4 Modeling Hunter-Gatherer Information Networks: An Archaeological Case Study from the Kuril Islands

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Abstract

This chapter develops a model to frame differences in the degree and intensity of hunter-gatherer information networking as strategic responses to differing degrees of environmental variability and interaction costs. With this model, we argue that hunter-gatherer bands (i.e., more or less egalitarian, small-scale, and mostly wild-food-producing groups) should be more connected at local, intergroup, regional, and supraregional scales when the costs of networking are low and environmental productivity and predictability are also low (probability of local failure is high). At the other extreme, high-cost landscapes with high predictability and reasonable productivity should lead to greater insularity, but with punctuated failures due to rare and unpredictable environmental perturbations. High-cost, low-predictability/low-productivity landscapes should necessitate higher levels of investment in networking, through the generation of specialized traders, subsidized to serve the essential function of connecting groups. And low-cost, high-predictability/high-productivity landscapes should generate networks that are less focused on linking groups for mutual benefit and are instead more political and competitive due to the reduction in interdependence between communities despite the inevitability of social contacts. This model is then applied to an initial study of ceramic and lithic artifacts from the Kuril Islands of the northwest Pacific, where intersettlement distances and ecological productivity and predictability vary across the geographical scale of the island chain.

INTRODUCTION

It is well known that small-scale hunter-gatherer societies use several strategies to buffer resource unpredictability, among other goals. The information-based strategies documented seek to increase information about alternate resource patches and their productivity and to preserve information about rare but particularly severe resource failures and possible strategies for their mitigation (e.g., Minc 1986; Wiessner 1982). In this paper, we advance a model that simultaneously takes account of differences in the imperative for information sharing at different scales of space and time and factors in the limits and costs of maintaining such information exchange strategies (see also Whallon, Chapter 1, this volume). This model shares similarities with Whallon's (2006) recent "non-utilitarian" model of hunter-gatherer information exchange, while focusing more on mechanisms of transmission and geographical variability.

Our goal is to better predict variability in the structure of hunter-gatherer information networks as a result of adaptation to environments of differing degrees of marginality and levels of constraints on information sharing. Using initial data from archaeological research being conducted in the Kuril Islands of the North Pacific Ocean, we highlight several predictions that can be drawn from this model. This model provides a framework for understanding the evolution of important aspects of hunter-gatherer interaction patterns as well as changes in vulnerability and resilience to socio-ecological variation.

Definitions and Assumptions

We define information here as

> *a coherent symbolic code of relevance to some topic of interest or concern that can be recorded, supplemented, preserved, transmitted, retrieved, enacted, or even forgotten.*

This definition has an advantage over others (e.g., knowledge, instruction, data) in that it can apply to a wide range of domains (individual learning, social transmission, signaling, genetics) that we might wish to compare when generalizing about evolutionary processes. It emphasizes the dynamic and contextual nature of information.

In the context of information exchange, it is important to recognize the strategic context of social transmission. In exchange networks, information can be shared or denied. It can be reliably transmitted or falsified, and recipients need to evaluate their degree of trust in information sources. Recognizing the political context of information transmission is important if we want to understand the mechanisms structuring information networks.

We assume that all people monitor environmental variables and that they maintain a degree (but not an infinite degree) of flexibility to adjust their behaviors in locally optimal directions to enhance survival, well-being, reproductive success, and other more proximate goals. We are particularly interested in exploring the limits of adaptive capacity in the context of information acquisition and exchange, which will be most identifiable in marginal environments, where failure is more likely than elsewhere. Once we understand how people succeed and fail at the limits of viability, we can explore how evolutionary histories change the boundaries of marginality, making once marginal environments more viable and, in some cases, rendering less marginal environments less viable.

