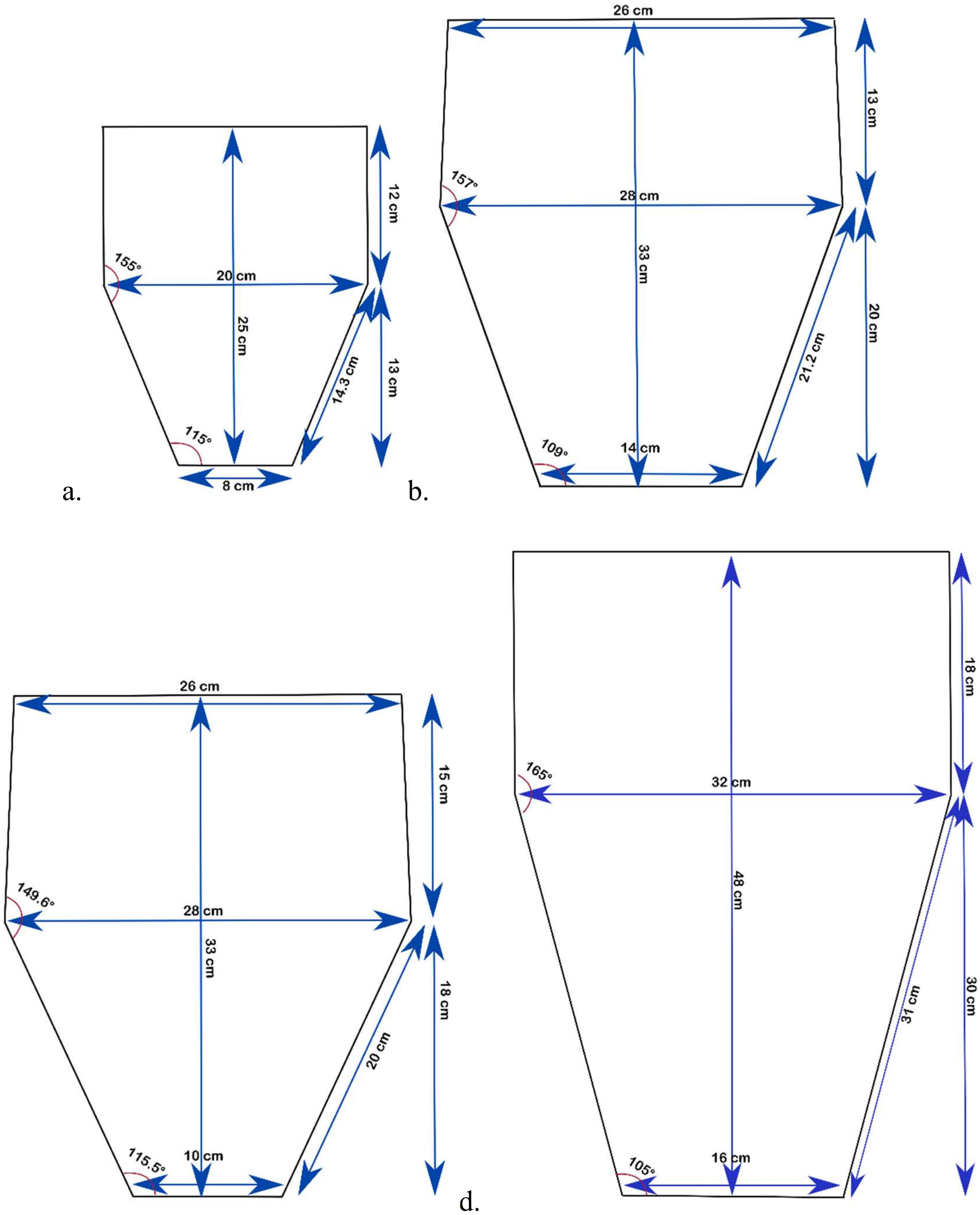
CHAPTER VI. DISCUSSION

In this chapter, I first elaborate on my findings about the manufacture and characteristics of Koniag pottery, then discuss the practical ramifications of the s-values derived in the previous chapter. I close by going over some of the factors that qualify and complicate the interpretation of the results.

The "Average" Koniag Pot

A range of dimensional values exists within the sample of ancestral Alutiiq pottery I was able to study, though overall levels of variation are low enough to confirm that all sherds examined likely fall into a single basic vessel form (see Appendix A for a brief discussion of standardization analysis as it relates to this sample). In particular, the angle of the shoulder was surprisingly consistent. This could potentially indicate that the shoulder angle was a key component in the ancestral Alutiiq conception of what a pot should look like—it certainly plays an important role in determining the overall proportions of the finished vessel. This consistency could also result from practical considerations, either in terms of the vessel's manufacture or of its function once completed.

Figure 33 displays a few options of what typical Koniag tradition pots might look like, using the mean and mode measurements from Table 4 as a baseline and referencing the most complete specimens (Figure 10) to fill in the gaps. Proportionally, base diameters generally appear to be no more than half the shoulder diameter, with the rim diameter being slightly smaller than or equal to that of the shoulder. The dimensions of the most intact specimens suggest that the lower wall was usually taller than the upper wall, though this is difficult to judge from such a small sample. The trends in base and shoulder diameters, however, combined with the consistency of the shoulder angles, tend to produce lower wall heights that are at least as great as the observed upper wall heights.



a. b. c. d.

Figure 33. Extrapolated diagrams of possible complete pots. Example a) is based on the small end of the observed dimensions; b) and c) are based on the specimens pictured in Figure 10a and c respectively; and d) is based on the large end of the observed dimensions. Example d) was used to generate the volume for the high yield estimates. Rim diameter is equal to shoulder diameter unless otherwise specified.

The qualitative results also yielded some interesting insights. First, the variation in temper types by collection suggests that the temper materials used by Koniag tradition potters varied based on what materials were most readily available. This is consistent with ethnographic evidence that Alaskan potters, while being very picky about clay sources, use a wide array of tempering agents, a pattern that Anderson (2019) interprets as indicating an indifference to temper content. In my experiments, I found it most convenient to gather temper when I gathered my clay, although I did not then have to carry it back to a village. It would be fascinating to know whether most pots are tempered with materials found adjacent to their corresponding clay source, or perhaps near the villages where they are found. A broader study of Koniag pottery collections would be helpful, if only to establish whether the trend of local temper variation holds true for other sites.

The second interesting point is the tendency for interior surfaces to be smoother than exterior ones (Figure 23). In my experience, it is much more difficult to smooth the interior of a tall pot than the exterior, so I suspect that even this subtle trend reflects a deliberate prioritization of effort. It suggests that the finish of what one might call the “performance” surface (the one in contact with the pot’s contents) was prioritized over that of the “display” surface (the one most readily visible). In other words, it likely reflects an emphasis on function over appearance, which is consistent with the overall lack of decoration. Both patterns, combined with the variations in wall widths observed even within a single sherd, suggest that ancestral Alutiiq potters were not terribly perfectionistic, preferring a neatly constructed vessel that would do the job over a painstakingly crafted aesthetic object.

I have found no reason to disagree with the evaluations of previous scholars regarding the basic manufacturing method of the pots (i.e. patch-building, with use of the paddle-and-anvil technique). I would add my observation that Kodiak clay, even when heavily tempered, tends to flow and slump. It is difficult to find a middle ground of moisture content where the clay is both stiff enough to support itself, and malleable enough to withstand further shaping. I addressed this difficulty by a) in some cases, constructing the base of the pot on an interior (convex) mold; and b) in all cases, propping up the lower wall with exterior supports for a time after turning out/while adding the upper wall (this latter tactic was not necessary when using the beginner-friendly clay). The use of such external supports, made from a variety of organic materials and used to brace the walls of vessels while drying, is documented ethnographically elsewhere in Alaska (Reid 1989:171).

An alternative technique would be to use a concave mold (perhaps made from the lower half of a large broken pot) to both shape and support the base; the pot could then be inverted, once the upper wall was attached and had begun to dry, and the mold lifted off. One advantage of concave molds is that the natural shrinkage of the clay while drying encourages the pot to detach from the mold, making turning out more straightforward (Rice 2015:138). A convex mold, on the other hand, would be consistent with the phenomenon of interior surfaces being smoother than exterior surfaces, as the interior surface would then be formed by pressing against the mold (Rice 2015:139). It is entirely plausible that both methods were used by different ancestral Alutiiq potters, or even by a given individual trying to produce differently sized vessels.

Either method could help to explain the consistency of the shoulder angles. The mold would act as a template for the lower wall, establishing the base angle, as well as the base and shoulder diameters and the lower wall height. The shoulder angle would then vary only by the degree of neck constriction desired in the finished vessel, which seems usually to have been low. And, if the lower wall construction were assisted using interior and/or exterior supports, it would be reasonable to exaggerate the height of the lower wall in comparison to the less-well-supported upper wall. A poorly supported upper wall would also be another reason to avoid extreme neck constriction (in addition to the easy access that wide mouths provide to the pot's contents while cooking), as the clay would be liable to collapse under its own weight if angled too sharply inward.

Evaluating the Plausibility of the Thresholds

To summarize the results discussed in the previous chapter, it was determined that, if only active time is considered, pottery and seal stomach containers do not constitute mutually competitive technologies—self-rendering in a stomach container, the cheaper of the two technologies, also has a higher return rate. This means that, based solely on efficiency of labor, there is no clear reason for anyone to make a pot to render oil. In this paradigm, therefore, either there was another impetus for pottery adoption, or there is some other factor that makes pottery a preferable technology for rendering large amounts of oil.

The inclusion of passive time appears to be that other factor. If the gross amount of time that elapses over the course of the rendering process is considered, the return rate for pottery becomes greater than that for stomach containers, and the r / m ratios work out such that the two technologies may be considered mutually competitive. The only remaining obstacle is the plausibility of the resulting s-values—if the s-value is low enough that a household producing only for their own subsistence would meet it, then the threshold becomes functionally irrelevant, and pottery becomes preferable in every case.

It is typical for contemporary Alaska Native households which practice a degree of traditional subsistence to take one or two seals each year and to consume the corresponding quantities of oil (Haynes and Wolfe 1999). This level of consumption meets the threshold calculated for seal stomachs in all cases but the conservative/high yield scenario. Further, since these households presumably supplement their diet with store-bought foods, and since Koniag tradition households were likely larger, one would expect precontact families to have consumed more oil than this. It thus seems plausible that Alutiiq ancestors producing oil at a subsistence level could have also met the threshold quantities of oil calculated for pottery, corresponding to the total blubber yield for up to four seals—again, in every case but the conservative/high yield scenario.

The threshold for this scenario, however, being in approximately the 5 – 10 seal range for either technology, represents five times the level of oil consumption seen among contemporary households. It is therefore plausible, in the conservative/high yield case only, that the threshold at which pottery becomes worthwhile would be reached only by producing surplus quantities of oil. This is thus the only case in which the model, in and of itself, supports the hypothesis—and even this may be questioned, depending on how large the typical Koniag tradition household was, and how much more oil each of them consumed than their modern counterparts.

The contrast between the conservative/high yield case and the liberal/low yield case is fascinating. The low threshold produced by the latter scenario means that the smallest pot, which takes the longest to make and use, becomes superior almost instantly to the smallest and slowest-drying stomach. On the other hand, even a truly enormous pot, efficiently constructed and based on the large end of all measurements obtained for pottery (Figure 33d), only becomes superior to a moderately larger stomach after rendering more oil than several people would consume in a year. There is no definitive resolution to this tension—both pots and stomachs would have varied considerably in size. It seems likely, however, that the most common case would be somewhere in the middle, and that a typical household would have a decent chance of hitting the threshold in the course of a year. In terms of the gross time spent, therefore, heat-rendering in a pot looks in most cases to be outright superior to self-rendering in a stomach.

Other Factors

There are a few caveats that must be kept in mind when considering these results. To begin with, the manufacturing time estimates are based on making one pot/stomach container at a time (including firing one pot at a time) and do not account for failure rates in the construction of both technologies. These failure rates are almost certainly higher for pottery, as even experienced potters can routinely lose up to 100% of the vessels included in any given open firing attempt (Rice 2015:Table 10.3). For stomach containers, on the other hand, the main danger is puncturing the membrane, a mistake that can largely be avoided with practice (Frink and Giordano 2015). Compensating for this imbalance, however, one can consistently manufacture multiple pots simultaneously in a similar gross amount of time to that is needed to make one, whereas this is only possible for stomach containers if multiple seals are brought home on the same day.

Another issue is that all return rates are based on one instance of either technology being used sequentially. In reality, as mentioned in chapter 2, it is more likely that several stomach containers would be in use simultaneously. If several stomach containers have been saved from previous years, and a sufficiently large amount of blubber becomes available, one can easily fill one stomach after another and let them render together. The active time spent would grow with the number of containers being filled, but the passive time would be the same as for one, leading to only a small increase in the gross time spent. A similar effect could be achieved for heat-rendering by dividing one's attention between a few pots placed around the edges of hearth and/or heated indirectly. To determine the impact of such practices on the results would require further experimentation, ideally with larger pots and actual seal products.

The last wrinkle concerns the return rates for heat-rendering specifically. The processing times for different volumes of pot were calculated assuming a) that the amount of time required for heat-rendering is directly proportional to the weight of the fat being rendered, rather than it being more time-efficient to render larger amounts at once; and b) that all fat processing is done before the pot is set in the fire, rather than fat continuing to be cut up and added to the pot as it is being heated. The second factor does not affect the amount of active time spent, but it inflates the amount of passive time involved, whereas the first factor impacts both values. If these assumptions are false, the return rates especially for the gross time estimates of pottery use would increase, and the threshold values would decrease, potentially to the point that they could all be reached through basic household subsistence. Depending on the extent of the reduction in processing time, some of the scenarios might no longer fit the conditions for MCTs, with pottery instead being preferable for all values of s. In other words, when considering the gross time spent, pottery may be even more valuable than my results suggest.

CHAPTER VI. CONCLUSIONS

As laid out in the previous chapter, the case for pottery and seal stomach containers as MCTs is shaky at best. For active time estimates, stomachs were found to be superior outright; for most gross time estimates, pottery is superior, either outright or for a sufficiently low threshold value that households all over the archipelago could have benefitted from it. This chapter unpacks the implications of this finding. I begin by reassessing the core of the oil-rendering hypothesis, then go on to evaluate some of its variations in light of this new insight. I then discuss the broader archaeological significance of the study and propose some directions for future research.

The Hypothesis Revisited

It looks as though the deciding variable between the two technologies is not so much the quantity of blubber one wishes to render, but how quickly one needs it done. In other words, if the overall turnaround time for rendering a certain quantity of blubber matters more to you than the amount of labor (active time) required, then pottery becomes the clear solution. This concept will be familiar to scholars of the origins of agriculture, or of resource intensification in general, which involves increasing one's total caloric return (or the predictability of that return), but accepting a lower return *rate* to do so (Barlow 2002; Earle 1980). In both cases, the actor chooses a less efficient, more labor-intensive strategy in the service of some other desirable outcome.

Viewed through this lens, the oil-rendering hypothesis becomes quite logical. If the priest Gideon's account is accepted (Black 1977), a good whale catch could yield up to 50 barrels of oil, which should equate to ~2,100 gal, or ~16,000 lbs of blubber. That's

~3,000 large stomachs-worth, or enough to fill ~400 large pots. Furthermore, whale carcasses spoil very quickly—as soon as a whale is killed, its body heat begins to rot the body from the inside, sometimes to the point of the carcass exploding from the heat (Amy Steffian, personal communication, 2024). Even if only a fraction of the blubber was retrieved, whether due to meat sharing (Crowell 1994), spoilage, or transportation issues, it would be challenging to render and store it all before it was lost to decomposition. Therefore, even if whales were not taken any more frequently during the Koniag tradition than at other times, heat-rendering in large pots could have enabled Alutiiq ancestors to process more blubber from each whale-fall than would otherwise have been possible.

This concept also aligns with Fitzhugh's (1996) suggestion that the hypothesized movement toward surplus oil-production was spurred on by increasing social inequality. Fitzhugh points mainly to the growing influence of a village chief over the endeavors of the community. Additionally, however, these chiefs might have been especially inclined toward this type of intensification because they would have had slave labor at their disposal. Both factors speak to the potential ability of chiefs to enact resource-processing behaviors that individuals and households would otherwise have no reason to participate in, or that they might not otherwise even have been willing to perform.

Thus, while the demands of the model are only dubiously satisfied, the crux of the hypothesis is still supported: if southern Alutiiq ancestors decided to start mass-rendering oil, and if they did not mind having to put in more work to meet a deadline, then pottery could have helped them to do so. However, the results do change the framing of the argument somewhat. The original argument, which cast the increasing volume of oil production as the motivation for pottery adoption, may still hold true to an extent, in terms of the increased capacity that pots offer over stomachs. However, given the amount of blubber that can come from even a single whale, northern villages could also benefit from this increased capacity, especially if the rarity of their whaling successes motivated them to make the most of each one. To preserve the original explanatory power of the hypothesis, therefore, it becomes necessary to argue not just that southern Alutiiq ancestors wanted to render *more* oil than their northern neighbors, but that they wanted to render it *faster.*

Variations on the Hypothesis

The question then becomes, why would the speed of oil-rendering be a priority? What were they doing with all that oil, and why did they need it so quickly? Three things could have happened to the oil rendered in traditional Alutiiq pottery: it could have been stored (to buffer against shortages), transported (as in trade), or used immediately (as in a feast). If the oil was either stored or transported, it would have to either stay in the pot, or be transferred to another container. I will go through these possibilities and assess how well they align with the need to render oil on a tight schedule.

