

The Paradox of Pottery in the remote Kuril Islands

Erik Gjesfeld

University of California, Los Angeles, Institute for Society and Genetics
University of Washington, Department of Anthropology

1. Introduction

Archaeological research on pottery technology has traditionally emphasized the importance of agriculture, sedentism and population size to explain the adoption and use of ceramics (Eerkens et al. 2002). However, evidence accumulated in recent years disputes these traditional explanations by highlighting the widespread production and use of pottery by small-scale, semi-sedentary, hunter-gatherer communities (Jordan and Zvelebil 2009). This chapter contributes to the growing knowledge of hunter-gatherer pottery technology by investigating the manufacture and use of ceramics among maritime foragers in the remote Kuril Islands of Northeast Asia. In these islands, foraging populations produced pottery for nearly three millennia despite strong environmental limitations. Through a combination of traditional and archaeometric methods, this chapter explores the question of why Kuril populations produced and used pottery in such a remote and challenging environment? Results of the research suggest that pottery was not only used in cooking activities but also served as an important technology for the production of marine oil and the economic livelihood of Kuril inhabitants.

2. The remote Kuril Islands

2.1 Biogeography

The Kuril Islands are located in Northeast Asia and include thirty-two islands varying in size from 5 km² to 3,200 km². The archipelago stretches in line for almost 1,200 km from the island of Hokkaido in the south to the Kamchatka peninsula in the north. The most significant

geographic features of the Kuril Islands are the large and numerous open-water straits between islands. The largest of these is the Bussol strait, which has a significant influence on the biogeography of the island chain (Pietsch et al. 2003; Fitzhugh et al. 2004). In general, islands south of the Bussol strait (Kunashir, Iturup and Urup) maintain significantly higher biological diversity based on their large island size and proximity to Hokkaido. This trend is most clearly observed in the flora of the archipelago with the southern islands having abundant trees and shrubs, including spruce, larch and oak as compared to the tundra-covered islands located north of the Bussol strait (Anderson et al. 2008). The distribution of fauna also demonstrates this pattern with the southern islands containing a wide diversity of terrestrial mammals (Hoekstra and Fagan 1998), insects, mollusks and fish (Pietsch et al. 2001; Pietsch et al. 2003).

In this chapter, focus will be placed on the remote Kuril Islands, which are defined here as the set of islands bounded by the Bussol Strait to the south and the Fourth Strait to the north. These islands, while ecologically less diverse and smaller than the southern islands, do contain higher abundances of marine mammals, particularly sea lions, seals and sea otters (Burkanov and Loughlin 2005). The abundance of marine mammals in the remote Kuril Islands was first documented by European explorers, such as Capt. Snow (1897), who in 1855 described 18 different rookeries with up to one hundred thousand sea lions “hauled up” during the summer months. The modern climate conditions of the remote Kuril Islands are strongly influenced by northwestern winds deriving from Siberia (Leonov 1990). These winds help deliver nearly 138 snowstorm days per year and stable snow cover from November until May (Ganzei et al. 2010). Summers are typically short and characterized by dense fog and very high air humidity (Fitzhugh et al. 2002; Ganzei et al. 2010; Razzhigaeva et al. 2009).

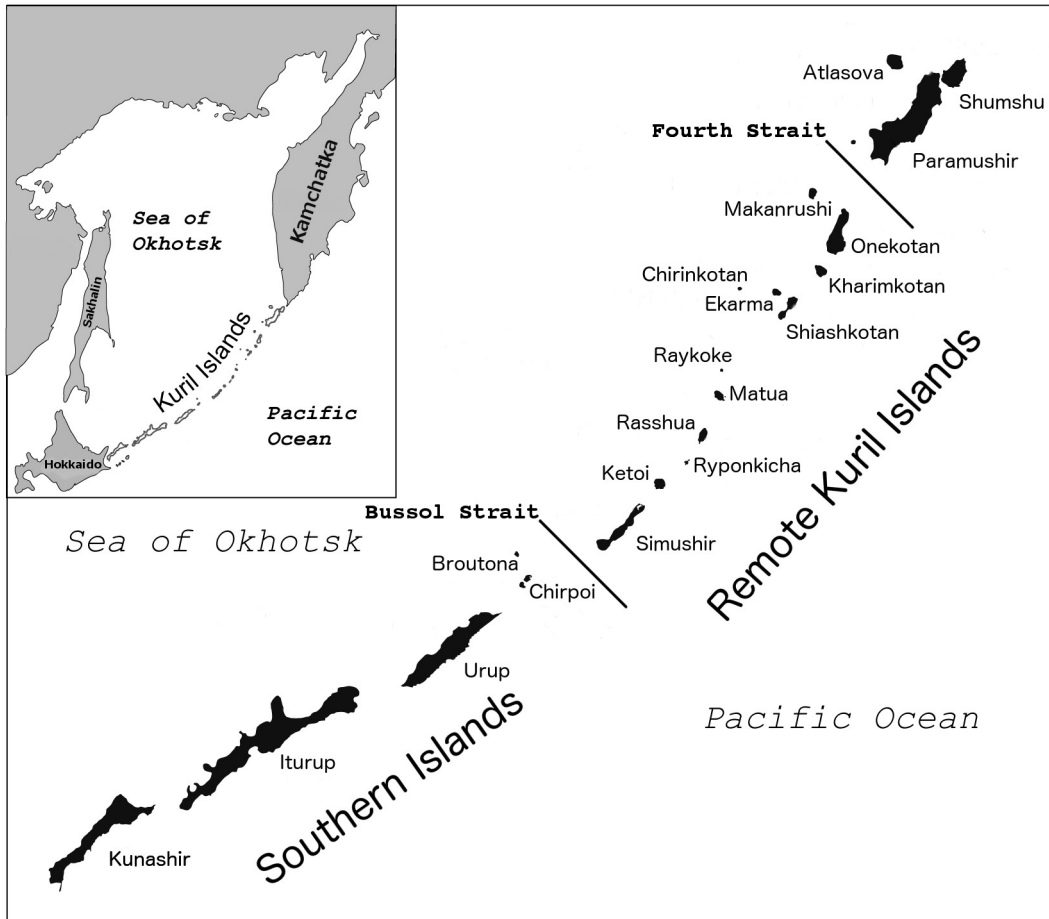


Figure 1. Map of the Kuril Islands with names of islands, straits and regions discussed in the text.