Information Acquisition Strategies of Hunter-Gatherer Bands

Hunter-gatherers have used a number of different strategies to mitigate environmental unpredictability. These strategies (e.g., mobility, sharing, trade) are usually understood in relation to costs and benefits associated with acquiring resources in spatio-temporally heterogeneous environments. Information flow about changing socio-environmental conditions is critical to thriving in such contexts, and anthropologists have discussed a number of strategies used by hunter-gatherer bands to facilitate this flow (Gamble 1993, 1998; Minc 1986; Wiessner 1982). Among others, these strategies include oral traditions, fluid group composition, occasional social aggregation, widespread exchange friendships, and journeying (Figure 4.1). Here, we explore these and other potential mechanisms of information acquisition and preservation as they fit into broader geographical and temporal variability.

Information exchange is embedded within and can be facilitated by social gatherings, ranging from small opportunistic meetings between two or more individuals or family groups to large megaband aggregations brought together for planned ceremonies, trade fairs, and the harvest of temporarily concentrated resources (Whallon, Chapter 1, this volume). Regardless of the scale, periodicity, or regularity of these social gatherings, the result is an expanded pool of *potential* information about the broader state of the environment and available mates and trading partners.

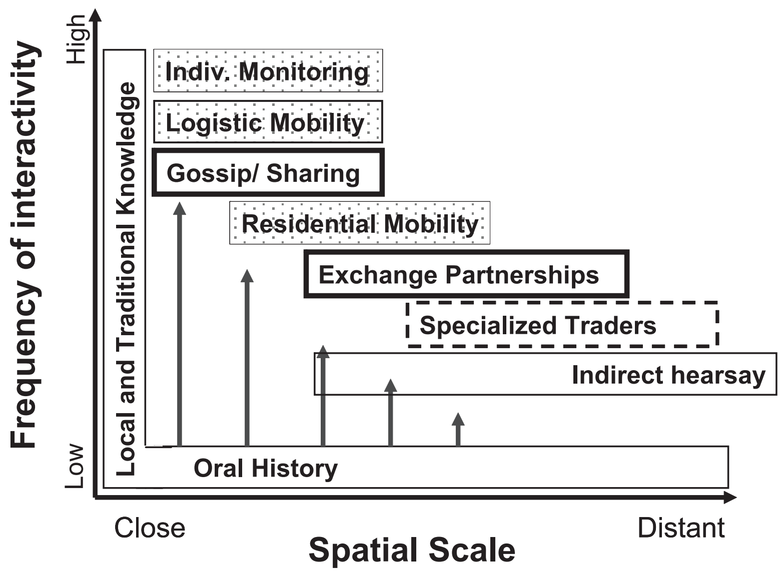

Figure 4.1. Adaptive strategies used by hunter-gatherer bands to maintain information for mitigating environmental unpredictability. The horizontal axis represents the distance over which the strategy is considered effective. The vertical axis reflects the relative rate at which the information is refreshed.

Polly Wiessner's (1982) discussion of the *hxaro* trading partnerships among the !Kung has become the standard model for small-scale hunter-gatherer information sharing beyond the microband. In the *hxaro* model, exchange partnerships serve as a pretext and social interaction as a mechanism for the sharing of environmental information. This model is particularly attractive archaeologically because the information-sharing networks are highly materialized through the exchange of artifacts.

These strategies of information acquisition emphasize the opportunity for sharing of information across different *spatial scales*. Other mechanisms have been proposed for the storage of information about environmental variability *through time and space*, such as the development and transmission of local and traditional knowledge.