Storage. Some of the oil produced using pottery would certainly have been stored. If the *main* use of pottery was the production of oil for storage, however, it would indicate that marine mammal oil production did not reach the point of true over-production, as is assumed in the initial hypothesis. Besides being in tension with Fitzhugh's (2003) interpretations of the period, this scenario would make it harder to reach the threshold level of oil production needed for pottery to be useful. That being said, given the size of Koniag tradition households, and the possibility that these thresholds have been overestimated, it is still plausible that a family's effort to increase their food security could tip the balance.

However, if the end goal is storage, the need for speed disappears—the oil, by definition, will not need to be accessed for some time. Whether the oil is being stored in the pot after rendering, or being transferred to stomach containers (which could hold more if filled with pre-rendered oil instead of solid fat), the main advantage of a pot over a stomach is the increased capacity it offers, not its timeliness. As mentioned above, speed is helpful in trying to process as much whale blubber as possible in the short window of time available before it spoils, but again, this advantage would apply to any village that practiced even occasional whaling. Thus, the storage variation of the oil-rendering hypothesis does not explain the absence of pottery in the north of Kodiak.

Trading. The second option, and the one favored by Fitzhugh's formulation of the hypothesis, is for the surplus oil to be transported for trade. Being able to produce oil quickly would enable trading expeditions to depart more frequently and to carry more with them. Koniag pots, however, are poorly suited to transport—being large, heavy, wide-mouthed, and fragile, they would not be ideal for packing into a skin-covered kayak, and even less so for carrying on foot when full. There is also little evidence of pots being taken north and left there, with the possible exception of the pottery found at Pasagshak Bay and Crag Point (Figures 1 and 2).

More likely, the oil would be transferred to other containers for transport—likely stomach containers, which in contrast are lightweight and water-tight. One might well ask whether the oil-traders would have had enough stomach containers to make such a trade sustainable, but this problem is resolved if the oil is eventually transferred into the customers' own containers. This is the cleanest version of the trading model, in which the pottery-using village can produce massive amounts of oil, store it temporarily, and dispose of it in a way that frees them up to produce (and transport) even more.

Feasting. The third option is the feasting model, in which these surpluses are produced in advance of specific feasting occasions, with the purpose of being consumed and/or given away by the host (an existing or aspiring elite). While the motivation derives more from social rather than economic factors, the scenario still plays to pottery's functional strengths: a feast would require a large amount of oil, on a specific timeline. The pots' wide mouths would also be very convenient for many hands to reach into at a large gathering, or for the host to serve from when distributing gifts.

There are two issues here. One is that feasts are thought to be predominantly winter affairs. And, while a level of marine mammal hunting was practiced year-round (Amy Steffian, personal communication, 2024), most of the blubber would still be obtained during the summer months. If oil rendered during the summer was set aside to be used in winter feasting, then the feasting model essentially becomes a special form of the storage model, and the time pressure again disappears. If it were possible (and desirable) to store large quantities of blubber unrendered for long periods of time, perhaps in pits such as are used elsewhere in Alaska (Frink and Giordano 2015; Haynes and Wolfe 1999), then it could perhaps be rendered to order, so to speak, when the chief chose to hold a feast. Otherwise, the model works best if at least some feasts are held during the summer or autumn.

The other problem is that, while this model gives a good explanation for the value of pottery as an oil-rendering technology, it does not necessarily explain the spatial patterning of pottery adoption. Feasting was presumably not unique to the southern regions of the archipelago, and again, even occasional whale-falls could potentially furnish adequate materials and justification for a feast. However, large amounts of marine mammal oil would likely have been a more regular feature of southern feasts than of northern ones, which may have made the difference.

The Verdict. The foregoing discussion seeks to identify the most likely single impetus that pushed some Alutiiq ancestors to begin making pots, or perhaps the conditions that helped the technology to catch on—but only in the south. On those grounds, no version of the storage model is particularly convincing. This leaves the trading and feasting models. Both trading and feasting would likely have been driven by the elites, and both offer avenues to increase, solidify, and demonstrate elite status, whether through the acquisition of exotic luxury goods (in the case of trade with the mainland) or performative extravagance and generosity. We also know that both feasting and mainland trade increased during the Koniag tradition as compared to the Kachemak.

The two models have very different groundings. The most efficient version of the trading model (where the customers provide their own containers) is grounded in HBE and makes the most sense from an etic perspective—it is the most optimized, perhaps the most economically savvy. It is the most closely aligned with Fitzhugh's formulation of the oil-rendering hypothesis and thus has all the benefits of that formulation, offering a more robust rationale for the spatial distribution of pottery adoption on Kodiak than any other model. On the other hand, it requires the most forethought and the largest scale of logistical coordination to execute, and it would likely involve the largest departure from preexisting lifeways. It is also difficult to spot in the archaeological record—imports may be detected, in the form of exotic goods, but exports are much harder to identify.

The feasting scenario, on the other hand, feels very grounded in the emic human experience. Feasting is a commonly recorded occurrence among socially complex hunter-gatherers, and most of us can relate more viscerally to the joy of a full pot at a feast than to the entrepreneurial spirit required for the trading scenario. This model also provides for the incorporation of pottery technology into existing practices of feasting and ceremonialism, which can be key in facilitating the adoption of new technologies by the larger population (Eerkens and Lipo 2014). The justification for pottery only being used in the south is difficult to demonstrate objectively without a clear idea of how much oil might be rendered for such an event—how many feasts per year are enough to justify pottery investment? Intuitively, however, it is easy to see how the abundance of oil at southern feasts could have grown into a social fixture of its own, perhaps becoming a matter of local pride and identity, in a way that might be absent in the north.

The theoretical differences between these two scenarios mean that either may seem more convincing, depending on one's own background and tastes. Perhaps future evidence will reveal a clear frontrunner. That said, it is not necessary to choose between them. Both practices could well have occurred simultaneously—the taking of a whale might be celebrated with an oil-rich feast, adjacent to which more oil might be rendered for trade (as well as household-level storage). They might not even have been seen, at the time, as separate behaviors—both involve taking fuller advantage of the region's abundance of marine mammals, one to increase the community's (and the chief's) wealth, the other to celebrate that wealth.

In fact, all the scenarios described above may well have played out to varying extents, as Alutiiq ancestors experimented with the uses of this new craft. Perhaps some pottery-producing villages did trade pots to other settlements, with or without oil in them, found it unrewarding, and stopped; perhaps other villages saw their example and decided not to follow suit. HBE is grounded in evolution, which is driven by trial and error. Given that the ceramic tradition on Kodiak existed for only a few centuries before the entire region was disrupted by Russian influence, they may not even have had time to settle on the optimal pattern of pottery use for their environment.

And, of course, that environment would have continued to change. It is difficult for archaeology to track generation-by-generation developments, but from an ancestral Alutiiq perspective, the Koniag tradition must have felt very eventful. Beyond Clark's (1968) tentative observation of increasing rim style complexity through time, we know very little about the development of pottery use in Kodiak. However, once ceramic technology became a fixture of life in southern Kodiak, it is only natural that it would be turned to a variety of purposes, some of which may not have been strictly optimal. Variations in physical environment, social circumstances, and individual preference would have conspired to produce a range of behaviors, such as using them to process fish in riverine settlements (Admiraal, Lucquin, von Tersch, et al. 2020), or to store traditional foods and symbolize persistent cultural identity during the colonial period (Miller 2023:101–103).

Broader Significance

The main findings of this study are that heat-rendering oil in a pot a) is more labor-intensive than self-rendering it in a stomach container, but b) that it is superior for rendering large amounts of oil in a short period of time. This is something that, strictly speaking, no one ever *needs* to do—one can survive just fine on self-rendered oil. It is not even something that everyone would *want* to do—from a household management standpoint, tasks that are low in active time but high in passive time are ideal, as there is always something else to be doing in the meantime. Instead, the results further confirm what is suggested by even a superficial look at Kodiak's ceramic tradition: pottery offers something extra, an unnecessary service which, nevertheless, became important to the people of a particular time and place.

The above variations of the oil-rendering hypothesis—trading, feasting, and combined—each tell a story in which social change, particularly the emergence of elites, leads a group to alter their relationship to a special feature of their environment. In this account, increasing social complexity, including the solidification of villages as individual political units, drives a broader trend of regional differentiation within a culture area. Perhaps the common use of pottery fostered feelings of southern solidarity; perhaps existing solidarity facilitated its spread throughout the region (Eerkens and Lipo 2014). Regardless, the uneven distribution of pottery signals an emergent feature of Kodiak's social landscape that might otherwise have gone unnoticed.

The results of this study may be applied in various ways to the wider question of hunter-gatherer pottery adoption. If one focuses on the feasting model, the results could support Kodiak as another instance of the aggrandizer-feasting hypothesis of pottery adoption at work. The trade model, on the other hand, foregrounds pottery's potential as a tool for economic intensification, and one that opens up the potential for otherwise unviable strategies. Both models rely on the level of sedentism that had existed throughout Kodiak prior to the Koniag tradition, not just to make pottery more convenient, but to create the village-based social structure that made it valuable in the first place. If any form of the oil-rendering hypothesis is correct, then, the lessons from pottery adoption on Kodiak will apply most strongly to socially complex and prosperous hunter-gatherer groups, whose individual social units exhibit strong internal cohesion.

In any case, the presence and nature of self-rendering technology tells us that, if the main purpose of pottery was oil-rendering, it wasn't adopted for casual use as a labor-saving device. This finding in itself is relevant to discussions about Arctic pottery use, which frequently reference oil- and grease-related subsistence activities as potential benefits of pottery (Hayden 2019, Reid 1989). At the very least, it echoes the work of Harry and Frink (2009) in emphasizing the importance of understanding the full suite of food processing technologies in play before making statements about the advantages of pottery. It also suggests that, sometimes, the appeal of pottery may not be that it performs a particular task better, per se, but that it performs it differently. This only reaffirms the significance of the event of pottery adoption in a culture, in that it signals a change in tactics, a reorientation. The ceramicist's ongoing challenge, then, is identifying the nature of these reorientations.

Future Research

Many aspects of this study could be improved, with additional time and resources, simply by doing the same things more and better. In particular, as indicated above, it would be valuable to be able to repeat each of the experiments, testing different variations and, with the appropriate permits, using actual seal products. The interpretations would also benefit from the development of a model designed specifically to deal with container technologies. One starting point for this would be to incorporate ideas from the industrial world, which has developed extensive frameworks to deal with production capacity.

Some of the ambiguities in the above interpretations could also be addressed by targeted study of the Koniag tradition sites that have already been investigated. A detailed review of the evidence on population sizes, for example, in conjunction with the faunal record, could help reevaluate the possible presence of true overproduction. It would be very helpful to know things like how many seals a household generally took in a year, and how this changed over time. The specific provenience of pottery within a site, if found in or near a residence rather than the midden, could also shed light on its place in everyday life—a concentration of pottery in the homes of elites, for instance, would align well with the feasting model. And, given the importance of regional factors to the whole topic, it would be very interesting to know whether any of the pottery that has been found was, in fact, traded in from elsewhere in the archipelago.

But the main priority, as I see it, is the further incorporation of traditional knowledge through collaboration with contemporary practitioners. The process of carrying out these experiments threw into sharp focus for me how much I did not know about the specifics of these activities, in ways that could make crucial differences. How reusable *are* stomach containers? How long *can* blubber be stored, unrendered? What precise conditions and procedures are needed to self-render oil safely? What additional precautions need to be taken for fermentation? Much of this could be clarified through collaboration with frequent practitioners of the self-rendering technique, potentially in the form of joint experimentation (as described in Frink and Giordano 2015). And, for those crafts that are no longer frequently practiced, there are often people around, like Coral

Chernoff, who have already started the work of trying to reconstruct them. Any future experimental work of this kind should proceed in conversation with the wealth of practical knowledge already existing in these communities.

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APPENDICES

Appendix A. Summary of Data from AMAR Collections

In addition to basic summary statistics and data visualizations, I have included the coefficient of variation (CV) when the sample size is large enough to warrant it. The CV is defined as a sample's standard deviation divided (normalized) by the mean, creating a unitless metric expressed as a percentage. This metric is the accepted method for measuring the degree of standardization of an assemblage of artifacts, a characteristic that is meant to provide insight into the production context. The following table summarizes the interpretation of differing CVs, based on the Weber fraction which determines how precisely humans are able to perceive differences in an object's dimensions without measuring devices (Eerkens and Bettinger 2001):

CV	**Indicates**
<1.7%	Use of rulers/molds
1.7 – 5%	Highest possible unaided human standardization
5 – 20%	"Regularized" production, existence of mental template
~57.7%	Completely random production
>57.7%	Deliberate differentiation, existence of multiple "types"

Table A.1. Interpretations of varying coefficients of variation (Eerkens and Bettinger 2001; Eerkens 2000; Mączyńska 2021; Warden 2013).

Overall, CVs for the assemblage tend to hover in the 15 – 25% range, indicating that a single type of vessel was manufactured, and that the makers likely shared a rough mental template of what a pot "should" look like (Mączyńska 2021; Warden 2013). CVs for the shoulder angle, however, are surprisingly low, falling closer to the 5% mark. As discussed in the main text, this could indicate that the shoulder angle was key to the functionality of the pot in some way, or that it was limited by some aspect of the manufacturing process.

I also performed tests for difference on these data, separating them both by collection and by riverine vs. coastal setting (AM503 vs. all other collections), but I have not included the results here. The main finding (as evidenced by the plots below) was that AM106 tended to differ significantly from the other collections, tending to have thicker walls and smoother inner surfaces, as well as possibly having larger shoulder diameters and smaller rim diameters. Riverine vs. coastal differences were also often significant, but this is likely due to the presence of AM106 in the coastal data.

Wall Thickness

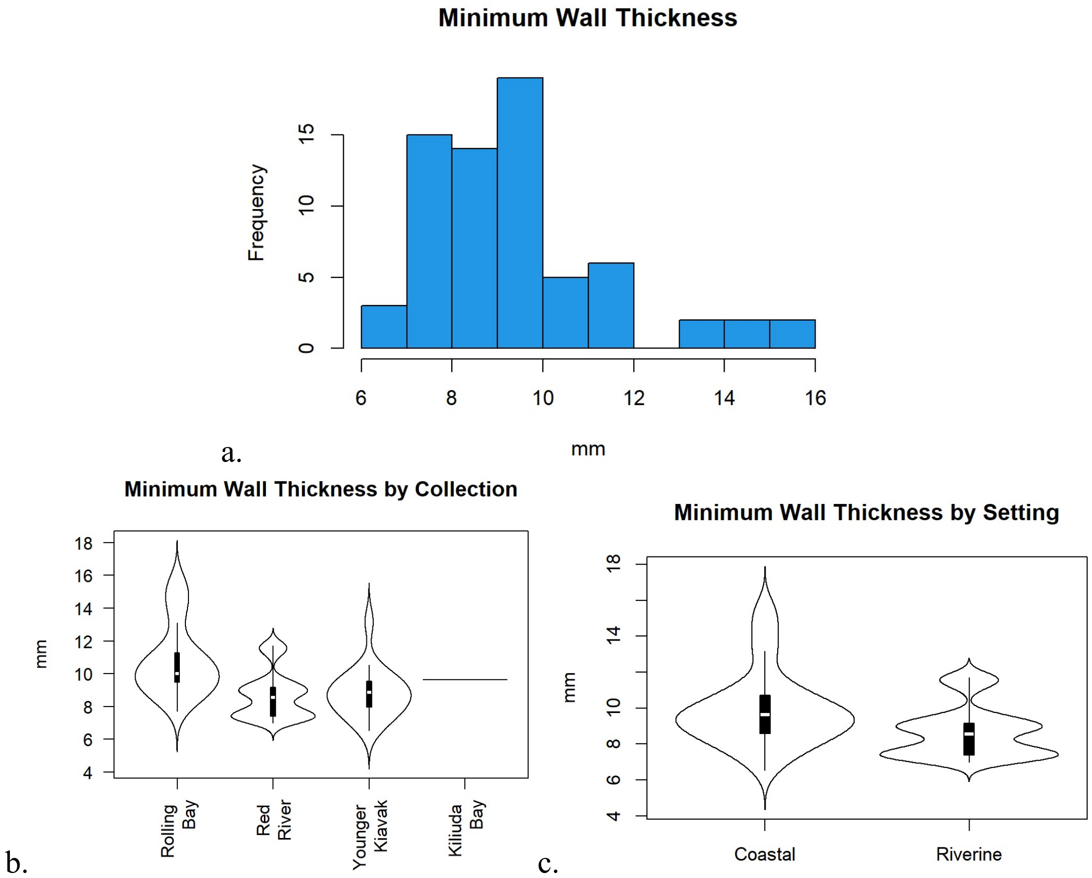

Figure A.1. Summary figures for minimum wall thickness. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

Sample	***n***	**Min**	**Median**	**Mean**	**Max**	**SD**	**CV**
Overall	*68*	6.53	9.07	9.50	15.7	1.98	21%
AM106	*25*	7.7	19	10.78	15.7	2.41	21%
AM596	*19*	6.53	8.87	8.80	13.18	1.49	17%
AM821	*2*	9.63	–	–	9.64	–	–
AM503/Riverine	*22*	7	8.56	8.65	11.71	1.42	16%
Coastal	*46*	6.53	9.635	9.92	15.7	2.09	21%

Table A.2. Minimum wall thicknesses in mm.