2.2 History of Archaeological Research

The isolated geographic location of the remote Kuril Islands has long proven to be a significant barrier in performing systematic archaeological research. The first European knowledge of this remote region came in the form of diaries and reports from explorers, hunters and traders in the seventeenth to nineteenth centuries. Two of the most prominent contributors from this period were Georg Wilhelm Steller (1709-1746) and his student Stepan Krasheninnikov (1711-1755). Their combined works (Steller 1899, 1988, 2003; Krasheninnikov 1963, 1972), provide some of

the earliest accounts of the social practices, house structures, trading practices and hunting methods of foraging communities around the Sea of Okhotsk. Nearly 100 years later, Captain H.J. Snow chronicled his travels in the book *Notes on the Kuril Islands* (Snow 1897). Captain Snow, a prolific sea otter hunter, led an expedition into the remote Kuril Islands that detailed the geography, flora, fauna, geology and Ainu inhabitants of the island chain.

While systematic investigation of the northern and southern regions of the islands chain were performed by Japanese, American and Russian archaeologists over the last 100 years (Torii 1919; Baba 1934, 1939; Chubarova 1960; Befu and Chard 1964; Golubev 1972; Knozorov et al. 1989; Zaitseva et al. 1993; Shubin 1994), extensive archaeological research was not performed in the remote Kuril Islands until the late twentieth century. Beginning with the International Kuril Islands Project (IKIP) lasting from 1994 to 2000 and culminating in the Kuril Biocomplexity Project (KBP) extending from 2005 to 2012, the remote Kuril Islands became the central focus of large-scale interdisciplinary research that investigated fundamental questions such as the geological, ecological and cultural history of the archipelago.

2.3. Occupation History

Based on archaeological evidence and radiocarbon dates, (Fitzhugh et al. 2002; Fitzhugh et al. 2004; Fitzhugh et al. *in revision*; Kuzmin et al. 2012), three main occupation periods of the remote Kuril Islands are commonly recognized. While the earliest pottery remains in the southern region extend to nearly 8,000 years ago (Zaitseva et al. 1993; Yanshina and Kuzmin 2010), it is not until approximately 4000 cal BP that the first occupation of the remote Kuril Islands takes place. Given the increasing reliance on marine resources in northern Japan and Hokkaido during the Late and Final Jomon (Kusaka et al. 2008, Habu 2004, Yamaura 1998), it is

not surprising that we find the earliest archaeological evidence in the remote Kuril Islands associated with these periods. However, based on the frequency of radiocarbon dates shown in Figure 2, population density during this early occupation period remained relatively low (see Fitzhugh et al. *in revision*, for details on the estimation of population density from radiocarbon dates).

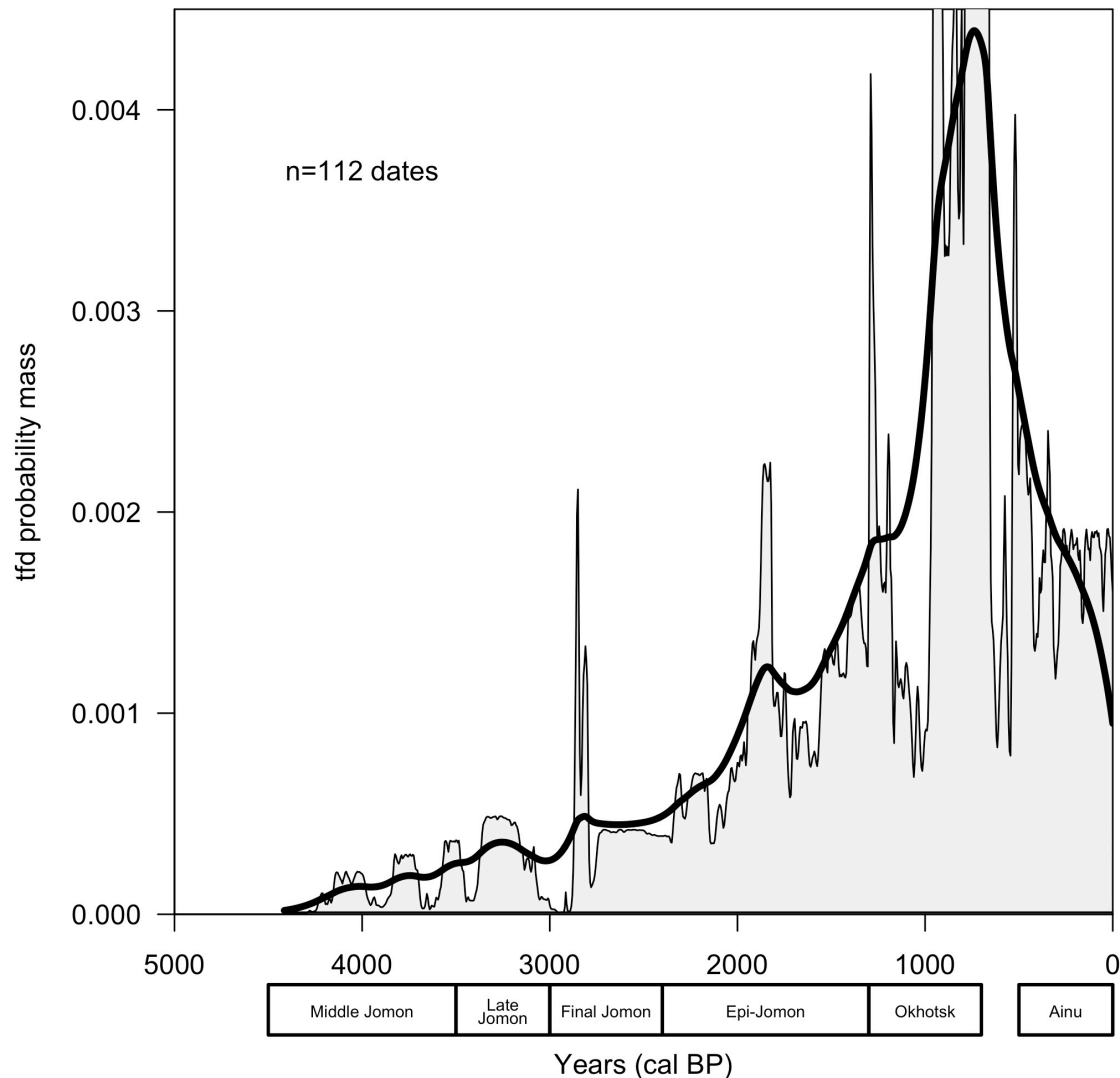


Figure 2. A temporal frequency distribution of summed radiocarbon probabilities from the remote Kuril Islands that are used to estimate population density. The summed probability distribution is shown in grey and the black line represents the smoothed kernel density estimate. See Fitzhugh et al. (*in revision*) for additional details on the analysis of radiocarbon dates.