Local and Traditional Knowledge as Information Storage

Local and traditional knowledge (LTK) refers here to information that is accumulated, stored, and transmitted through "micro-media" methods (storytelling/oral history and non-mass-replicated forms of literacy such as pictography, journaling, and letter writing, in literate societies). LTK can encode information about past social and environmental states, cycles, and interventions. LTK is a two-dimensional (time and place) form of information storage against which new information is balanced and to which new information is added. *Traditional knowledge* is the accumulation of information observed and shared about such topics as spatio-temporal variations and suitable strategies for exploiting and mitigating variability. Traditional knowledge can develop information about landscapes beyond local experience and store knowledge of historical relationships with neighboring social groups. *Local knowledge* is that part of traditional knowledge that relates individual experiences of local variability to a growing corpus of pooled information held more or less commonly by members of an established group and maintained through a combination of personal experience, instruction, and storytelling. Local knowledge is expected to be the most reliable and accurate form of information, due to its frequent transmission and redundancy with common, everyday experience. LTK forms the bedrock of cultural tradition that grows stronger the longer a group lives in a region and the more variability the population experiences (and survives). *Oral history* is the primary mode of social transmission that preserves LTK, and its fidelity will be based on the population of tradition bearers, the frequency of transmission events, and the consistency of contemporary information relative to the information maintained about past conditions (refreshing information counters loss of fidelity, discussed in terms of the game of "telephone" or "Chinese whispers" by Whallon, Chapter 1, this volume). Colonists to a new environment or survivors of unprecedented environmental and social changes face significant challenges in building relevant knowledge about new or significantly altered ecological settings (Fitzhugh 2004).

Social Network Theory and Relative Vulnerability to Uncertainty

Network theory provides a framework for considering the nature of vulnerability and resilience of information exchange networks (and the people who form them). Assuming comparable capacities of information flow between connected interactors, highly interconnected networks transmit larger amounts of information through multiple pathways, allowing for greater redundancy and high system-resilience to environmental perturbations experienced locally (but see Allenby and Fink 2005 regarding the vulnerability of networks containing a few hubs with higher connectivity). By contrast, low-density networks with fewer connections have a lower capacity to transmit information and are more vulnerable to similar perturbations, though they are potentially more insulated from nonlocal environmental and social impacts. Networks can vary from higher-density (resilient to local perturbations) to lower-density (vulnerable to local perturbations) structures as a function of geographic variability or changes in underlying characteristics of ecology, demography, technology, economy, and society. This systematic relationship allows us to consider spatial variation and temporal change in efforts to understand the place of information strategies in the adaptations of small-scale societies.

INFORMATION NETWORK MODEL

For the purposes of the model described here, the environmental perturbations that matter to people are assumed to scale together in time and space. That is, unpredictable fluctuations in environmental conditions that are locally scaled are also the most frequent and of lowest amplitude. Less frequent but higher amplitude perturbations are also more likely to be manifest over greater areas; thus, the rarest anomalies are also the ones that will affect the largest area and will be the hardest to mitigate. At some scale of space and amplitude, no adaptive strategy will be appropriate, and catastrophic change can be expected. The important derivative of this relationship is that strategies that enable information flow across larger regions and that deal with increasingly rare and severe perturbations are more costly to maintain.

Individual monitoring of the local environment on a fairly regular basis is relatively inexpensive. It can be accomplished more or less incidentally in the course of daily activities. Observations are made of local surroundings, weather, vegetation, animal behaviors, and the skills and moods of colleagues. Social transmission diffuses information about the physical and social environment, reinforcing and qualifying individual observations. Direct observation and social transmission at the local scale are ongoing, allowing for frequent updating and redundancy in information flow (building up local knowledge). These modes of information acquisition are effective for monitoring rapidly changing characteristics of the environment at relatively close spatial and temporal scales. Redundancy allows for an increase in reliability of information and greater confidence in decisions based on that information. Redundancy also encourages honesty in social transmission, since dishonesty is easily disclosed and punished. We call the resulting network a *local* or *inter-band information network* (Figure 4.2). Local network structures provide high connectivity with low opportunity costs.

As geographic distance increases between areas of regular interaction and movement, the frequency and redundancy of information flow deteriorate. Greater degrees of logistical and residential mobility can increase the geographic area under direct observation, though with a modest decrease in the intensity of more local-scale monitoring. In foraging societies where group membership is often relatively fluid, the more socially mobile *individuals* are able to access information over a greater range than others, presumably also facilitating greater social information transfer across multiple residential groups or bands.

Multi-band social aggregations for feasts, parties, and trade fairs provide a mechanism for *supra-band* information sharing among individuals in different minimal bands. These aggregations occur most commonly in the course of other activities where patterns of movement intersect or where large resource windfalls draw bands together (e.g., Legros 1985; Lucier and VanStone 1995). Benefits of aggregation, in addition to updating information about neighboring territories, include the maintenance of reproductive networks. The information that is shared between bands should be more selective than that shared within bands, and we can expect a greater degree of effort placed in establishing and maintaining trust.