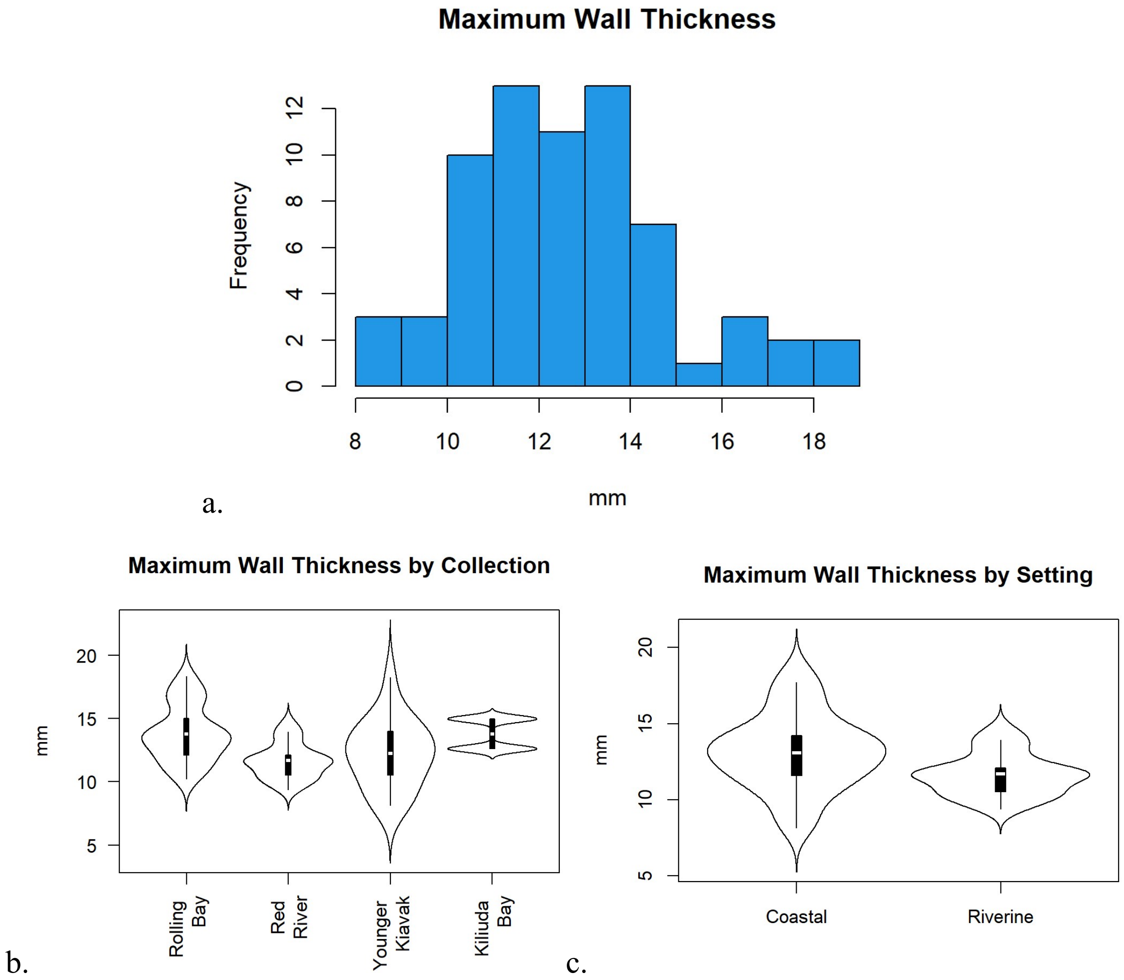

Figure A.2. Summary figures for maximum wall thickness. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

Sample	***n***	**Min**	**Median**	**Mean**	**Max**	**SD**	**CV**
Overall	*68*	8.15	12.31	12.66	18.31	2.29	18%
AM106	*35*	10.25	13.76	13.82	18.31	2.24	16%
AM596	*19*	8.15	12.25	12.20	18.24	2.63	22%
AM821	*2*	12.61	–	–	14.97	–	–
AM503/Riverine	*22*	9.4	11.68	11.63	14.62	1.39	12%
Coastal	*46*	8.15	13.08	13.15	18.31	2.48	19%

Table A.3. Maximum wall thicknesses in mm.

Base Thickness

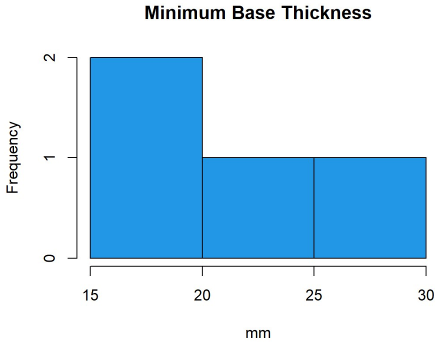

Figure A.3. Bar chart showing findings for minimum base thickness.

Sample	***n***	**Min**	**Median**	**Mean**	**Max**	**SD**	**CV**
Overall	*4*	18	20.33	21.92	29	4.87	22%
AM106	*3*	18	19.84	22.28	29	4.87	22%
AM596	*1*	–	20.82	–	–	–	–

Table A.4. Minimum base thicknesses in mm.

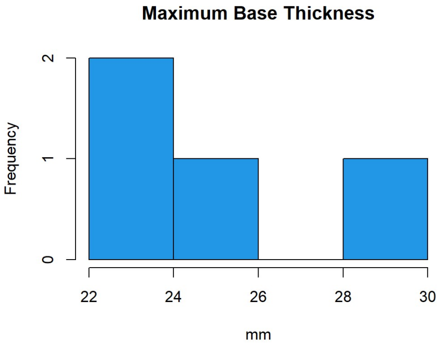

Figure A.4. Bar chart showing findings for maximum base thickness.

Sample	***n***	**Min**	**Median**	**Mean**	**Max**	**SD**	**CV**
Overall	*4*	23.13	24.09	25.08	29	2.71	10.80%
AM106	*3*	23.13	24.76	25.63	29	3.03	12%
AM596	*1*	–	23.43	–	–	–	–

Table A.5. Maximum base thicknesses in mm.

Diameters

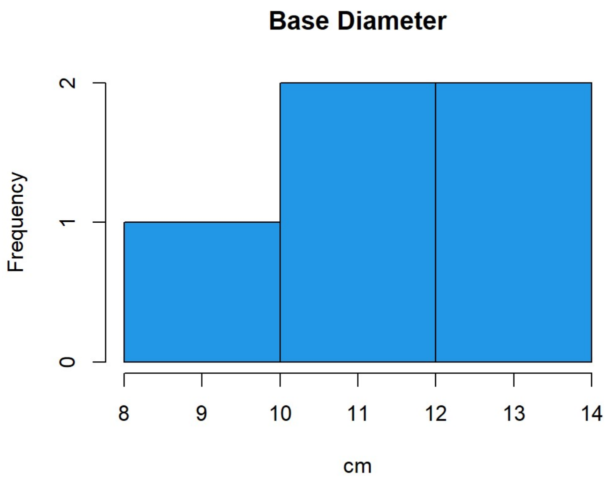

Figure A.5. Bar chart showing findings for base diameter.

Sample	*n*	Min	Median	Mean	Max	SD	CV
Overall	*5*	8.15	12	11.55	14	2.28	19.73%
AM106	*1*	–	13	–	–	–	–
AM596	*1*	–	12	–	–	–	–
AM821	*2*	8.15	–	–	14	–	–

Table A.6. Base diameters in cm.

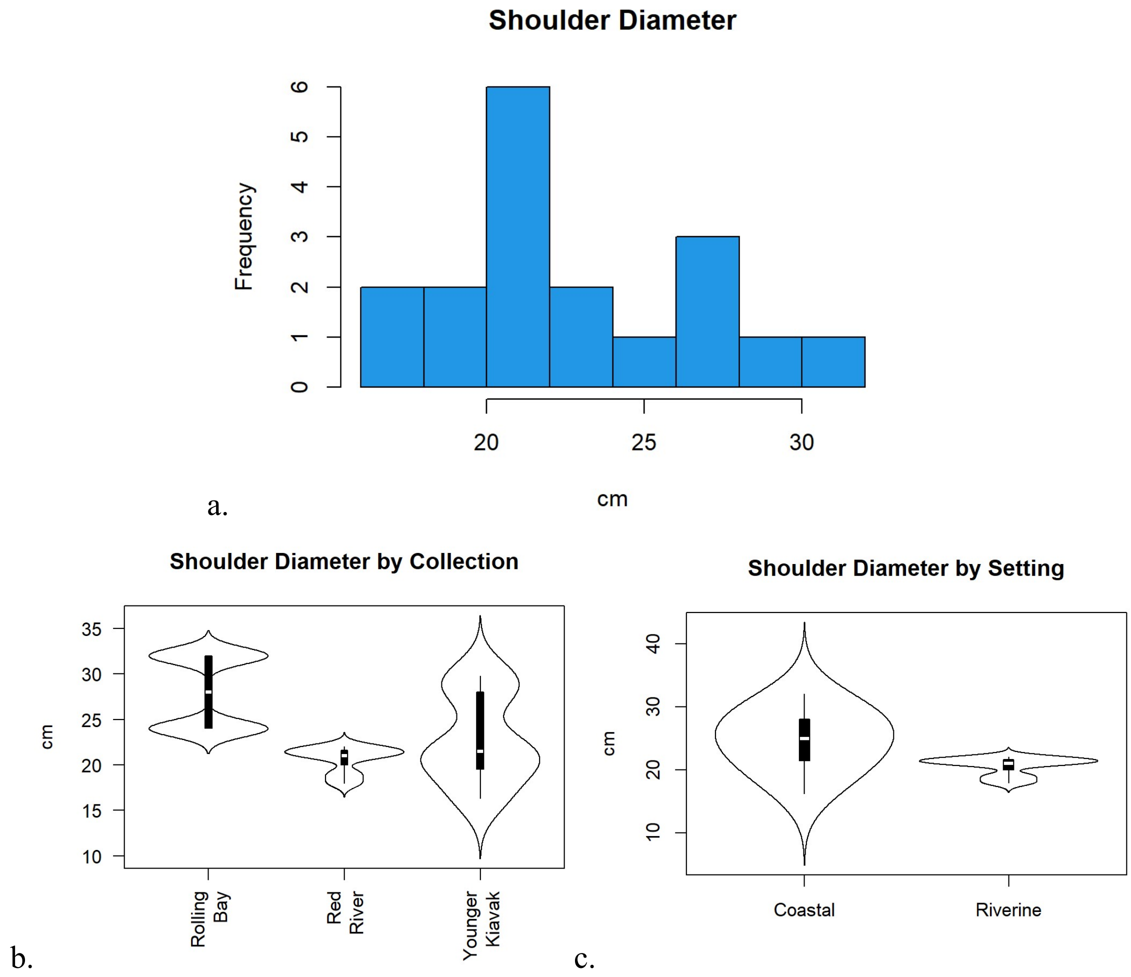

Figure A.6. Summary figures for shoulder diameter. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

Sample	***n***	**Min**	**Median**	**Mean**	**Max**	**SD**	**CV**
Overall	*18*	16.3	21.85	23.14	32	4.27	18.47%
AM106	*2*	24	–	–	32	–	–
AM596	*6*	16.3	21.5	22.77	29.8	5.16	23%
AM821	*1*	–	25	–	–	–	–
AM503/Riverine	*7*	18	21	20.61	22.03	1.50	7%
Coastal	*11*	16.3	25	24.75	32	4.73	19%

Table A.7. Shoulder diameters in cm.

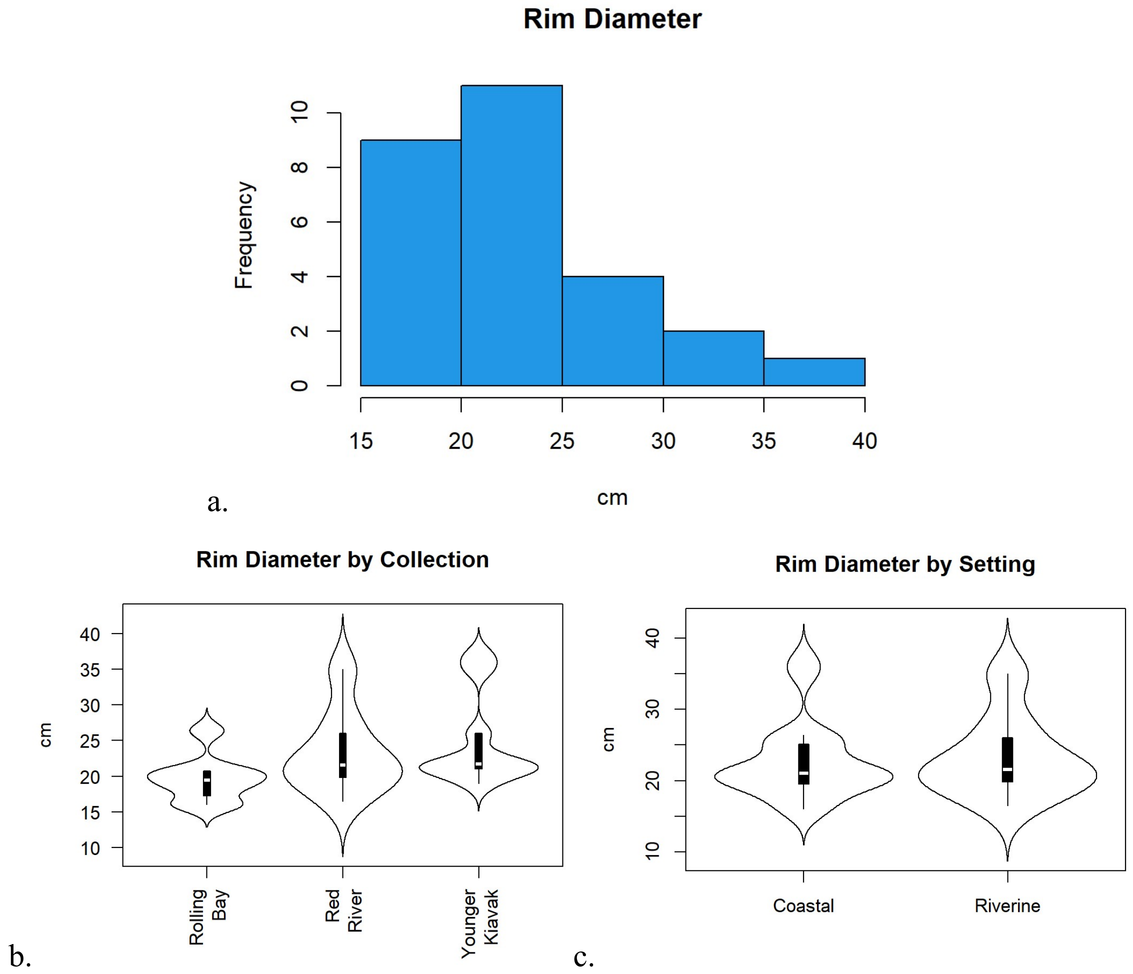

Figure A.7. Summary figures for rim diameter. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

Sample	***n***	**Min**	**Median**	**Mean**	**Max**	**SD**	**CV**
Overall	*27*	16	21	22.87	37	5.23	24.16%
AM106	*8*	16	19.42	19.64	26.4	3.31	17%
AM596	*9*	19	21.7	24.89	37	6.59	26%
AM821	*1*	–	24.67	–	–	–	–
AM503/Riverine	*8*	16.5	21.53	23.27	35	5.84	25%
Coastal	*19*	16	21	22.70	37	5.55	24%

Table A.8. Rim diameters in cm.

Angles

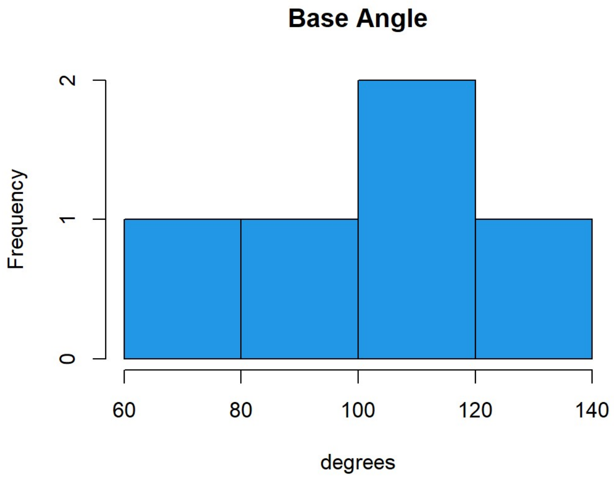

Figure A.8. Bar chart showing findings for base angle.

Sample	*n*	Min	Median	Mean	Max	SD	CV
Overall	*5*	75.45	103.65	106.21	135	22.29	20.98%
AM106	*1*	–	103.7	–	–	–	–
AM596	*2*	75.45	–	–	118.35	–	–
AM821	*1*	–	98.6	–	–	–	–
AM1012	*1*	–	135	–	–	–	–

Table A.9. Base angles in degrees.