The first consistent occupation north of the Bussol Strait is generally recognized to occur just after 3000 cal BP (Niimi 1994; Fitzhugh et al. 2002). Based on stylistic similarities in pottery, the populations occupying these more remote islands are connected to the Epi-Jomon (or Zoku-Jomon) culture. Epi-Jomon culture is largely associated with the holdover of foraging practices in northern Japan and Hokkaido as opposed to populations in central and western Japan that relied heavily on rice agriculture, referred to as Yayoi (Aikens and Higuchi 1982). For reasons currently unknown, Epi-Jomon populations in the Kuril Islands appear to experience a gradual decline between 2000 and 1600 cal BP and are difficult to recognize in the archaeological record after 1500 cal BP.

Immediately following (and perhaps overlapping) the Epi-Jomon cultural tradition in the remote Kuril Islands is the presence of artifacts associated with the Okhotsk culture. In Hokkaido, the Okhotsk culture flourished under a time of significant social and economic change throughout East Asia from 1500 to 800 cal BP (Hudson 2004:293). The development of Okhotsk culture is argued to have occurred in three distinctive stages (Amano 1979 in Hudson 2004:294). The first stage involves an eastern expansion from south Sakhalin Island into the Japanese archipelago including Rishiri, Rebun and northern Hokkaido. This is followed by a second stage of movement to the northeastern corner of Hokkaido and into the Kuril archipelago (Hudson 2004). In later stages of the Okhotsk period, populations inhabiting northeastern Hokkaido and the southern Kurils are believed to have been assimilated by proto-Ainu populations associated with the Satsumon culture (Deryugin 2008). By 700 cal BP, artifacts associated with Okhotsk populations in the remote Kuril islands are no longer identifiable with radiocarbon dates suggesting a fairly rapid abandonment of the region.

The third major occupation of the remote Kuril Islands is associated with the Ainu culture. Ethnographically, the Kuril Ainu lived throughout the island chain in relatively large pit house villages as well as smaller seasonal camps (Fitzhugh et al. 2002; Kono and Fitzhugh 1999). Kikuchi (1999) suggests that the Ainu movement from Hokkaido into the remote Kuril Islands would have likely taken place during the fourteenth or fifteenth centuries AD (600-500 cal BP) following abandonment by the Okhotsk culture. Based on his interactions with the Kuril Ainu, Capt. Snow (1897) describes strong differences between the Ainu inhabitants of the remote Kuril Islands and their relatives in the southern islands and Hokkaido. As he states, “they had few things in common with their brethren of the south...the food of these people consisted of the flesh of seal, sea-lion, sea-otter, sea-fowl and their eggs, berries, a few roots and fish. They did not however, appear to be large eaters of the last named” [pp. 18-19].

During the early eighteenth and nineteenth centuries the Russian-American Company settled regions of the remote Kuril Islands with transplanted Alaskan and Siberian sea mammal hunters (Shubin 1994). The Japanese occupation of the Kuril archipelago during the twentieth century displaced many Ainu populations and World War II saw the fortification of the islands by the Russian military.

3. Pottery production in the remote Kuril Islands

Coastal arctic and sub-arctic climates provide numerous challenges to pottery production (Frink and Harry 2008; Harry and Frink 2009; Harry et al. 2009; Zhushchikhovskaya 2005). In general, winters are long, cold and dark and summers are wet, windy and cool (Harry and Frink 2009:333). These conditions make it particularly difficult to form, dry and fire ceramics during the summer season and nearly impossible during all other seasons. Due to the interaction of the

cold Oyashio current and the warm Soya current, the climate of the Kuril archipelago is no exception. The summer season is extremely wet (Razzhigaeva et al. 2009) and it is statistically one of the foggiest places on earth with nearly 215 fog occurrence days per year (Tokinaga and Xie 2009). In addition, many of the remote Kuril Islands are characterized as tundra, with limited wood resources in the form of brush alder (*Duschekia fruticosa*) and dwarf pine (*Pinus pimula*), although driftwood can be periodically found on some islands.

While the remote Kuril Islands do not offer a favorable environment for pottery production, the reality of the archaeological record is that pottery remains are spatially and temporally ubiquitous. Based on cross-cultural research on the adoption of pottery by arctic and sub-arctic populations (Harry and Frink 2009), it is the initial assumption of this research that pottery in the remote Kuril Islands was primarily produced as cooking vessels that would be used in the boiling or stewing of meat, particularly sea-mammal. This assumption differs slightly from the expectation that hunter-gatherers may have initially developed pottery for use in ritual or prestige contexts (Hayden 1995). It is important to note that the division between the production of ceramic vessels for cooking and the production of ceramic vessels for ritual or prestige activities is a simplistic assumption, as pottery is commonly used in both social contexts. However, given the limited analysis of pottery from the remote Kuril Islands, this dichotomy is convenient for the initial assessment of production and use.

Building from the expectation that pottery in the remote Kuril Islands is primarily tied to cooking activities, it is the archaeological expectation that a majority of pottery sherds in this study should display “coarse-ware” attributes. This includes plain or no decorations, simple design forms and little uniformity in the abundance, sorting and coarseness of temper found in ceramic

pastes (Rice 1981:220). Alternatively, the production of pottery for ritual or prestige contexts is expected to demonstrate features of “fine-wares” including intricate geometric decorations, diverse vessel forms and consistency in manufacturing techniques (Zhushchikhovskaya 2009), such as the size and proportion of temper.

	Cooking (Coarse)	Prestige (Fine)
Decoration	Plain	Intricate / Geometric
Form	Simple	Complex
Temper (Abundance)	Variable	Consistent
Temper (Sorting)	Poorly Sorted	Well-Sorted
Temper (Coarseness)	Coarse	Fine

Table 1. Expectations for pottery vessels that are produced in association with either cooking or prestige activities.

3.1. Collecting and Sampling the Kuril Pottery Assemblage

Pottery sherds used in this research were recovered through survey and excavation performed by the Kuril Biocomplexity Project (KBP) from 2006 to 2008. The sampling of pottery sherds recovered by KBP used a multi-stage strategy combining non-random judgment sampling and random sampling. The sampling process proceeded by separating sherds within each site assemblage that contained distinctive features, such as recognizable decorative motifs (cord-marking, applique, incisions, geometric patterns or stamping). After isolating distinctive sherds, all rim or base sherds not yet included in the sample were selected for analysis. Finally, non-distinctive (undecorated) medium to large body sherds (those greater than 20 mm in any one dimension) from each site were randomly sampled until at least one-quarter of the total site assemblage was analyzed. Five out of twenty-five archaeological sites did not have at least 25% of their assemblage analyzed due to either very large assemblages (>750 sherds) and/or a large

proportion of very small (<5 mm) fragments. In total, 1,114 sherds were analyzed from archaeological sites located in the island chain with 419 sherds analyzed from sites in the remote Kuril Islands.