Overlapping and expanding the scale of aggregations, *hxaro*-like "friendships" are a special kind of supra-band relationship in which individuals (or families) invest significant energetic and material resources in maintaining information and mutual support networks beyond the band level (see Supra-band networks in Figure 4.2). Compared with wholesale aggregation, these egocentric friendship relationships allow for greater fidelity of information transmission between partners. Multiple ties to partners in different bands increase the diversity of information available, while multiple partners in the same band or close area increase the redundancy of information on particular regions. At greater distances, partnerships become increasingly costly to maintain, requiring more significant tokens to show good faith and trustworthiness. As a result, the costs of exchange partnerships can be measured in the material goods that have to be acquired or produced to fuel the exchange, as well as in the effort involved in traveling to visit with partners (e.g., a function of distance and terrain difficulty). These are real constraints on the number of partners any individual can maintain while they are also obligated to sustain themselves and their families on a daily basis.

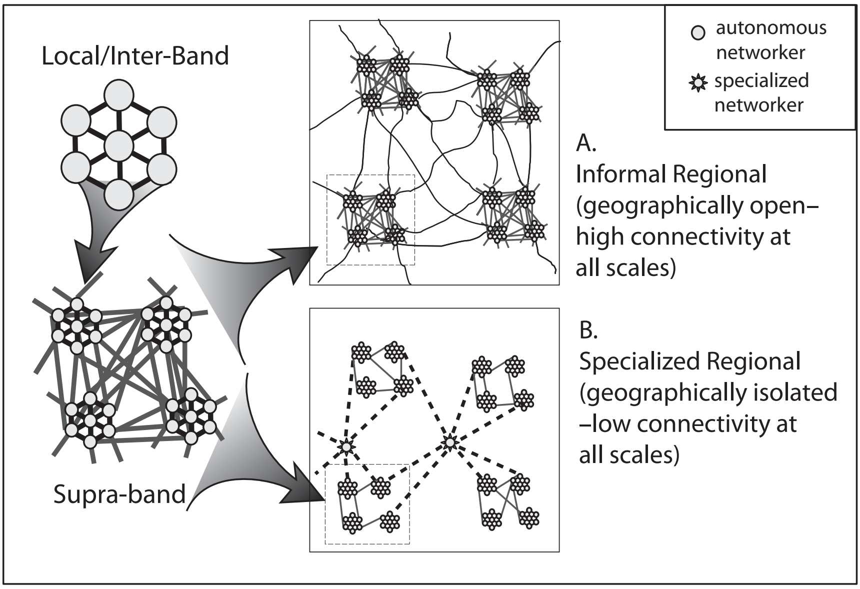

Figure 4.2. Organization of information networks operating at different spatial scales (local/inter-band network; supra-band network, and regional network) and in different extremes of network connectedness: (A) Highly connected, "informal regional" networks should be found on open landscapes with few constraints to interaction across space, in which multiple channels of information flow occur from local to supra-regional scales; (B) minimally connected "specialized regional" network should be found where significant constraints prevent easy interaction over space, in which connections are severely limited and tenuous beyond local scales. In these diagrams, clusters of circles (autonomous networkers) represent co-residential groups or "minimal bands."

Compared with local networks, supra-band information exchange networks (aggregations and exchange partnerships) are moderately connecting and have reduced content volume and reduced redundancy. Individual opportunity costs are relatively high, and fidelity of the information transmitted is reduced due to lower redundancy. Trust is expensive, leading people to invest in more costly signals of friendship. Likewise, as transaction costs increase with distance and reduced redundancy, the average number of dyadic partnerships declines, further limiting flow of effective information networks over distance. As a result of these characteristics, supra-band networks will be most effective in providing information about lower-frequency environmental variability with relatively gradual onset. Knowing which friends to turn to in an environmental catastrophe depends on knowing where conditions have deteriorated and where they are still favorable, as well as which "friends" are most likely to be "friends in need."