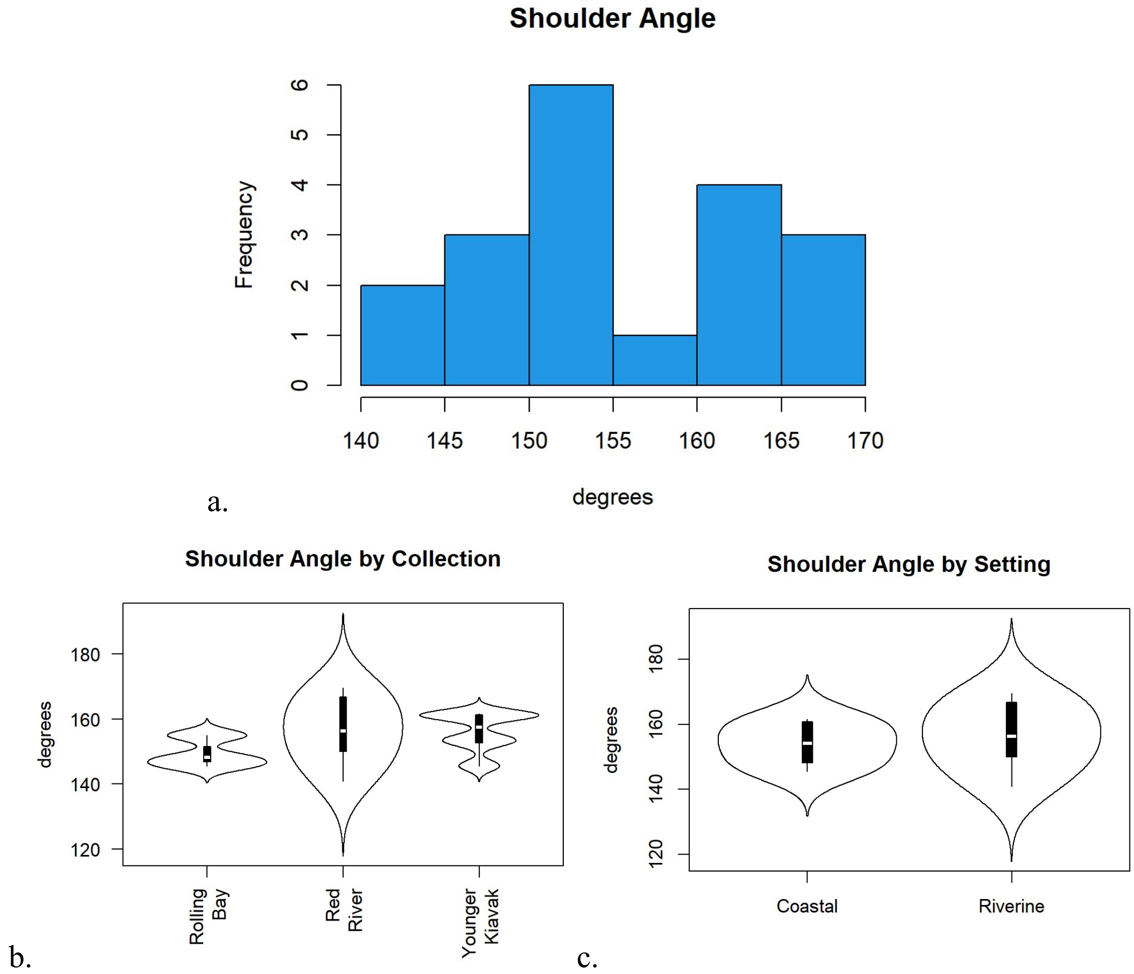

Figure A.9. Summary figures for shoulder angle. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

Sample	***n***	**Min**	**Median**	**Mean**	**Max**	**SD**	**CV**
Overall	*19*	140.9	154.8	155.13	169.5	8.39	5%
AM106	*3*	145.5	148.1	149.53	155	4.91	3%
AM596	*6*	145.6	157.4	156	161.6	6.37	4%
AM503/Riverine	*10*	140.9	156.2	156.29	169.5	10.02	6%
Coastal	*9*	145.5	154.2	153.84	161.6	6.47	4%

Table A.10. Shoulder angles in degrees.

Surface Finish

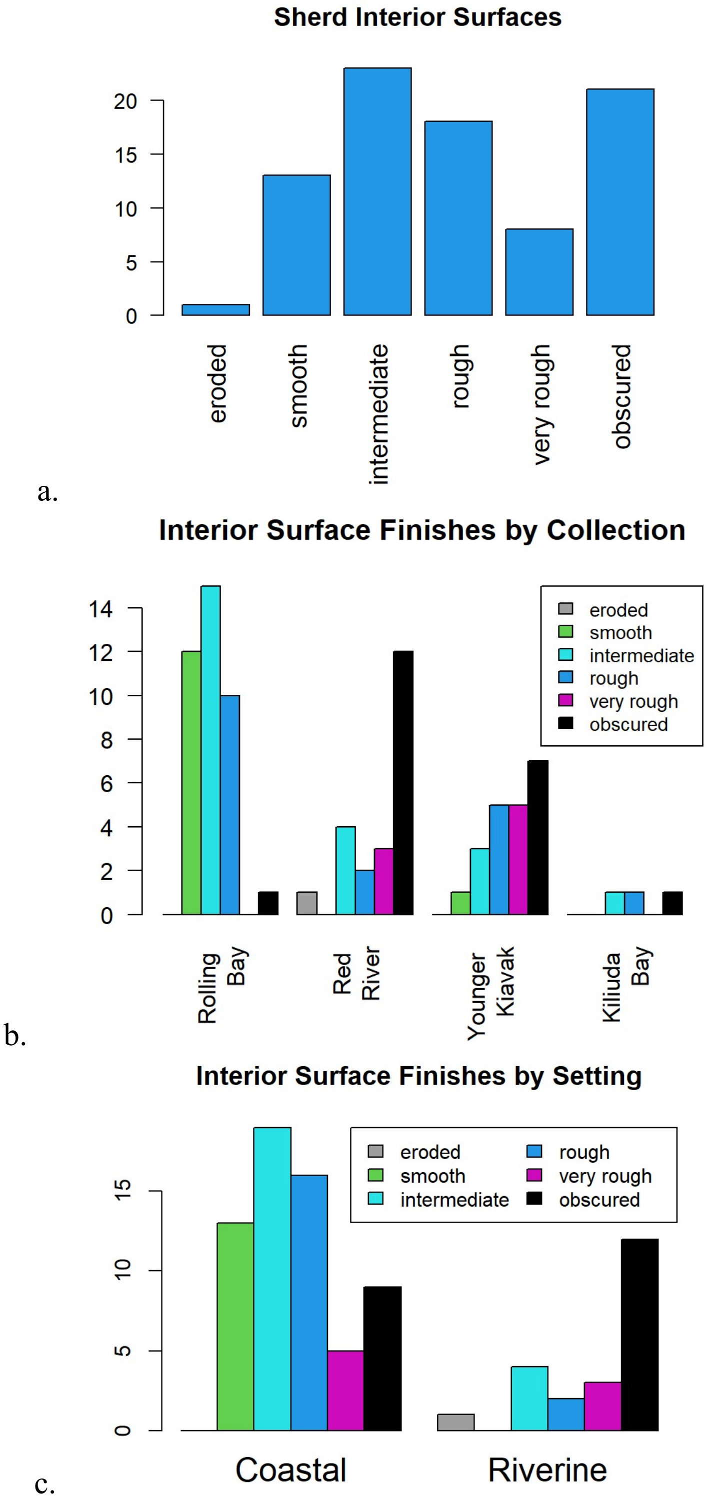

Figure A.10. Summary figures for interior surface finish. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

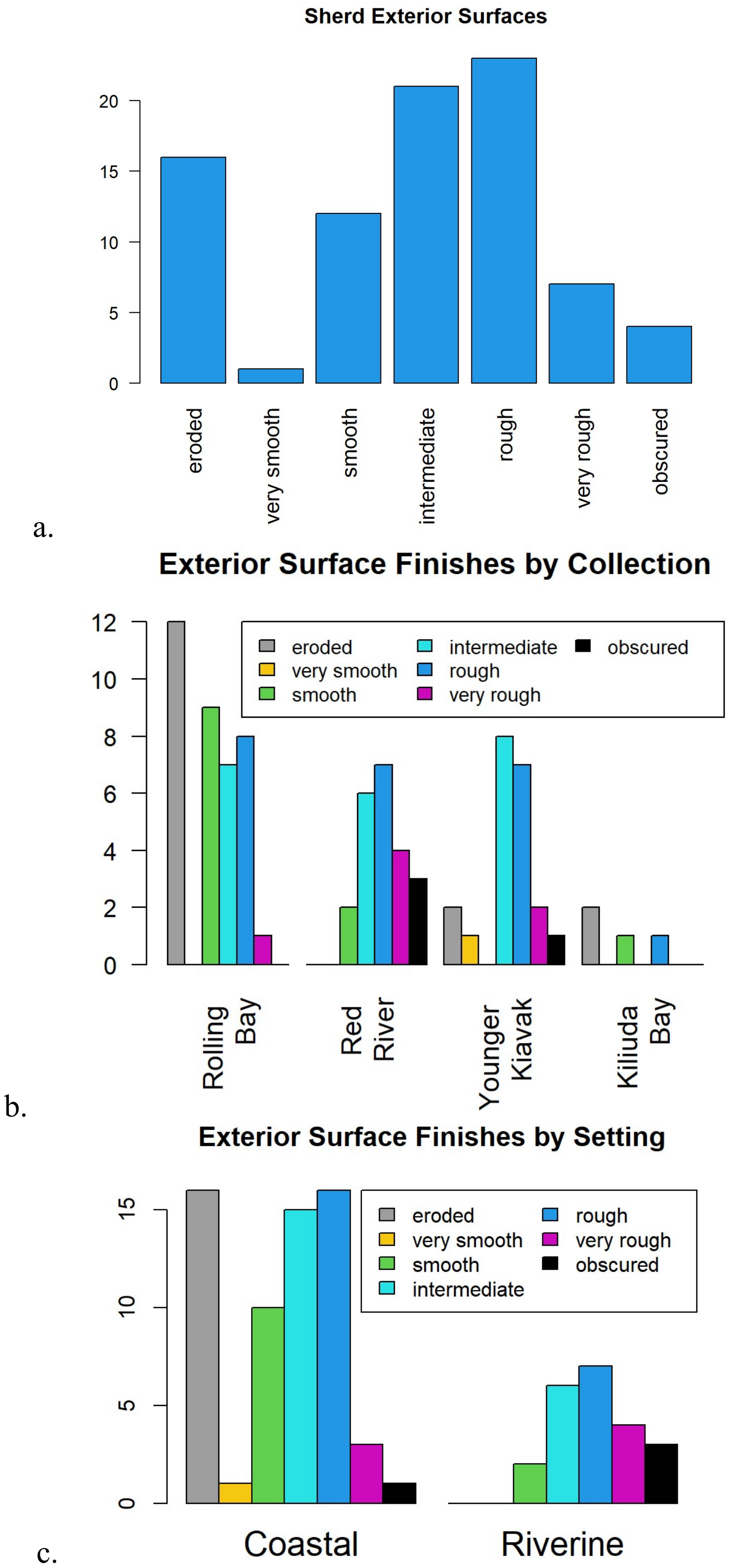

Figure A.11. Summary figures for exterior surface finish. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

Temper Characteristics

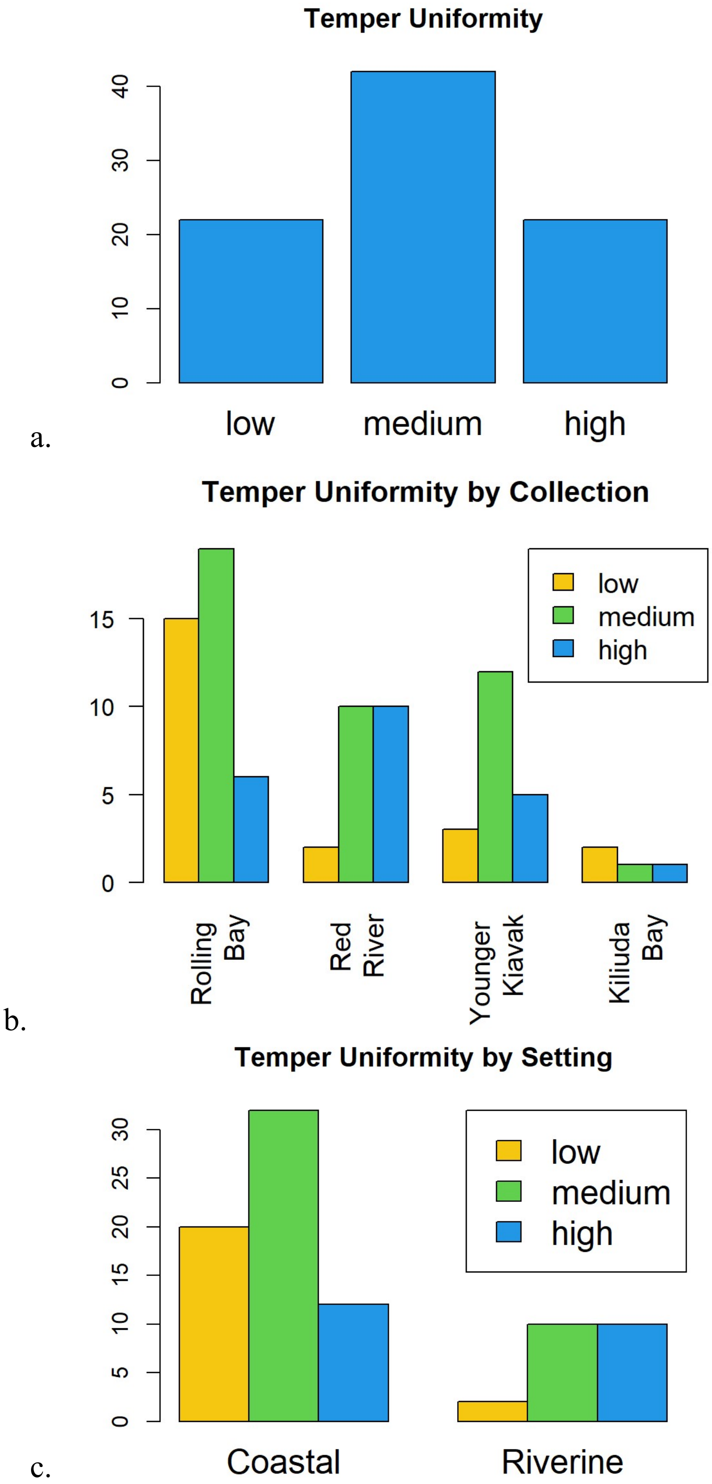

Figure A.12. Summary figures for temper uniformity. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

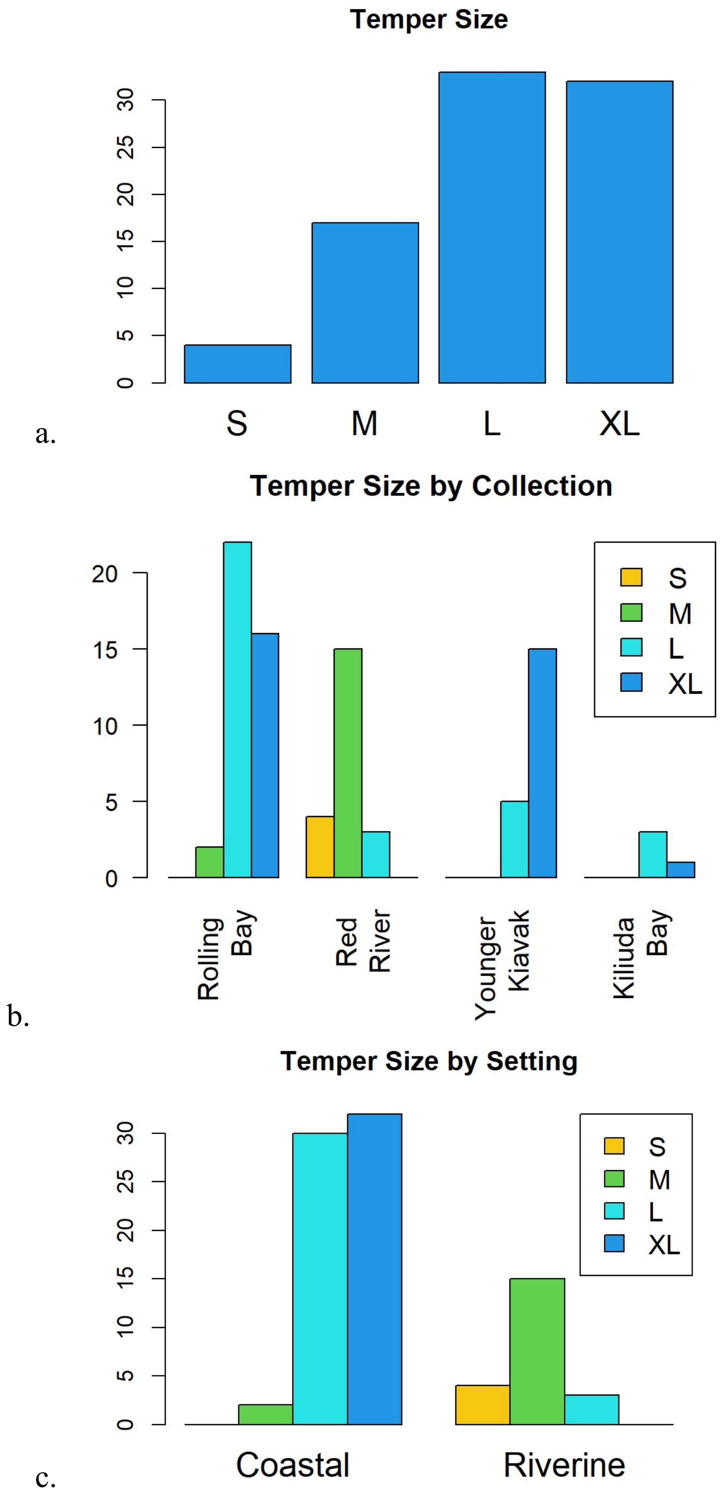

Figure A.13. Summary figures for temper size. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