Analysis of the pottery assemblage involved the measurement and description of all sampled sherds. Descriptive information included weight, average wall thickness, length, width, interior curvature, vessel part (body, rim, base) and surface treatment. For sherds identified as rims, additional descriptions included rim thickness, rim dimensions, rim symmetry and lip type. For sherds identified as bases, additional measurements included base thickness, base angle and base diameter. For sherds with decorative motifs, additional descriptions included the location of the design (interior/exterior), the style of decoration (cord-marking, incisions, applique, etc.), dimensions of the motif and a written description and/or photograph of the decorative elements. The measurement data collected in this research is archived with The Digital Archaeological Record (tDAR) and freely accessible at <https://core.tdar.org/dataset/393044>.

3.2 Decorative Features

The evaluation of pottery vessel decoration was accomplished through the development of a paradigmatic classification scheme that summarized the presence and absence of decorative features. In contrast to taxonomic classification, a paradigmatic classification uses an unordered and unweighted structure of predetermined characters (attributes) and their states to construct artifact classes (Dunnell 1971; O'Brien and Lyman 2003). The main advantage of a paradigmatic classification scheme in analyzing pottery decorations is that multiple character states can be combined in order to provide an unambiguous assignment of pottery sherds with no sherds remaining unassigned. Predetermined attributes used in this research were based on

decorative features highlighted in published literature (Ohya 1975; Tezuka and Fitzhugh 2004; Deryugin 2008) and included cord-marking, applique, incisions, punctuation, scratching and rim projections. In total, 58 unique decorative types were identified in the assemblage with four examples highlighted in Figure 3.

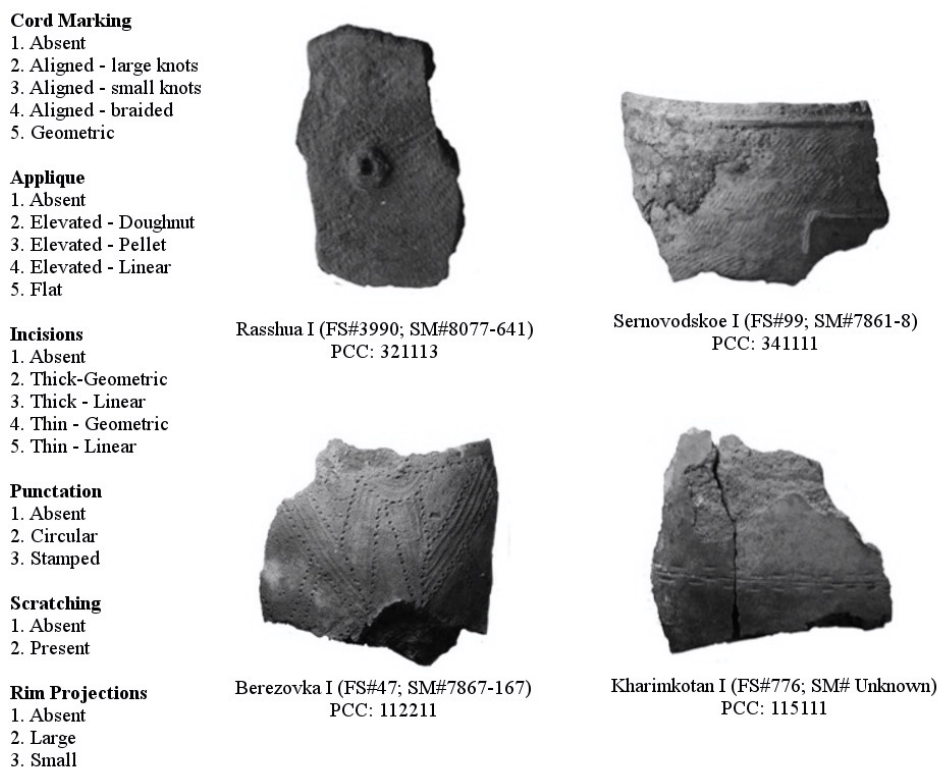


Figure 3. Paradigmatic classification scheme for decorative features with examples of common decorations including the field sample number (FS#), Sakhalin Museum accession number (SM#) and paradigmatic classification code (PCC)

Based on the paradigmatic classification scheme, decorated pottery sherds accounted for 38.6% of analyzed sherds from the remote Kuril Islands. Cord-marking represents the most common decoration with 76.7% of decorated sherds displaying this element. The high proportion of cord-marking decoration in the pottery assemblage of the remote Kuril Islands is not surprising given that initial occupation of the region occurs during the Epi-Jomon cultural period. Similar to

earlier Jomon pottery, cord-marking is a distinctive characteristic associated with Epi-Jomon pottery and is identifiable throughout the Kuril archipelago, Hokkaido and Sakhalin. The furthest geographical extent of cord-marked pottery was on the island of Shiashkotan at the site of Drobyne I.

In a comparison of pottery recovered from the remote Kurils with pottery originating in the southern Kuril Islands, a few differences in decorative styles are noticeable. The most prominent difference is the presence of elaborate geometric designs and rim projections on Epi-Jomon pottery from sites in the southern region as opposed to only simple cord-marked decoration found on pottery from sites in the remote islands. The absence of more intricate geometric patterns is can be recognized in the decorative diversity index for each region. Using a Shannon Diversity Index (Shannon and Weaver 1948) to estimate decoration diversity (similar to Nelson et al. 2011), pottery from the southern regions not only has a significantly higher number of paradigmatic types than the remote region but also higher diversity scores. These results suggest that even when considering the larger sample size, the variety of decorative features in the southern region is higher than in the remote islands.

Region	Sample Size	Percent Decorated	Number of Paradigmatic Types	Shannon Diversity Index	Diversity Interpretation
South	678	49.4%	53	2.00	Moderate
Remote	419	38.6%	23	1.13	Low

Table 2. Summary statistics and diversity indices for the southern and remote regions of the Kuril archipelago

Perhaps the most intriguing feature of pottery decoration from the remote islands is the near complete absence of diagnostic features associated with the Late Epi-Jomon period (2000-1300 cal BP) or the early Okhotsk period (1300-1000 cal BP), with the exception of a single Kohoku C2-D fragment found on the island of Chirpoi. The absence of Kohoku type pottery in the remote Kuril Islands is important for not only inferring the extent of Late Epi-Jomon occupation but also because Kohoku pottery often demonstrates more “fine-ware” characteristics such as elaborate geometric designs. The absence of Kohoku-style pottery in the remote Kuril Islands initially suggests that the production and use of “fine-ware” pottery was confined to the southern region.

The analysis of decorative features also provided the opportunity to compare the current pottery typology of the remote Kuril Islands to the cultural chronology of the region as inferred from radiocarbon dates. Out of the 58 unique pottery types identified through paradigmatic classification, 40 types can be considered diagnostic to one of three culture-historical periods: Middle/Late Jomon (4500-2500 cal BP), Epi-Jomon (2500-1400 cal BP) and Okhotsk (1400-700 cal BP). Out of the 40 diagnostic types, 12 types (110 total sherds) can be chronologically affiliated with at least one radiocarbon date from the same excavation level. The remaining 28 diagnostic types were either recovered from surface contexts or excavations levels without an associated radiocarbon date.