At scales beyond local and supra-band networks, some individuals can establish and maintain networks of information flow with relatively low connectivity, leading to lower volume and lower redundancy in information (see Regional networks in Figure 4.2:A, B). The costs of maintaining these far-flung networks can be reduced for the networker through direct subsidies provided by the groups that they visit or by permission of those groups to forage in their territories. The Australian Aboriginal traditions of "walkabout," for example, give some individuals an opportunity to directly observe and become familiar with landscapes and populations beyond the annual rounds and territorial rights of families, bands, and macro-bands (Berndt and Berndt 1999). Returning pilgrims bring with them a fresh store of information about the state of the broader world to share with their families and neighbors. The rate at which this information is refreshed is influenced partially by environmental and demographic circumstances closer to home (local food scarcity, numbers of individuals in appropriate age grades, family dependency on local labor inputs, etc.).

Moving desirable goods from one group to another serves as a particularly attractive proximate justification for acceptance and logistical support during travel away from home and in some conditions can justify the emergence of more or less *specialized traders* who devote disproportionate time and effort to maintaining networks between relatively isolated communities. The networks connected by such traders are good for maintaining information flow about low frequency and large amplitude variations. Examples of specialized traders—albeit better known from more complex societies than is the focus here—can be seen, for instance, in Mesoamerica with the Aztec *pochteca* traders (Charlton et al. 1991; Kristan-Graham 1993). We might expect to see a gradation between walkabout-style travelers (*informal regional networks*) and specialized traders (*specialized regional networks*) based on the capital investments required to travel, with walkabouts and pilgrimages more common across relatively interconnected social landscapes and where provisioning is not too capital intensive. By contrast, specialized traders might be supported more commonly where social landscapes are punctuated by difficult terrain, where travel is risky and requires specialized technology and specialized knowledge, and where provisioning is costly.

We recognize that nonlocal information is often acquired in any group through networks of communication embedded with multiple nodes or transmission events, such as trade and gossip networks. This *indirect hearsay* form of information flow permeates social life and is the primary mechanism through which individuals come to understand the larger world and its changing state. Resulting from the linkage of multiple networks of information flow (e.g., partners of partners of partners), indirect hearsay has the greatest geographical reach of all, but the lowest fidelity over distance. Indirect or down-the-line information exchange is vulnerable to increasingly biased transmission at its joints—those places in network structure where fewer independent pathways exist to carry redundant information—for exactly the same reasons that the game of telephone leads to information distortion (Whallon, Chapter 1, this volume).

Temporal and Spatial Dimensions of Variability

The foregoing discussion focuses on social and spatial scales of information acquisition and transmission. To more fully explore the importance of information strategies to people in small-scale societies, we also need to consider the temporal scale of environmental variation and how different information strategies might serve to minimize people's exposure to hardship at different scales.

Temporal variability has a generally predictable relationship to spatial variability, such that larger amplitude fluctuations tend to have the largest "footprint," requiring more extensive information networks to mitigate negative fluctuations (Figure 4.3). Local information networks and direct observation are most effective for dealing with relatively common, low amplitude shifts in resource productivity, diversity, and distribution, as these networks allow for the most frequent updating of information and the greatest flow of information about local conditions and options. Supra-band-scale networks, such as *hxaro* partnerships, are less effective for dealing with high frequency variability, both because of the reduced frequency of interaction and the higher cost of network maintenance. These networks would instead help to distribute information about inter-annual to decadal-scale variability that might require temporary adjustments or even reorganization of populations into new groups at the regional scale. Such adjustments could extend to somewhat broader scales (though often with increased intergroup conflict) by means of information collected through walkabouts and indirect hearsay over greater distances (facilitated by specialized traders and/or down-the-line social transmission). In rare cases when perturbations are strong but highly localized, mobility and broader networks should provide suitable mitigation strategies, assuming available options for relocation.