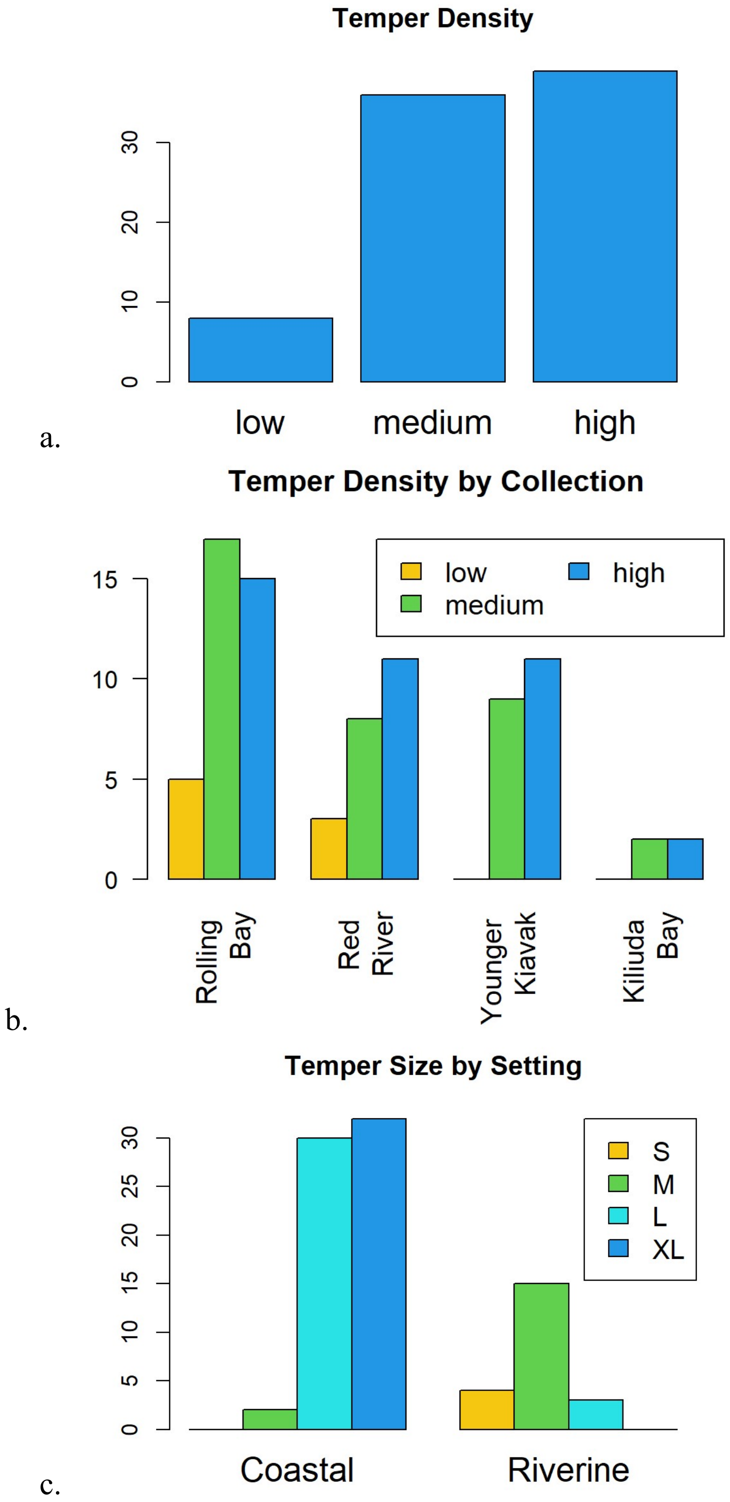

Figure A.14. Summary figures for temper size. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

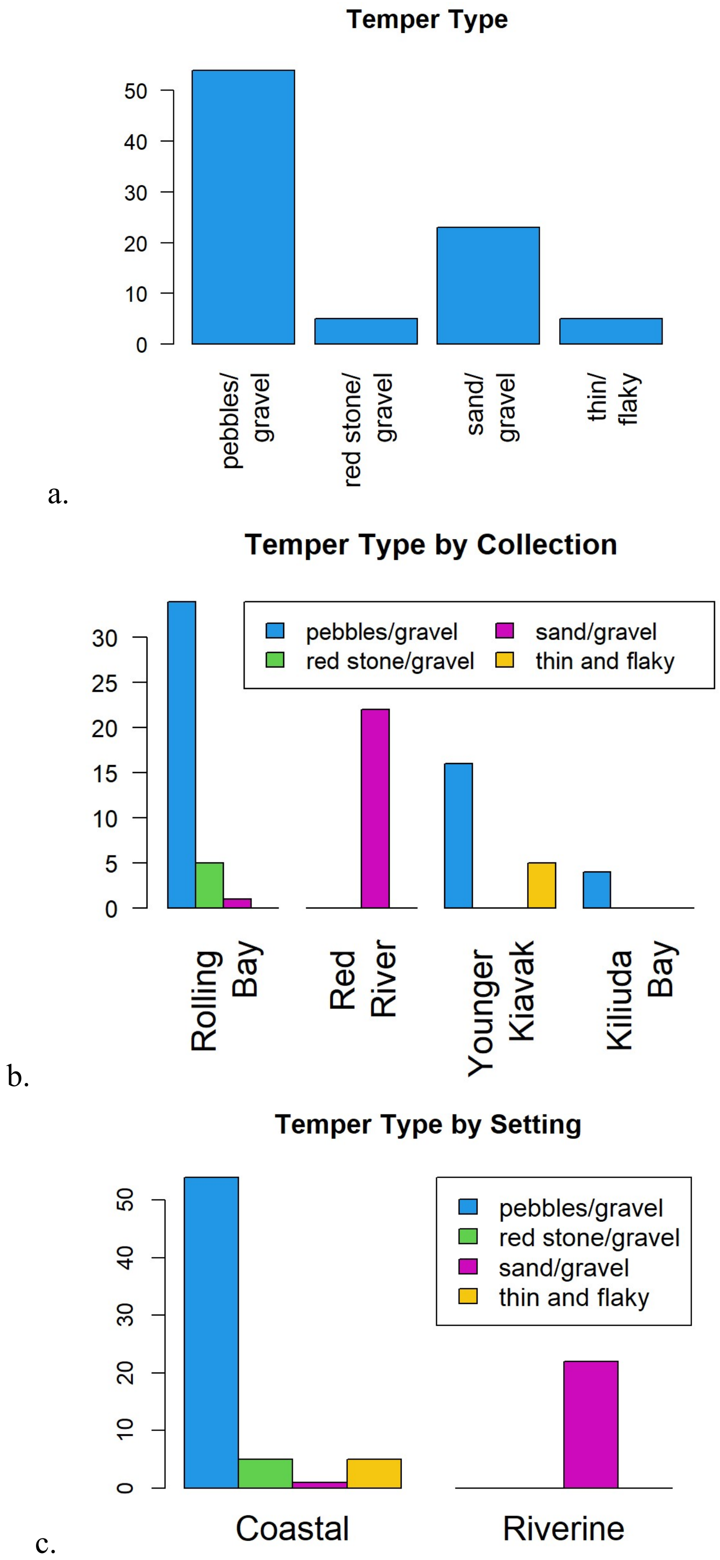

Figure A.15. Summary figures for temper type. a) Bar chart of overall distribution, b) by collection, and c) by coastal vs. riverine setting.

Appendix B. Breakdown of Pottery Manufacturing Time

Vessel:		**Base B**		**Pot C**		**Pot D**		**Base E**		**Pot F**		**Overall**	
Stage	**Step**	**Lib**	**Cons**	**Lib**	**Cons**	**Lib**	**Cons**	**Lib**	**Cons**	**Lib**	**Cons**	**Max**	**Min**
Matls	**Collection**	2495	1067	2495	1067	2495	1067	2495	1067	2495	1067	2495	1067
	Processing	3796	1704	3796	1704	4791	2625	4791	2625	4791	2625	4791	1704
	Incidental	298	141	634	141	105	0	289	289	75	75	634	0
	Total	6589	2912	6925	2912	7391	3692	7575	3981	7361	3767	7920	2771
Base	**Initial Disc**	49	49	30	30	52	52	49	49	75	75	75	30
	Wide Tier	133	133	285	285	641	641	298	298	124	124	641	124
	Narrow Tier	132	132	254	254	459	459	298	298	298	298	459	132
	Joins	621	621	160	160			238	238	758	758	758	160
	Interior Coil	104	104	0	0	229	229			339	339	339	104
	Shaping	74	44	660	250	179	109	156	44	279	229	660	44
	Supports	165	41	231	0	151	0	85	0	376	0	376	0
	Total	1278	1124	1620	979	1711	1490	1124	927	2249	1823	3308	594
18L	**W/ 1 Addit Base Tier**	2032	1878	2065	1424	2352	2131	1660	1463	3131	2705	4707	878
Shldr	**Edge Cleaning**	55	55	154	154	0	0			0	0	154	54
	Edge Coil			269	253	220	220			0	0	269	220
	Interior Coil			0	0	472	472			0	0	472	472
	Total	55	55	423	407	692	692			0	0	895	747
UW	**Patchings**			519	519	1292	1292			416	416	1292	416
	Joins			0	0	53	53			404	404	404	53
	Rim Coil			469	469	534	534			0	0	534	469
	Rim Shaping			0	0	82	0			472	472	472	0
	Total			988	988	1961	1879			1292	1292	2702	938
5.5L, 18L	**W/ 1 Addit UW Tier**			1507	1507	3306	3224			2112	2112	4398	1407
18L	**W/ 2 Addit UW Tiers**			2026	2026	4651	4569			2932	2932	6094	1876
Shape	**Paddling**			2822	2790	268	195			314	301	2822	195
	Cracks			1135	1135	1349	1349			168	100	1349	100
	Divots					273	251			14	14	273	14
	Scrape					3640	3372			0	0	3640	3372
	Total			3957	3925	5530	5167			496	415	8084	3681
Finish	**Smoothing**					295	237			741	234	2220	1624
	Burnishing					1479	1390			0	0	1479	1390
	Total					1774	1627			741	234	2220	1624
Overall Totals													
	Original Size				**Seconds**	19059	14547			12139	7531	25129	10355
					Hours	5.294	4.041			3.372	2.092	6.980	2.876
	Adjusted Volume: 5.5L				**Seconds**	20404	15892			12959	8351	26825	10824
					Hours	5.668	4.414			3.600	2.320	**7.451**	**3.007**
	Adjusted Volume: 18L				**Seconds**	22390	17878			14661	10053	29920	11577
					Hours	6.219	4.966			4.073	2.793	**8.311**	**3.216**

Table B.1. Breakdown of the active time spent on pottery manufacture, pre-firing. All times are in seconds unless otherwise specified. Final totals used in the results are rendered in bold.

Interpretation of Pottery Manufacturing Times. The time lengths in seconds were calculated by categorizing the time lengths recorded for all manufacturing sessions and summing all like time lengths for each vessel. Not all steps were done for each vessel; zero-values indicate that a step was skipped, whereas blank cells indicate that the vessel was abandoned before the step was reached. The final minimum and maximum active time estimates are based on the completion of all steps listed.

As discussed in the main text, the pots I made from the Kodiak clay were notably smaller than my estimates of typical vessel sizes from the museum data. I therefore approximated the time needed to attach additional tiers of clay patches to the lower and upper walls, allowing for one additional upper wall tier for a 5.5 L pot (used for the Low Yield estimates) and two additional upper wall tiers/1 additional lower wall tier for an 18 L pot (used for the High Yield estimates). These values were then added to the corresponding estimates derived from the firing experiment (not adjusted for vessel volume) to produce the final active manufacturing times. All completed vessels were completed over a few days to allow time for the clay to dry, both between different construction and surface finishing stages and between surface finishing and firing. The passive manufacturing times reflect this, and the difference between the liberal and conservative estimates represents a range of possible drying times (not adjusted for vessel volume).

Further description of the different steps identified in Table B.1, as well as raw time data for all experimental sessions, are with the author and are available upon request.

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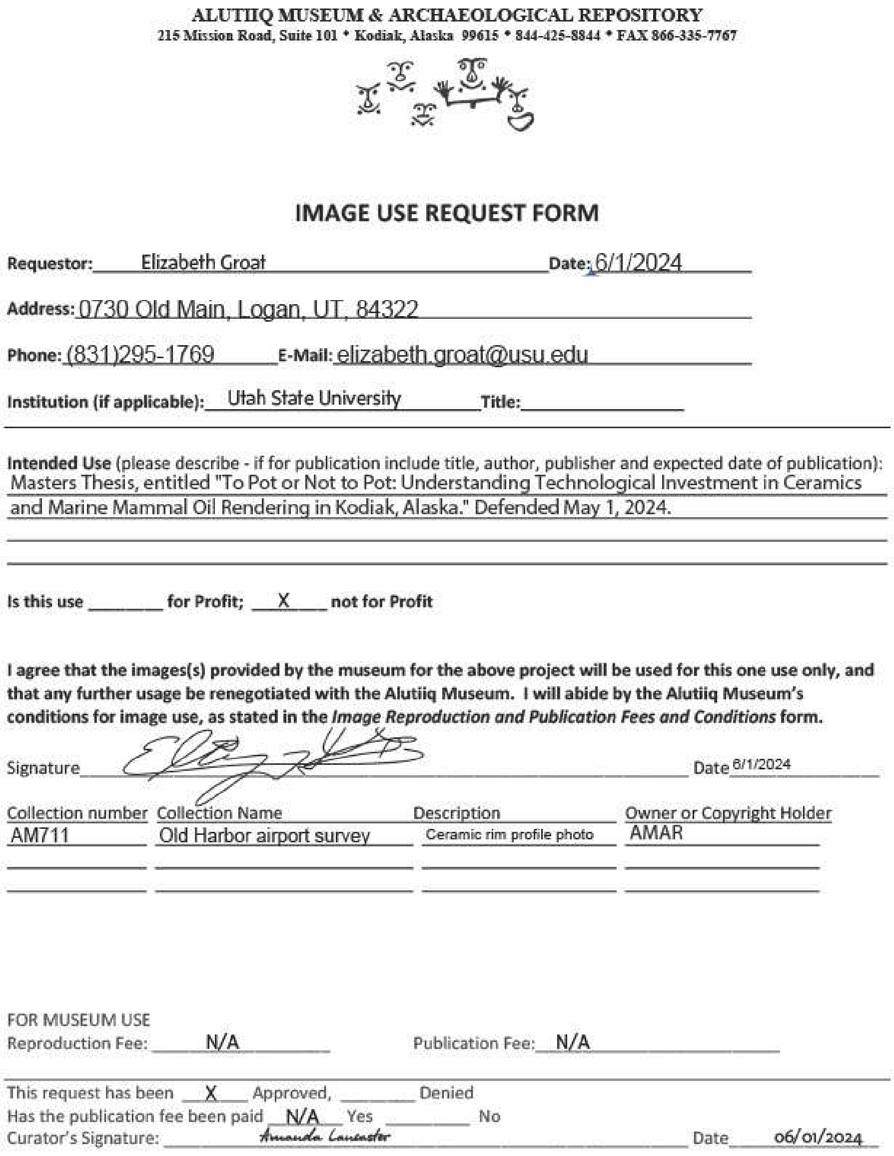

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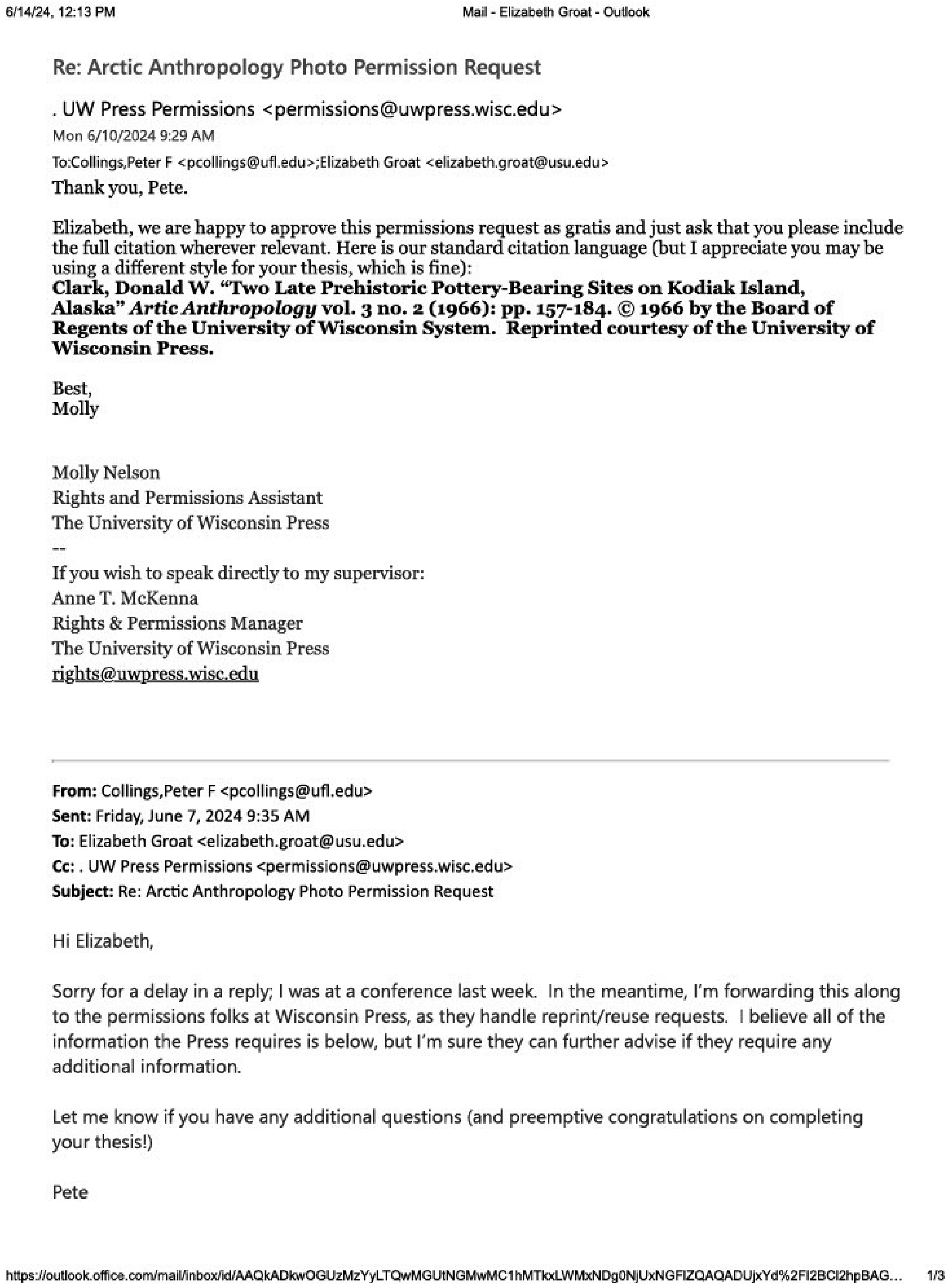