As highlighted in Figure 4, the chronological expectations of pottery types generally conform to expected age ranges. With the exception of type #314111, all diagnostic types culturally affiliated with the Epi-Jomon have mean ages within the expected culture-historical boundaries of the Epi-Jomon. While fewer radiocarbon (RC) and pottery samples (Sherds) are available for

Okhotsk pottery types, radiocarbon dates also generally coincide with expected culture-historical ages. Of particular interest is the chronological association of pottery type #115111 (thin linear incisions) with the Middle and Late Okhotsk culture-historical period. If accurate, these pottery sherds represent one of the first pottery types in the remote Kuril assemblage to be associated with a specifically northern Hokkaido pottery style (Chinsemon).

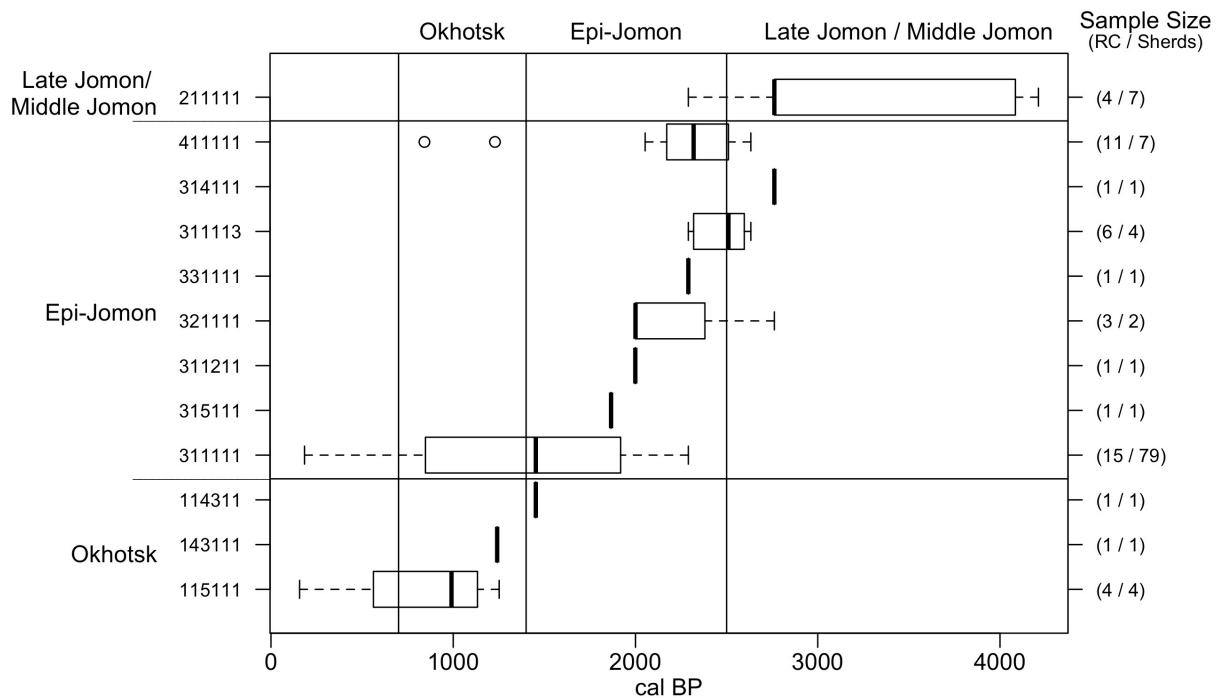


Figure 4. Boxplots of calibrated radiocarbon dates (weighted mean) with diagnostic pottery types and their associated cultural period (y-axis) as well as chronological periods with their associated cultural periods (x-axis)

3.3 Vessel Shape

Vessel shape was evaluated through the analysis of three components considered to be informative about the construction and function of a vessel, these include the shape of the body/neck, orifice size and base shape (Cochrane 2006; Rice 1987). Using a classification scheme based on points of curvature or angling, the body / neck shape is defined as the shape of the vessel from just below the rim end point (lip) extending down to the first inflection point

above the maximum diameter of the vessel (Rice 1987). Based on this scheme six different body / neck shapes were identified within the remote Kuril Islands pottery assemblage (Figure 5). These include lower recurved, upper recurved, lower incurved, upper incurved, vertical and everted. Given the difficulty in distinguishing between vertical and everted rim sherds without full vessels, these shapes were combined into a more generic neck shape referred to as “direct”. Analysis of neck shapes indicates two primary body / neck shapes in the assemblage, direct (31.9%) and lower recurved (30.2%). Both of these body / neck shapes are most often associated with cooking practices as this shape allows for the greatest access to vessel contents, as opposed to restricted vessel shapes that are more characteristic of storage vessels (Rice 1987). The high proportion of vessels with a substantial neck or collar region, classified as a lower recurved body, should not be surprising as this vessel shape is a diagnostic feature of Okhotsk-style ceramics (Deryugin 2008). The likely function of the large neck or collar region is to create a lower vessel shoulder (or inflection point), which enhances the balance and “graspability” of the vessel (Rice 1987).

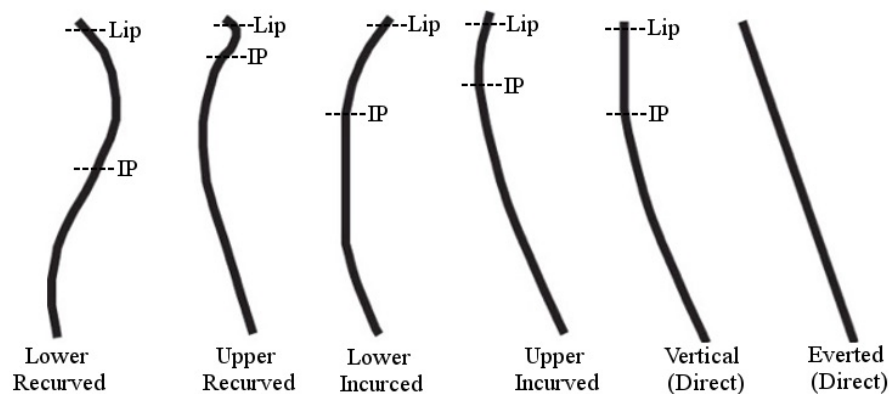


Figure 5. Range of body / neck shapes identified in the Kuril pottery assemblage (IP refers to the first inflection point).