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Best,
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Pete

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MS Student, Utah State University

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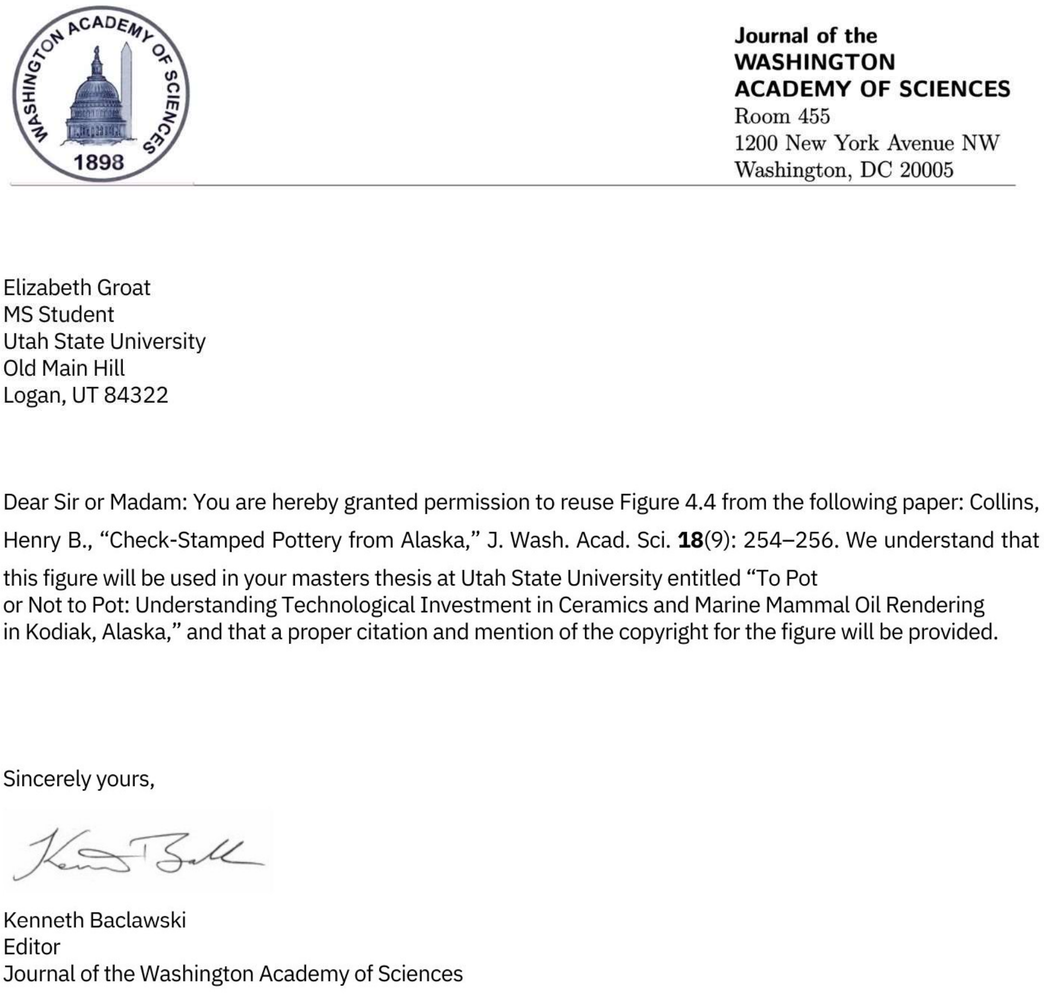
Figure from Collins 1928



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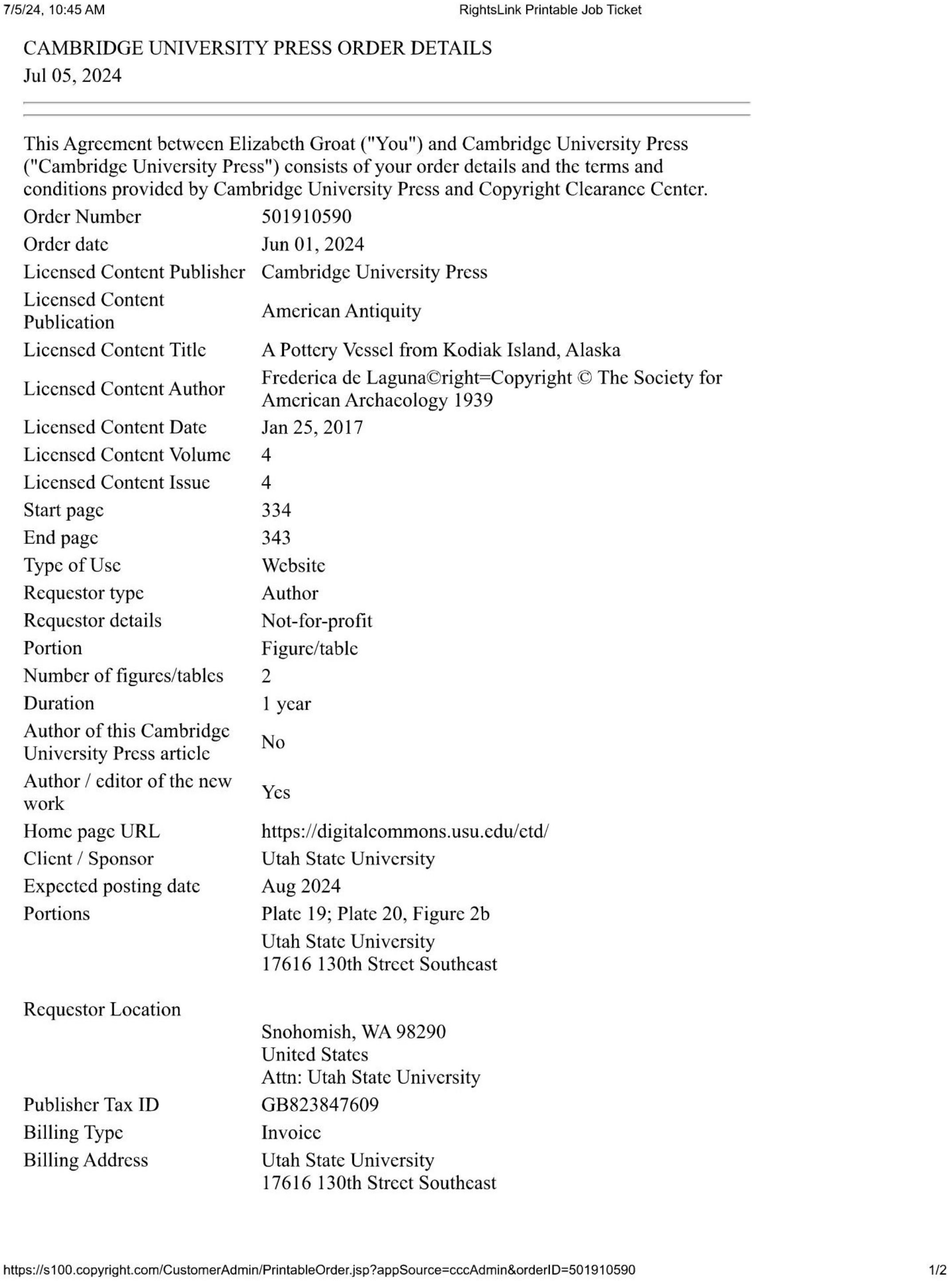

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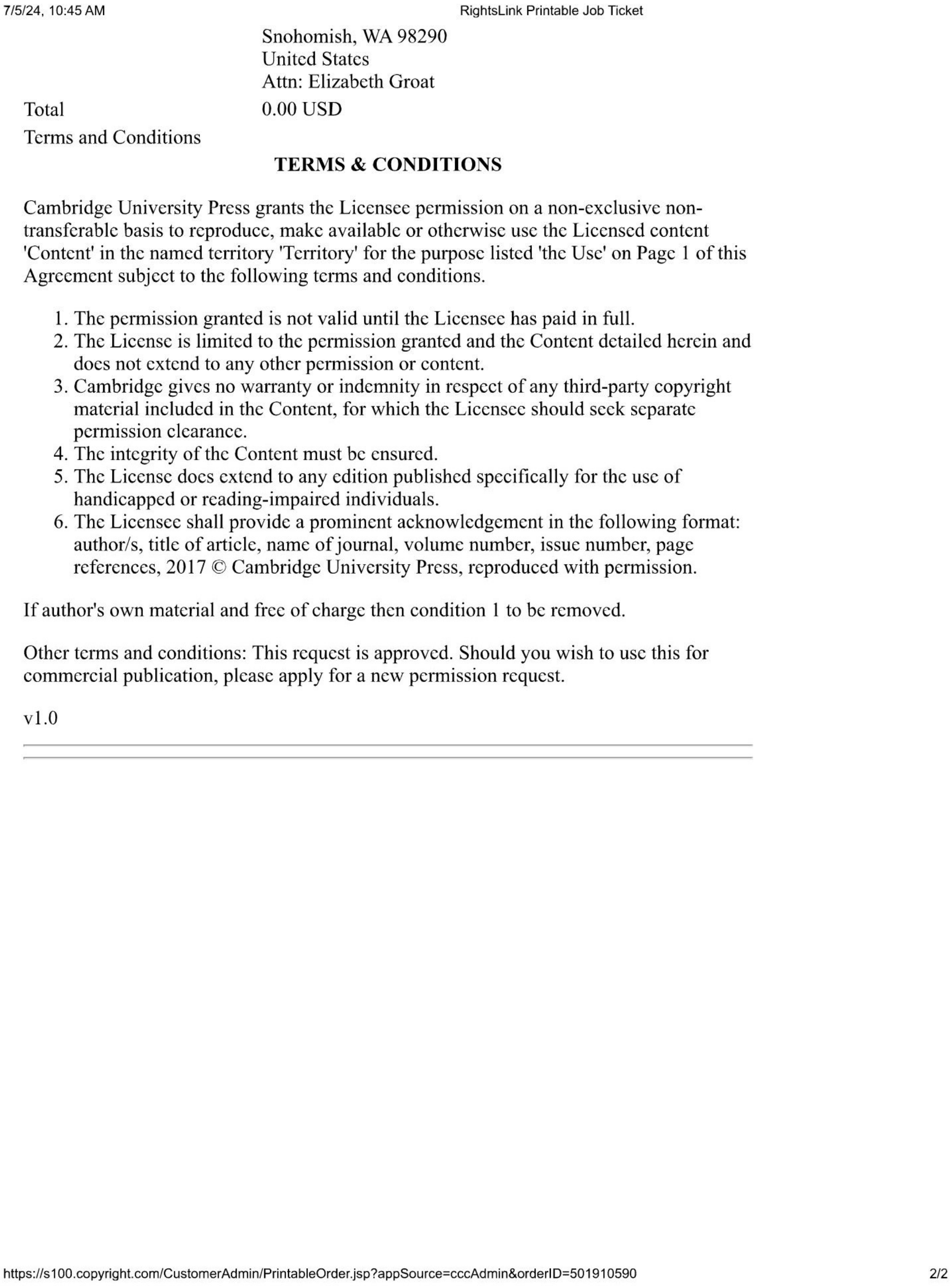

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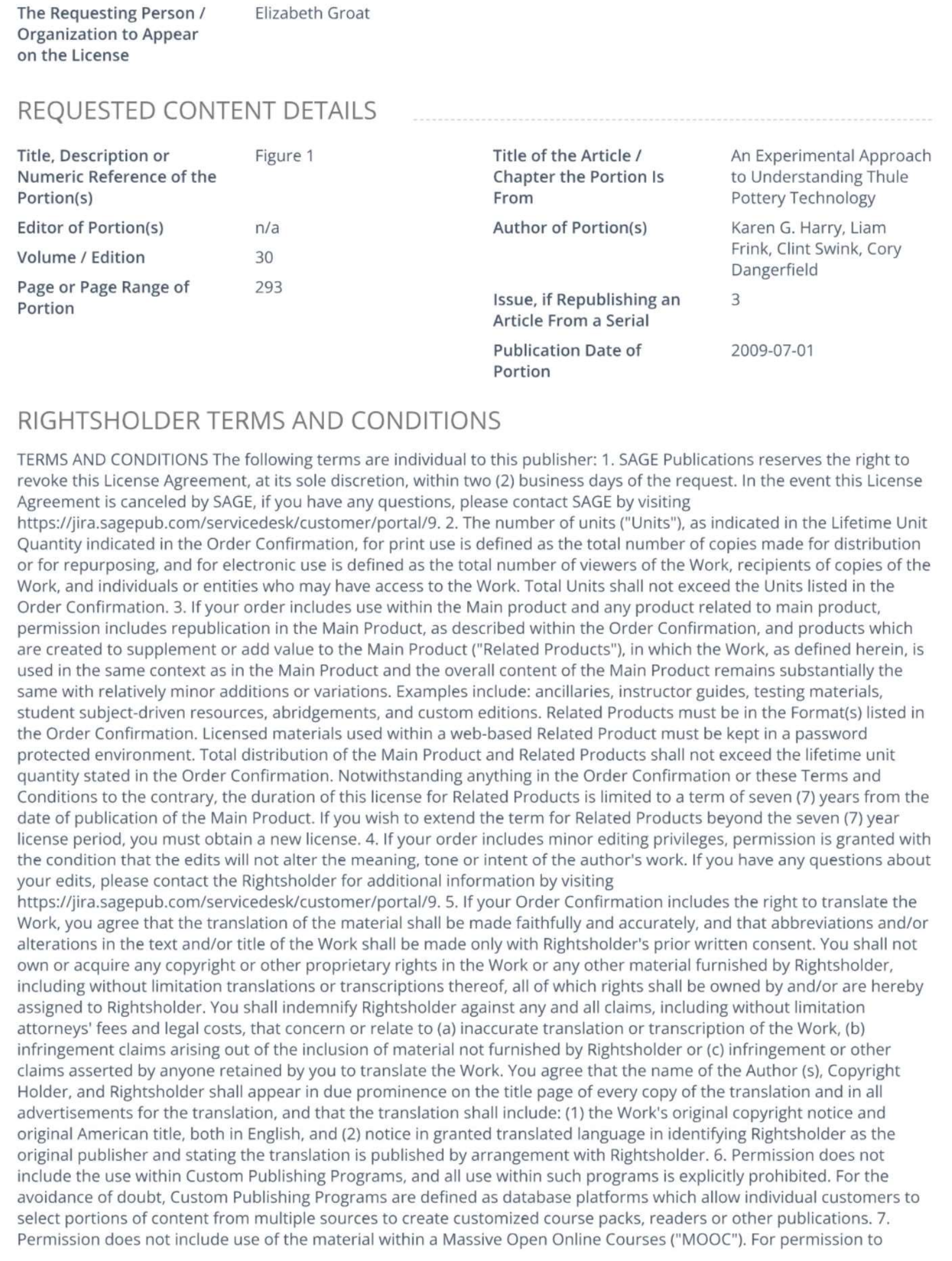