Reconstructing vessel size from pottery sherds relies heavily on the use of rim sherds to determine the orifice diameter, which in turn is used to broadly estimate overall vessel size. Based on comparison of vessel sizes from nearby regions including Hokkaido and Sakhalin, small vessels are considered to have an orifice diameter of less than 15 cm, medium vessels between 15 and 30 cm and large vessels greater than 30 cm. In the remote islands, medium vessels are the most common accounting for 43% of all sizes with small vessels accounting for 37% and large vessels making up 20% of the rim assemblage.

Base sherds are often less informative than rim sherds on reconstructing vessel size although neither provides direct information concerning vessel height. From an analytical perspective, base sherds can only provide a very general classification between tall or short vessel forms with a wide base angle and large diameter suggesting flatter and shorter forms such as a platter or shallow bowl. Base sherds with a higher angle (closer to 90°) and smaller base diameter suggest taller and more cylindrical forms. In the Kuril pottery assemblage, few basal fragments were recovered with base sherds totaling only 9.8%. Of these basal sherds, all base types were flat with an average diameter of 9.7 cm and an average base angle of 108°. These dimensions suggest that most all vessel forms were tall, cylindrical bowls of medium size.

3.4 Paste Composition

In the manufacture of pottery throughout the world, a wide diversity of material is often utilized for temper including organic and inorganic materials. However, in previous analysis of ceramics from around the Sea of Okhotsk (Kidder 1976; Hall 2004; Tezuka and Fitzhugh 2004; Zhushchikhovskaya and Shubina 2006; Deryugin 2008), a majority of vessels are tempered with inorganic mineral temper. Exceptions to this include the use of organic temper (fiber temper)

among early pottery traditions of the Initial, Early and Middle Jomon periods and the use of shell temper among the Imchin culture of northern Sakhalin (Zhushchikhovskaya and Shubina 2006). In the remote Kuril pottery assemblage, the sole temper type is mineral-based, either crushed rock or sand. This is visually recognized in both the macroscopic and microscopic cross-sections of pottery sherds.

The abundance, coarseness and sorting of non-plastic inclusions (temper) was examined in this research through the analysis of petrographic thin sections and non-impregnated polished sections. It is assumed here that a high degree of coarseness (large grains) and a poorly sorted matrix (many different sizes of mineral temper) imply a less uniform manufacturing method (Rice 1981). The distribution of temper abundances from the analysis of thin section (Figure 6A) suggests the use of mineral temper to reduce thermal stress and cracking during firing and cooking activities. The average proportion of temper in clay pastes (14.8%) is generally low enough to enhance stability during firing but not high enough to cause major changes to the density and porosity of the clay paste (Rye 1981). Examination of temper coarseness and sorting indicate a high proportion of coarse grains that are poorly sorted, Figure 6B. In other words, the predominant paste composition is characterized by many different sized grains with large mineral grains being the most abundant. These results suggest that paste recipes were not standardized and that a wide diversity of clay paste recipes were used among potters of the remote Kuril Islands.

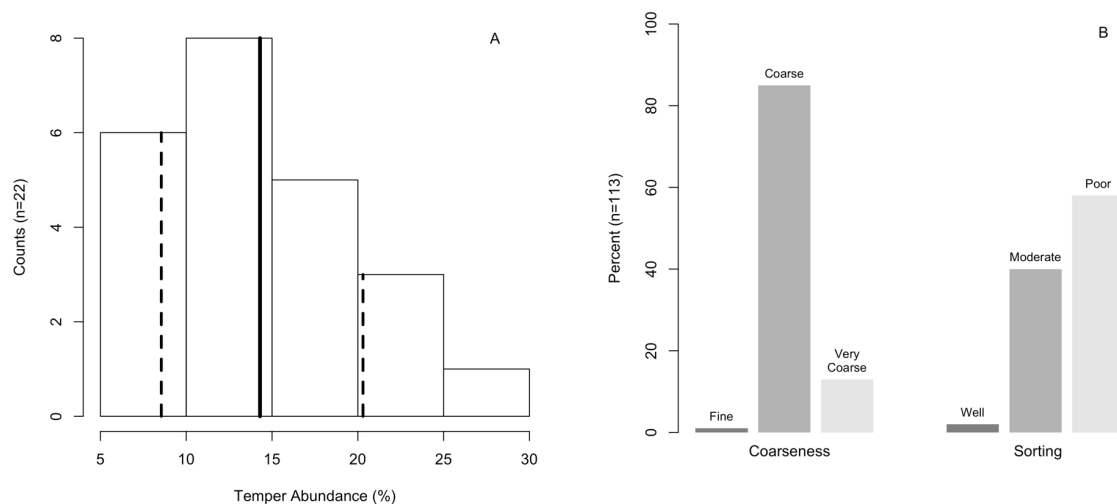


Figure 6. Histogram of temper abundances showing mean (solid line) and spread (dashed lines) as well as distribution of temper coarseness and sorting classes

The analysis of pottery decoration, form and paste suggests most pottery vessels from the remote Kuril Islands were used as cooking vessels. This conclusion is based on the low diversity of decorative features, the high proportion of unrestricted tall bowls of medium size and the lack of uniformity in paste composition. Based on the assumed relationship between “fine-ware” and ritual or prestige activities, there is little to no evidence for the production of “fine-ware” pottery in the remote Kuril Islands. However, it should be noted that at archaeological sites located in the southern region, a small number of sherds do demonstrate decorative feature that are suggestive of “fine-ware” production.

4. Investigating Pottery Function in the Remote Kuril Islands

The starting expectation of this research is that pottery was produced in the remote Kuril Islands for the cooking of meat, specifically sea mammal. Through the analysis of vessel decoration, form and paste composition, compelling evidence exists for the production of pottery vessels that

are designed for cooking. However, our understanding of **how** remote Kuril populations were using these cooking vessels and **what** they were cooking still remains poorly understood. In order to more fully explore these questions, this research examined differences in cooking strategies through the analysis of vessel thickness as well as a pilot analysis of organic residues that identified the subsistence resources that were cooked in pottery vessels and the temperatures at which these resources were cooked.

4.1 Cooking Strategies

One of the most significant factors influencing the cooking performance of ceramic vessels is the thickness of vessel walls and bases. In cooking practices that use direct heating methods, thin walls are often more advantageous as they tend to be more resistant to thermal shock and conduct heat better, allowing food to cook faster and saving fuel (Henrickson and McDonald 1983; Harry and Frink 2009). In contrast, thick walled vessels can be advantageous when used with hot-stone cooking methods as the thick walls reduce the loss of heat by providing greater insulation (Reid 1989). In this chapter, the use of either direct heating or hot-stone cooking methods by remote Kuril populations is evaluated by examining differences in the thickness of ceramic vessel walls and bases. Based on research from Alaska, the choice of groups to use either direct or indirect (hot-stone) heating methods is based on raw-material availability. Populations living in tundra conditions with limited access to fuel tend to prefer direct heating methods and interior populations with greater access to wood prefer indirect heating methods (Harry and Frink 2009). Therefore, it is the starting expectation of this research that populations inhabiting the tundra environment of the remote Kuril Islands would favor direct heating methods and thin-walled (4-8 mm) pottery, as using wood to indirectly heat stones is far less efficient than directly heating ceramic vessels (Harry and Frink 2009).

Thickness measurements of pottery walls and bases were determined by averaging digital caliper measurements from two different locations on body and base sherds. In total, 303 sherds from six different archaeological sites were examined. The average thickness of vessel walls from these sites is 8.7 mm and the average thickness of vessel bases is 9.7 mm. In comparison with pottery recovered from the southern region, no significant statistical differences ($p < 0.01$) could be identified in thickness measurements (see table 3a). However, based upon previous research from around the Sea of Okhotsk (Zhushchikhovskaya and Shubina 2006), differences in vessel thickness are known to be highly correlated with different cultural traditions. Using diagnostic traits, pottery sherds from the remote islands were assigned a cultural affiliation with cord-marking indicating Epi-Jomon affiliation and either linear incision, stamping or lower recurved body form indicating Okhotsk affiliation. As highlighted in table 3b, statistical tests indicate that strong significant differences ($* = p < 0.01$) do occur in thickness measurements between these two cultural traditions.

a) Regions	Wall Thickness (mm)			Base Thickness (mm)		
	n	Mean	S.D.	n	Mean	S.D.
South	585	8.5	2.0	52	7.9	1.7
Remote	303	8.7	1.9	33	9.7	4.7

b) Remote Islands by culture	Wall Thickness (mm)			Base Thickness (mm)		
	n	Mean	S.D.	n	Mean	S.D.
Epi-Jomon	136	7.8*	1.1	12	7.4*	1.2
Okhotsk	167	9.4*	2.0	21	11.1*	5.5

Table 3. Average wall and base thickness measurements for a) the southern and remote regions of the Kuril Islands and b) the average wall and base thickness for Epi-Jomon and Okhotsk sherds from the remote Kuril Islands. (*) indicates strongly significant differences ($p < 0.01$) as determined by the Welch's two-sample t-test for populations of different sizes and variances.

The identification of statistically significant differences in vessel thickness between Epi-Jomon and Okhotsk pottery provides preliminary evidence for cultural rather than regional differences in cooking strategies. For example, Reid (1989:173) suggests that vessels used in conjunction with hot-stone boiling methods should display “an over-thickened, flat, stable base” and thicker walls that can act as an insulator to absorb the radiant and impact energy of hot stones. In contrast, the thinner walls and bases of Epi-Jomon pottery are more useful in the direct transfer of heat from an external fire. Given that hot-stone boiling methods are far less efficient and use higher amounts of fuel (Harry and Frink 2009), why would Okhotsk populations living in the remote Kuril Islands use indirect heating methods? One possible advantage of hot-stone boiling compared to open fire cooking is the greater control of cooking temperature over longer periods of time. Based upon ethnographic evidence from northwestern North American foragers (Reid 1989), hot-stone boiling methods were used when a long simmer (85-88° C), rather than a boil, is desired. Drawing on modern industrial rendering methods, low temperature heating (~60° C) is typically used in the more delicate extraction of oils from liver or blubber (Shahidi et al. 1994) rather than the higher temperatures associated with extraction from bone marrow (Church and Lyman 2003).

4.2 Exploratory Lipid Residue Analysis

Building from the analysis of vessel thickness, a pilot study was conducted to identify what resources were being cooked and how these resources were being cooked. If pottery was routinely used by remote Kuril populations in cooking practices that utilized high and direct heat, it is expected that lipid residues extracted from pottery sherds would demonstrate marine lipid signatures *and* marine biomarkers that are produced by the repeated heating of fatty acids to high temperatures (Reid 1989; Copley et al. 2004; Hansel et al. 2004; Evershed et al. 2008; Heron et

al. 2010; Craig et al. 2011). If pottery was used in low-heat practices, such as the rendering of marine oils, it is expected that organic residues would display marine lipid signatures but lack marine biomarkers that are formed during repeated heating to higher temperatures.

Organic residues associated with marine fats/oils have traditionally been difficult to identify due to the rapid degradation of unsaturated fatty acids during pottery vessel use and burial (Evershed et al. 2008). However, despite these challenges, recent research (Copley et al. 2004; Hansel et al. 2004; Evershed et al. 2008; Heron et al. 2010; Craig et al. 2011) has demonstrated two fatty acids that provide evidence of marine fats/oils. These are two isoprenoid acids: phytanic acid (3,7,11,15-tetramethylhexadecanoic acid) and 4,8,12-TMTD (4,8,12-trimethyltridecanoic acid). In addition to these biomarkers, experimental work has also demonstrated that ω -(*o*-alkaphenyl) alkanolic acids are produced through the prolonged heating of unsaturated marine fatty acids at 270° C or above (Evershed et al. 2008; Heron et al. 2010). By evaluating the presence of both isoprenoid marine biomarkers (phytanic acid and 4,8,12 TMTD) and alkanolic acids, this research tests for the use of ceramic vessels in the cooking of aquatic resources as well as the relative temperature (above or below 270° C) of cooking.

Lipid residue analysis of extracted fatty acids was performed in the Sachs Lab at the University of Washington on 15 ceramic sherds from four archaeological sites in the Kuril Islands (Ainu Creek (south), Vodopodnaya (remote), Rasshua (remote) and Ainu Bay (remote)). Lipid analysis was performed following established laboratory protocols (Evershed et al. 1990; 1994) by pulverizing pottery sherds and extracting lipids by accelerated solvent extraction (ASE) in a dichloromethane:methanol (DCM) solvent. The solvent extract was evaporated under N₂ to obtain a total lipid extraction (TLE). The total lipid extract was silylated and analyzed by gas

chromatography-mass spectrometry (GC-MS). Identification of lipid biomarkers was accomplished through the analysis of ion chromatograms with the identification of each biomarker based on their specific mass to charge ratio (m/z) using their trimethylester (TME) derivative.