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Last updated October 2022

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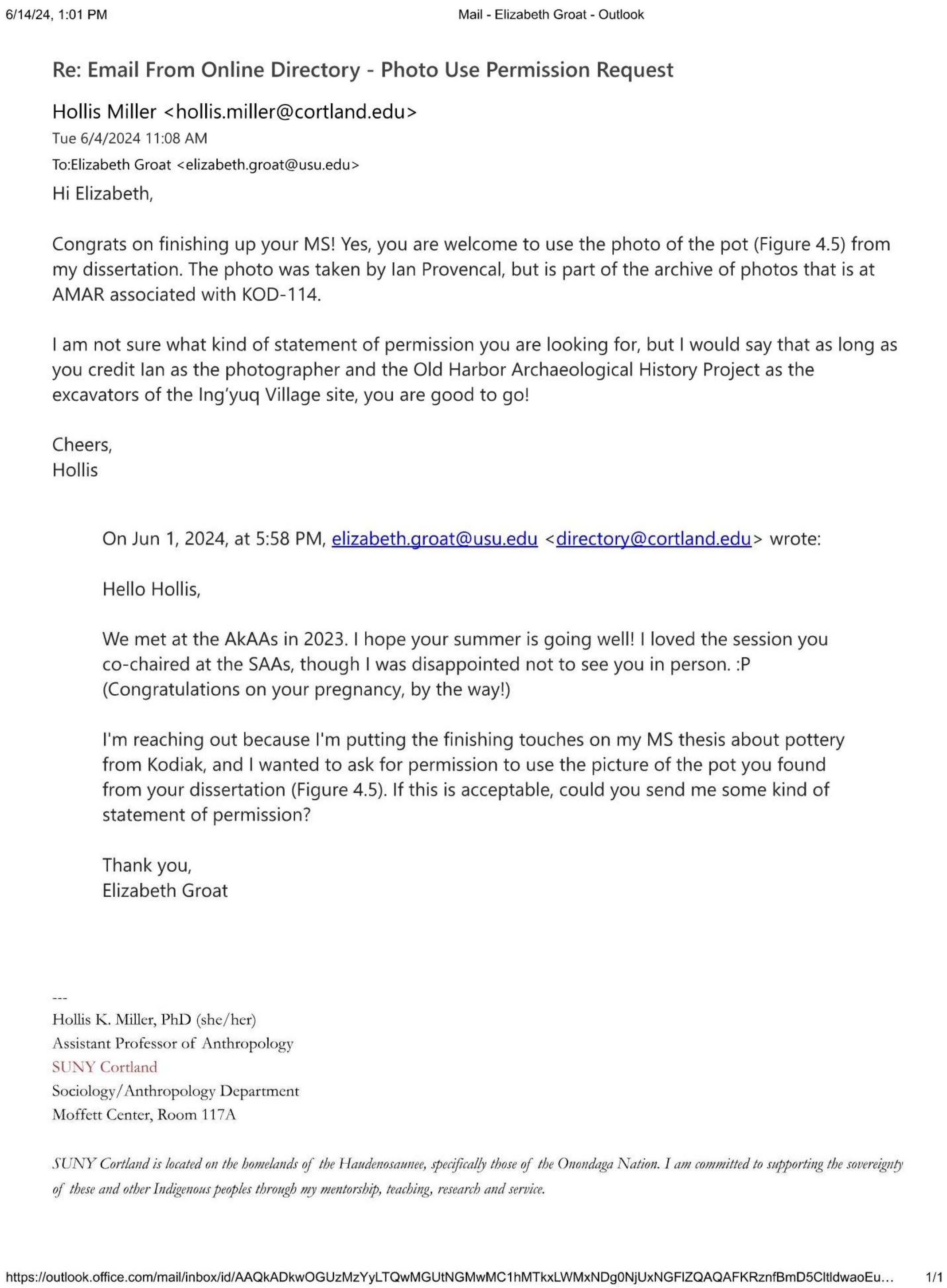

6/14/24, 1:01 PM Mail - Elizabeth Groat - Outlook

Re: Email From Online Directory - Photo Use Permission Request

Hollis Miller <hollis.miller@cortland.edu>
Tue 6/4/2024 11:08 AM
To:Elizabeth Groat <elizabeth.groat@usu.edu>

Hi Elizabeth,

Congrats on finishing up your MS! Yes, you are welcome to use the photo of the pot (Figure 4.5) from my dissertation. The photo was taken by Ian Provencal, but is part of the archive of photos that is at AMAR associated with KOD-114.

I am not sure what kind of statement of permission you are looking for, but I would say that as long as you credit Ian as the photographer and the Old Harbor Archaeological History Project as the excavators of the Ing'yuq Village site, you are good to go!

Cheers,
Hollis

> On Jun 1, 2024, at 5:58 PM, elizabeth.groat@usu.edu <directory@cortland.edu> wrote:
>
> Hello Hollis,
>
> We met at the AkAAs in 2023. I hope your summer is going well! I loved the session you co-chaired at the SAAs, though I was disappointed not to see you in person. :P (Congratulations on your pregnancy, by the way!)
>
> I'm reaching out because I'm putting the finishing touches on my MS thesis about pottery from Kodiak, and I wanted to ask for permission to use the picture of the pot you found from your dissertation (Figure 4.5). If this is acceptable, could you send me some kind of statement of permission?
>
> Thank you,
> Elizabeth Groat

Hollis K. Miller, PhD (she/her)
Assistant Professor of Anthropology
SUNY Cortland
Sociology/Anthropology Department
Moffett Center, Room 117A

SUNY Cortland is located on the homelands of the Haudenosaunee, specifically those of the Onondaga Nation. I am committed to supporting the sovereignty of these and other Indigenous peoples through my mentorship, teaching, research and service.

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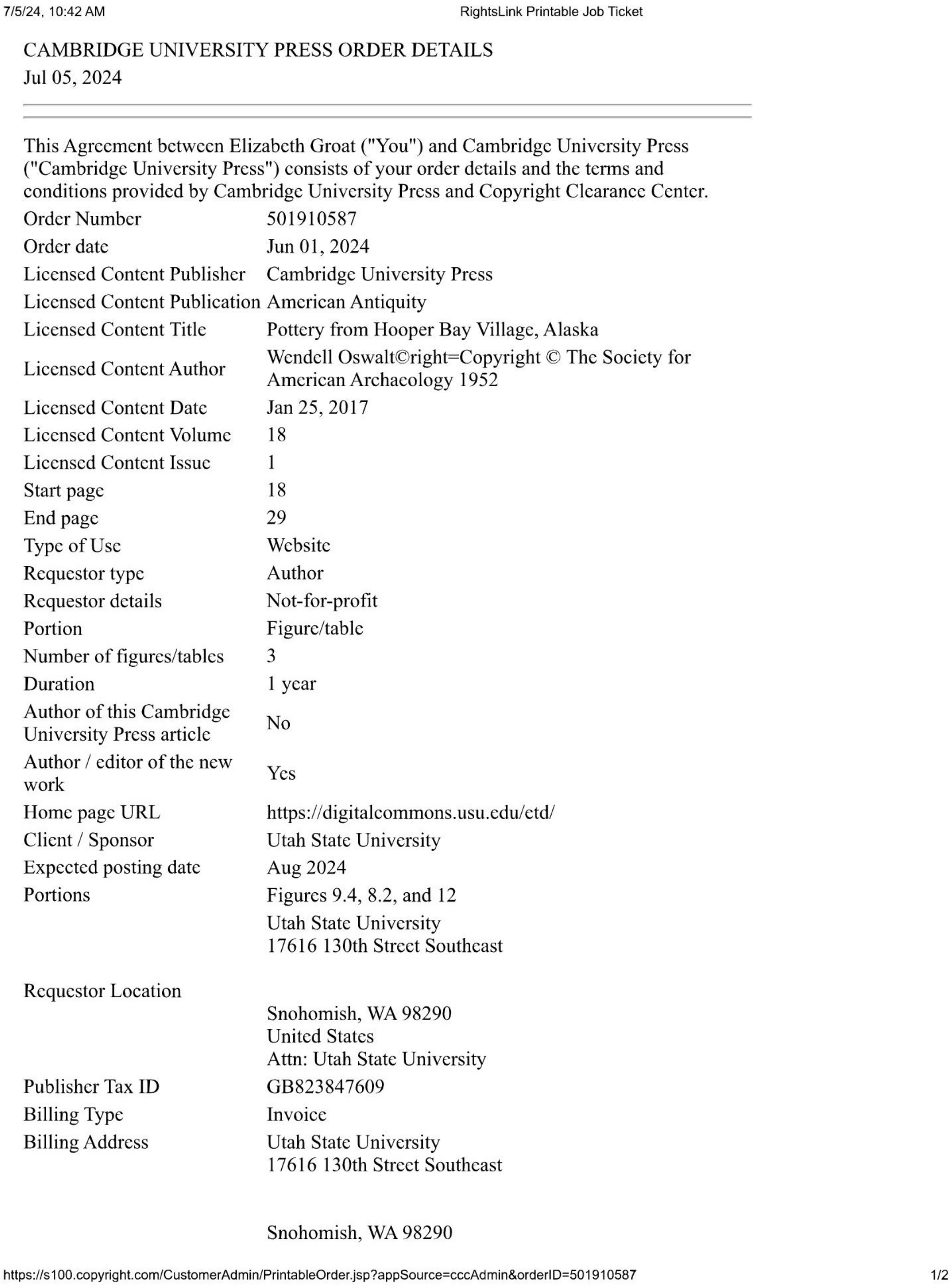
Figure from Oswalt 1952



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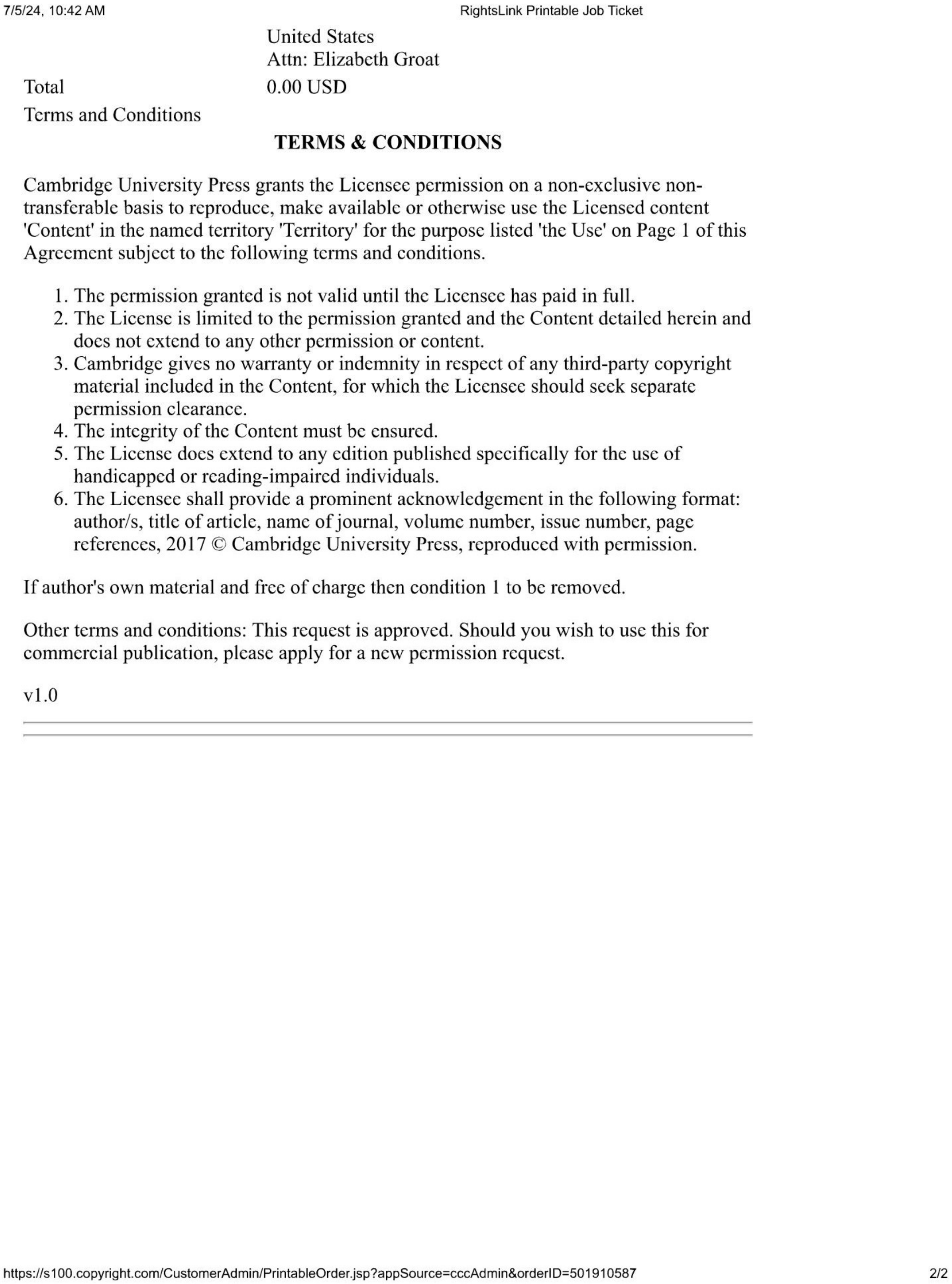

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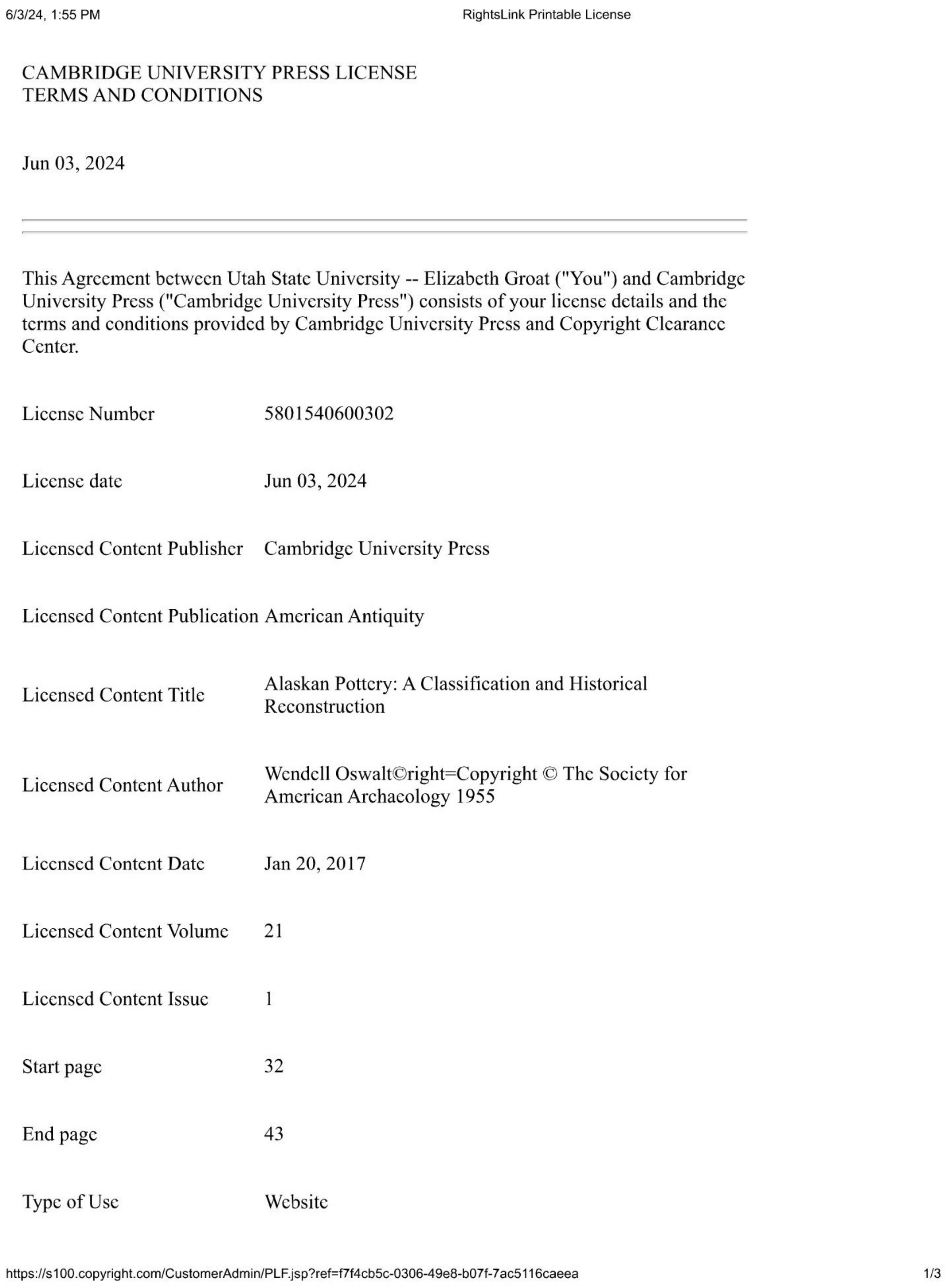

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Marketplace Permissions General Terms and Conditions

The following terms and conditions ("General Terms"), together with any applicable Publisher Terms and Conditions, govern User's use of Works pursuant to the Licenses granted by Copyright Clearance Center, Inc. ("CCC") on behalf of the applicable Rightsholders of such Works through CCC's applicable Marketplace transactional licensing services (each, a "Service").

1) **Definitions.** For purposes of these General Terms, the following definitions apply:

"License" is the licensed use the User obtains via the Marketplace platform in a particular licensing transaction, as set forth in the Order Confirmation.

"Order Confirmation" is the confirmation CCC provides to the User at the conclusion of each Marketplace transaction. "Order Confirmation Terms" are additional terms set forth on specific Order Confirmations not set forth in the General Terms that can include terms applicable to a particular CCC transactional licensing service and/or any Rightsholder-specific terms.

"Rightsholder(s)" are the holders of copyright rights in the Works for which a User obtains licenses via the Marketplace platform, which are displayed on specific Order Confirmations.

"Terms" means the terms and conditions set forth in these General Terms and any additional Order Confirmation Terms collectively.