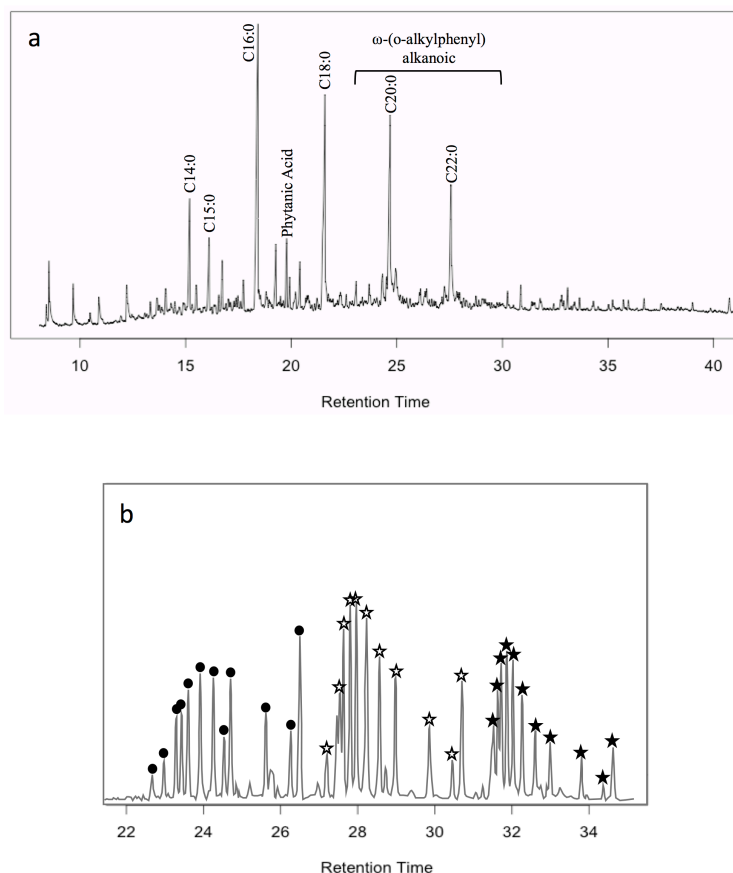


Figure 7. Partial gas chromatogram of lipid residue from an Okhotsk body sherd vessel (FS# 2283-5) from site of Ainu Creek on Urup. a) Ion chromatogram with major fatty acids identified as well as phytanic acid and the region of interest for ω -(*o*-alkylphenyl) alkanolic acids. b) A m/z mass chromatogram showing the range of alkanolic acids present including ω -C18s (filled circles), ω -C20s (open stars) and ω -C22s (filled stars).

Results of lipid residue analysis demonstrate that all pots examined contained marine lipid signatures but only pots from the southern site of Ainu Creek had a high proportion of Epi-

Jomon and Okhotsk samples (five of eight; 63%) that contain ω -(o-alkaphenyl) alkanolic acids, which are produced from repeated heating of marine fats to 270° C. In contrast, pottery remains from the remote Kuril Islands, where all sherds are associated with the Okhotsk culture, demonstrate a significantly lower proportion of sherds (two of seven; 29%) that show alkanolic acids (see Gjesfjeld 2014 for additional details).

One possible explanation for the reduced proportion of Okhtosk samples with ω -(o-alkaphenyl) alkanolic acids is the use of low-heat cooking strategies for the rendering of marine oils from fish or marine mammals. In comparison with other populations from the North Pacific, the production of marine oil from whale, seal, sea lion or fish fat is common. As ethnographic evidence from Kodiak Island, Alaska demonstrates, oil was an important commodity in the winter storage of edible roots, stems, berries and leaves that were collected during the summer months (Holmberg 1985:41-42). Early explorer Davydov (1976:16) goes so far as to remark, “without [oil] they could barely exist and would never be happy”. As suggested by Fitzhugh (2003:69) drawing from Speth and Spielman (1983), the importance of oil within communities around Kodiak Island may be a biological response to supplement the nutritional deficiencies of a lean-meat, high protein (fish) diet with marine fats that are vital to surviving late winter and early spring resource depressions. It is proposed here that a similar process is happening in the remote Kuril Islands, as the neighboring populations of northern Hokkaido (and potentially Kamchatka) are known to have relied heavily on fishing to survive the winter months (Hudson 2004). The production and exchange of marine oil by Okhotsk populations living in the remote Kuril Islands could have been important and valuable commodity to trade with populations in these neighboring regions.

5. Conclusions

This research presented in this chapter started with a simple question, why produce pottery in the isolated and challenging environment of the remote Kuril Islands? Through the descriptive analysis of vessel attributes and lipid residues, this research concludes that the production and use of ceramics in the remote Kuril Islands was tied to the cooking of marine resources with Okhotsk populations potentially using ceramics to specialize in the production of marine oils. It is important to note that even though the exchange of marine oil is difficult to recognize archaeologically, previous compositional analysis of pottery (Gjesfjeld 2015) and obsidian (Phillips and Speakman 2009) demonstrate that Okhotsk populations living in the remote Kuril Islands have broader and more dense exchange networks as compared to Epi-Jomon populations. In particular, obsidian sourcing demonstrates the extensive procurement and use of Kamchatka obsidian (Phillips 2011) by Okhotsk populations inhabiting the remote islands.

Overall, the pottery assemblage of the remote Kuril Islands presents an intriguing example of pottery production and use by maritime hunter-gatherers living in an isolated and sub-arctic landscape. Despite strong social and environmental constraints, pottery is consistently produced, used and repaired for nearly three millennia. An unexpected outcome of this research is that the motivation behind producing and using pottery in the remote islands likely differed between the Epi-Jomon and Okhotsk populations. Arguably, the Epi-Jomon produced and used pottery for the traditional cooking of aquatic resources, similar to their Jomon ancestors and Epi-Jomon relatives. Okhotsk pottery production, on the other hand, reflects a more specialized focus on the production of marine oil, similar to maritime hunter-gatherers from around the North Pacific.

Given the rapid abandonment of the remote Kuril Islands by Okhotsk populations is not tied to either major catastrophic events (Fitzhugh 2012) or climatic changes (Fitzhugh et al. *in revision*), future research in the remote Kuril Islands needs to strongly consider the economic motivations for the migration and abandonment of Okhotsk populations in this region. If, as suggested in this chapter, Okhotsk populations primarily inhabited the remote Kuril Islands to produce and exchange marine oil, their long-term occupation of the region is strongly tied to the demand for marine oil in the southern Kuril Islands, Kamchatka and Hokkaido. Therefore, if this broader regional demand for marine oil is reduced, either through shifting exchange networks, warfare, political instability or simply changes in preferences, abandonment of the remote Kuril Islands should not be unexpected. Perhaps the most important contribution of this research is to highlight that the remote Kuril Islands are influenced by the larger regional system of Northeast Asia. Based on similarities in pottery technology and the possibility of regional exchanges in marine oil, it is clear that the maritime hunter-gatherers of the Kuril Islands are not living in isolation but directly and indirectly participating in the economic, technological and political dynamics of the surrounding regions. By understanding how the remote Kuril Islands fit within the broader complexities of Northeast Asia, future research can refine and enhance our understanding of this unique region.

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