"User" or "you" is the person or entity making the use granted under the relevant License. Where the person accepting the Terms on behalf of a User is a freelancer or other third party who the User authorized to accept the General Terms on the User's behalf, such person shall be deemed jointly a User for purposes of such Terms.

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2) **Description of Service.** CCC's Marketplace enables Users to obtain Licenses to use one or more Works in accordance with all relevant Terms. CCC grants Licenses as an agent on behalf of the copyright rightsholder identified in the relevant Order Confirmation.

3) **Applicability of Terms.** The Terms govern User's use of Works in connection with the relevant License. In the event of any conflict between General Terms and Order Confirmation Terms, the latter shall govern. User acknowledges that Rightsholders have complete discretion whether to grant any permission, and whether to place any limitations on any grant, and that CCC has no right to supersede or to modify any such discretionary act by a Rightsholder.

4) **Representations; Acceptance.** By using the Service, User represents and warrants that User has been duly authorized by the User to accept, and hereby does accept, all Terms.

5) **Scope of License; Limitations and Obligations.** All Works and all rights therein, including copyright rights, remain the sole and exclusive property of the Rightsholder. The License provides only those rights expressly set forth in the terms and conveys no other rights in any Works

6) **General Payment Terms.** User may pay at time of checkout by credit card or choose to be invoiced. If the User chooses to be invoiced, the User shall: (i) remit payments in the manner identified on specific invoices, (ii) unless otherwise specifically stated in an Order Confirmation or separate written agreement, Users shall remit payments upon receipt of the relevant invoice from CCC, either by delivery or notification of availability of the invoice via the Marketplace platform, and (iii) if the User does not pay the invoice within 30 days of receipt, the User may incur a service charge of 1.5% per month or the maximum rate allowed by applicable law, whichever is less. While User may exercise the rights in the License immediately upon receiving the Order Confirmation, the License is automatically revoked and is null and void, as if it had never been issued, if CCC does not receive complete payment on a timely basis.

7) **General Limits on Use.** Unless otherwise provided in the Order Confirmation, any grant of rights to User (i) involves only the rights set forth in the Terms and does not include subsequent or additional uses, (ii) is non-exclusive and non-transferable, and (iii) is subject to any and all limitations and restrictions (such as, but not limited to, limitations on duration of use or circulation) included in the Terms. Upon completion of the licensed use as set forth in the Order Confirmation, User shall either secure a new permission for further use of the Work(s) or immediately cease any new use of the Work(s) and shall render inaccessible (such as by deleting or by removing or severing links or other locators) any further copies of the Work. User may only make alterations to the Work if and as expressly set forth in the Order Confirmation. No Work may be used in any way that is unlawful, including without limitation if such use would violate applicable sanctions laws or regulations, would be defamatory, violate the rights of third parties (including such third parties' rights of copyright, privacy, publicity, or other tangible or intangible property), or is otherwise illegal, sexually explicit, or obscene. In addition, User may not conjoin a Work with any other material that may result in damage to the reputation of the Rightsholder. Any unlawful use will render any licenses hereunder null and void. User agrees to inform CCC if it becomes aware of any infringement of any rights in a Work and to cooperate with any reasonable request of CCC or the Rightsholder in connection therewith.

8) **Third Party Materials.** In the event that the material for which a License is sought includes third party materials (such as photographs, illustrations, graphs, inserts and similar materials) that are identified in such material as having been used by permission (or a similar indicator), User is responsible for identifying, and seeking separate licenses (under this Service, if available, or otherwise) for any of such third party materials; without a separate license, User may not use such third party materials via the License.

9) **Copyright Notice.** Use of proper copyright notice for a Work is required as a condition of any License granted under the Service. Unless otherwise provided in the Order Confirmation, a proper copyright notice will read substantially as follows: "Used with permission of [Rightsholder's name], from [Work's title, author, volume, edition number and year of copyright]; permission conveyed through Copyright Clearance Center, Inc." Such notice must be provided in a reasonably legible font size and must be placed either on a cover page or in another location that any person, upon gaining access to the material which is the subject of a permission, shall see, or in the case of republication Licenses, immediately adjacent to the Work as used (for example, as part of a by-line or footnote) or in the place where substantially all other credits or notices for the new work containing the republished Work are located. Failure to include the required notice results in loss to the Rightsholder and CCC, and the User shall be liable to pay liquidated damages for each such failure equal to twice the use fee specified in the Order Confirmation, in addition to the use fee itself and any other fees and charges specified.

10) **Indemnity.** User hereby indemnifies and agrees to defend the Rightsholder and CCC, and their respective employees and directors, against all claims, liability, damages, costs, and expenses, including legal fees and expenses, arising out of any use of a Work beyond the scope of the rights granted herein and in the Order Confirmation, or any use of a Work which has been altered in any unauthorized way by User, including claims of defamation or infringement of rights of copyright, publicity, privacy, or other tangible or intangible property.

11) **Limitation of Liability.** UNDER NO CIRCUMSTANCES WILL CCC OR THE RIGHTSHOLDER BE LIABLE FOR ANY DIRECT, INDIRECT, CONSEQUENTIAL, OR INCIDENTAL DAMAGES (INCLUDING WITHOUT LIMITATION DAMAGES FOR LOSS OF BUSINESS PROFITS OR INFORMATION, OR FOR BUSINESS INTERRUPTION) ARISING OUT OF THE USE OR INABILITY TO USE A WORK, EVEN IF ONE OR BOTH OF THEM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. In any event, the total liability of the Rightsholder and CCC (including their respective employees and directors) shall not exceed the total amount actually paid by User for the relevant License. User assumes full liability for the actions and omissions of its principals, employees, agents, affiliates, successors, and assigns.

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13) **Effect of Breach.** Any failure by User to pay any amount when due, or any use by User of a Work beyond the scope of the License set forth in the Order Confirmation and/or the Terms, shall be a material breach of such License. Any breach not cured within 10 days of written notice thereof shall result in immediate termination of such License without further notice. Any unauthorized (but licensable) use of a Work that is terminated immediately upon notice thereof may be liquidated by payment of the Rightsholder's ordinary license price therefor; any unauthorized (and unlicensable) use that is not terminated immediately for any reason (including, for example, because materials containing the Work cannot reasonably be recalled) will be subject to all remedies available at law or in equity, but in no event to a payment of less than three times the Rightsholder's ordinary license price for the most closely analogous licensable use plus Rightsholder's and/or CCC's costs and expenses incurred in collecting such payment.

14) **Additional Terms for Specific Products and Services.** If a User is making one of the uses described in this Section 14, the additional terms and conditions apply:

a) ***Print Uses of Academic Course Content and Materials (photocopies for academic coursepacks or classroom handouts).*** For photocopies for academic coursepacks or classroom handouts the following additional terms apply:

i) The copies and anthologies created under this License may be made and assembled by faculty members individually or at their request by on-campus bookstores or copy centers, or by off-campus copy shops and other similar entities.

ii) No License granted shall in any way: (i) include any right by User to create a substantively non-identical copy of the Work or to edit or in any other way modify the Work (except by means of deleting material immediately preceding or following the entire portion of the Work copied) (ii) permit "publishing ventures" where any particular anthology would be systematically marketed at multiple institutions.

iii) Subject to any Publisher Terms (and notwithstanding any apparent contradiction in the Order Confirmation arising from data provided by User), any use authorized under the academic pay-per-use service is limited as follows:

A) any License granted shall apply to only one class (bearing a unique identifier as assigned by the institution, and thereby including all sections or other subparts of the class) at one institution;

B) use is limited to not more than 25% of the text of a book or of the items in a published collection of essays, poems or articles;

C) use is limited to no more than the greater of (a) 25% of the text of an issue of a journal or other periodical or (b) two articles from such an issue;

D) no User may sell or distribute any particular anthology, whether photocopied or electronic, at more than one institution of learning;

E) in the case of a photocopy permission, no materials may be entered into electronic memory by User except in order to produce an identical copy of a Work before or during the academic term (or analogous period) as to which any particular permission is granted. In the event that User shall choose to retain materials that are the subject of a photocopy permission in electronic memory for purposes of producing identical copies more than one day after such retention (but still within the scope of any permission granted), User must notify CCC of such fact in the applicable permission request and such retention shall constitute one copy actually sold for purposes of calculating permission fees due; and

F) any permission granted shall expire at the end of the class. No permission granted shall in any way include any right by User to create a substantively non-identical copy of the Work or to edit or in any other way modify the Work (except by means of deleting material immediately preceding or following the entire portion of the Work copied).

iv) Books and Records; Right to Audit. As to each permission granted under the academic pay-per-use Service, User shall maintain for at least four full calendar years books and records sufficient for CCC to determine the numbers of copies made by User under such permission. CCC and any representatives it may designate shall have the right to audit such books and records at any time during User's ordinary business hours, upon two days' prior notice. If any such audit shall determine that User shall have underpaid for, or underreported, any photocopies sold or by three percent (3%) or more, then User shall bear all the costs of any such audit; otherwise, CCC shall bear the costs of any such audit. Any amount determined by such audit to have been underpaid by User shall immediately be paid to CCC by User, together with interest thereon at the rate of 10% per annum from the date such amount was originally due. The provisions of this paragraph shall survive the termination of this License for any reason.

b) ***Digital Pay-Per-Uses of Academic Course Content and Materials (e-coursepacks, electronic reserves, learning management systems, academic institution intranets).*** For uses in e-coursepacks, posts in electronic reserves, posts in learning management systems, or posts on academic institution intranets, the following additional terms apply:

i) The pay-per-uses subject to this Section 14(b) include:

A) **Posting e-reserves, course management systems, e-coursepacks for text-based content,** which grants authorizations to import requested material in electronic format, and allows electronic access to this material to members of a designated college or university class, under the direction of an instructor designated by the college or university, accessible only under appropriate electronic controls (e.g., password);

B) **Posting e-reserves, course management systems, e-coursepacks for material consisting of photographs or other still images not embedded in text,** which grants not only the authorizations described in Section 14(b)(i)(A) above, but also the following authorization: to include the requested material in course materials for use consistent with Section 14(b)(i)(A) above, including any necessary resizing, reformatting or modification of the resolution of such requested material (provided that such modification does not alter the underlying editorial content or meaning of the requested material, and provided that the resulting modified content is used solely within the scope of, and in a manner consistent with, the particular authorization described in the Order Confirmation and the Terms), but not including any other form of manipulation, alteration or editing of the requested material;

C) **Posting e-reserves, course management systems, e-coursepacks or other academic distribution for audiovisual content,** which grants not only the authorizations described in Section 14(b)(i)(A) above, but also the following authorizations: (i) to include the requested material in course materials for use consistent with Section 14(b)(i)(A) above; (ii) to display and perform the requested material to such members of such class in the physical classroom or remotely by means of streaming media or other video formats; and (iii) to "clip" or reformat the requested material for purposes of time or content management or ease of delivery, provided that such "clipping" or reformatting does not alter the underlying editorial content or meaning of the requested material and that the resulting material is used solely within the scope of, and in a manner consistent with, the particular authorization described in the Order Confirmation and the Terms. Unless expressly set forth in the relevant Order Conformation, the License does not authorize any other form of manipulation, alteration or editing of the requested material.

ii) Unless expressly set forth in the relevant Order Confirmation, no License granted shall in any way: (i) include any right by User to create a substantively non-identical copy of the Work or to edit or in any other way modify the Work (except by means of deleting material immediately preceding or following the entire portion of the Work copied or, in the case of Works subject to Sections 14(b)(1)(B) or (C) above, as described in such Sections) (ii) permit "publishing ventures" where any particular course materials would be systematically marketed at multiple institutions.

iii) Subject to any further limitations determined in the Rightsholder Terms (and notwithstanding any apparent contradiction in the Order Confirmation arising from data provided by User), any use authorized under the electronic course content pay-per-use service is limited as follows:

A) any License granted shall apply to only one class (bearing a unique identifier as assigned by the institution, and thereby including all sections or other subparts of the class) at one institution;

B) use is limited to not more than 25% of the text of a book or of the items in a published collection of essays, poems or articles;

C) use is limited to not more than the greater of (a) 25% of the text of an issue of a journal or other periodical or (b) two articles from such an issue;

D) no User may sell or distribute any particular materials, whether photocopied or electronic, at more than one institution of learning;

E) electronic access to material which is the subject of an electronic-use permission must be limited by means of electronic password, student identification or other control permitting access solely to students and instructors in the class;

F) User must ensure (through use of an electronic cover page or other appropriate means) that any person, upon gaining electronic access to the material, which is the subject of a permission, shall see:

- a proper copyright notice, identifying the Rightsholder in whose name CCC has granted permission,
- a statement to the effect that such copy was made pursuant to permission,
- a statement identifying the class to which the material applies and notifying the reader that the material has been made available electronically solely for use in the class, and
- a statement to the effect that the material may not be further distributed to any person outside the class, whether by copying or by transmission and whether electronically or in paper form, and User must also ensure that such cover page or other means will print out in the event that the person accessing the material chooses to print out the material or any part thereof.

G) any permission granted shall expire at the end of the class and, absent some other form of authorization, User is thereupon required to delete the applicable material from any electronic storage or to block electronic access to the applicable material.

iv) Uses of separate portions of a Work, even if they are to be included in the same course material or the same university or college class, require separate permissions under the electronic course content pay-per-use Service. Unless otherwise provided in the Order Confirmation, any grant of rights to User is limited to use completed no later than the end of the academic term (or analogous period) as to which any particular permission is granted.

v) Books and Records; Right to Audit. As to each permission granted under the electronic course content Service, User shall maintain for at least four full calendar years books and records sufficient for CCC to determine the numbers of copies made by User under such permission. CCC and any representatives it may designate shall have the right to audit such books and records at any time during User's ordinary business hours, upon two days' prior notice. If any such audit shall determine that User shall have underpaid for, or underreported, any electronic copies used by three percent (3%) or more, then User shall bear all the costs of any such audit; otherwise, CCC shall bear the costs of any such audit. Any amount determined by such audit to have been underpaid by User shall immediately be paid to CCC by User, together with interest thereon at the rate of 10% per annum from the date such amount was originally due. The provisions of this paragraph shall survive the termination of this license for any reason.

c) ***Pay-Per-Use Permissions for Certain Reproductions (Academic photocopies for library reserves and interlibrary loan reporting) (Non-academic internal/external business uses and commercial document delivery).*** The License expressly excludes the uses listed in Section (c)(i)-(v) below (which must be subject to separate license from the applicable Rightsholder) for: academic photocopies for library reserves and interlibrary loan reporting; and non-academic internal/external business uses and commercial document delivery.

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iv) reproduction for resale to anyone other than a specific customer of User;

v) republication in any different form. Please obtain authorizations for these uses through other CCC services or directly from the rightsholder.

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d) ***Electronic Reproductions in Online Environments (Non-Academic-email, intranet, internet and extranet).*** For "electronic reproductions", which generally includes e-mail use (including instant messaging or other electronic transmission to a defined group of recipients) or posting on an intranet, extranet or Intranet site (including any display or performance incidental thereto), the following additional terms apply:

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ii) User may not make or permit any alterations to the Work, unless expressly set forth in the Order Confirmation (after request by User and approval by Rightsholder); provided, however, that a Work consisting of photographs or other still images not embedded in text may, if necessary, be resized, reformatted or have its resolution modified without additional express permission, and a Work consisting of audiovisual content may, if necessary, be "clipped" or reformatted for purposes of time or content management or ease of delivery (provided that any such resizing, reformatting, resolution modification or "clipping" does not alter the underlying editorial content or meaning of the Work used, and that the resulting material is used solely within the scope of, and in a manner consistent with, the particular License described in the Order Confirmation and the Terms.

15) **Miscellaneous.**

a) User acknowledges that CCC may, from time to time, make changes or additions to the Service or to the Terms, and that Rightsholder may make changes or additions to the Rightsholder Terms. Such updated Terms will replace the prior terms and conditions in the order workflow and shall be effective as to any subsequent Licenses but shall not apply to Licenses already granted and paid for under a prior set of terms.

b) Use of User-related information collected through the Service is governed by CCC's privacy policy, available online at www.copyright.com/about/privacy-policy/.

c) The License is personal to User. Therefore, User may not assign or transfer to any other person (whether a natural person or an organization of any kind) the License or any rights granted thereunder; provided, however, that, where applicable, User may assign such License in its entirety on written notice to CCC in the event of a transfer of all or substantially all of User's rights in any new material which includes the Work(s) licensed under this Service.

d) No amendment or waiver of any Terms is binding unless set forth in writing and signed by the appropriate parties, including, where applicable, the Rightsholder. The Rightsholder and CCC hereby object to any terms contained in any writing prepared by or on behalf of the User or its principals, employees, agents or affiliates and purporting to govern or otherwise relate to the License described in the Order Confirmation, which terms are in any way inconsistent with any Terms set forth in the Order Confirmation, and/or in CCC's standard operating procedures, whether such writing is prepared prior to, simultaneously with or subsequent to the Order Confirmation, and whether such writing appears on a copy of the Order Confirmation or in a separate instrument.

e) The License described in the Order Confirmation shall be governed by and construed under the law of the State of New York, USA, without regard to the principles thereof of conflicts of law. Any case, controversy, suit, action, or proceeding arising out of, in connection with, or related to such License shall be brought, at CCC's sole discretion, in any federal or state court located in the County of New York, State of New York, USA, or in any federal or state court whose geographical jurisdiction covers the location of the Rightsholder set forth in the Order Confirmation. The parties expressly submit to the personal jurisdiction and venue of each such federal or state court.

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