The ability to anticipate and deal effectively with high-amplitude centennial or longer-scale fluctuations is limited to strategies for preserving information about ancient experiences preserved in traditional knowledge (Minc 1986). People are most vulnerable to the longest-scale, highest-amplitude fluctuations, for which prior experience (if any) is distant in time and for which relevant information has been transmitted through the greatest number of transmitters (leading to greater opportunity for erosion of accurate content). Millennial-scale variability, such as the large-scale climate change currently affecting the Earth, approaches or exceeds the capacity of most (if not all) existing cultural information strategies to predict and mitigate effectively. Extreme hardship, as well as unprecedented opportunity, large-scale migration, social displacement or demographic expansion, colonization of new regions, and local extinctions are all expected outcomes of environmental fluctuations at these longest time scales.

It follows that, all else being equal, vulnerability to environmental fluctuations decreases the longer a group remains in a region and accumulates local

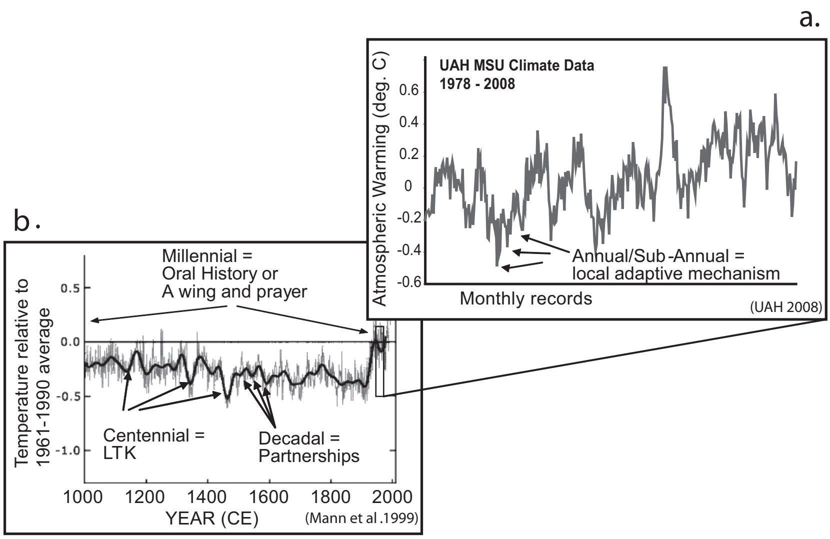

Figure 4.3. Environmental variability at different time scales, showing the inverse relationship between frequency and amplitude and the information networks most effective for different scales of temporal variability. (*a*) Monthly global temperature anomalies in the Lower Troposphere from 1978 to 2008 (data from UAH 2008) used as example of short-term environmental variability; ***(b)*** Mann et al.'s (1999) Northern Hemisphere multi-proxy paleo-temperature reconstruction ("hockey stick" model) for example of longer-term (decadal to millennial scale) environmental change.

and traditional knowledge about the variability affecting them at various spatial and temporal scales. With increased residence time, resiliency should expand from local to more regional scales and from shorter to longer cycles of variability through the accumulation of information.

Geography influences the ease with which different information networks can be implemented. Following basic principles of network theory, information networks should be most resilient (providing the greatest information by which people can adapt to environmental change) where the greatest connectivity is maintained, at all levels from local to supra-regional scales (Allenby and Fink 2005). Figure 4.2:A (informal regional network) shows a resilient social information network with maximum adaptive depth (cf. Slobodkin and Rapoport 1974). In this case, people interact frequently and with minimal constraint locally and regionally, with information of supra-regional conditions flowing into and through the network by means of relatively frequent trade interactions, walkabouts, and indirect transmission. This network structure would be supported by a relatively continuous social landscape, with few physical or social barriers to interaction and short, effective distances between interactors. Figure 4.2:B (specialized regional network) illustrates a vulnerable social landscape in which interaction is costly at all scales due to low population densities, and where interactions involve high opportunity costs. Following the predictions sketched in Figure 4.4, people on such a precarious landscape should put the greatest value in maintaining information networks, despite the greater costs involved in doing so, up to the point at which such connections are no longer sustainable.

PREDICTIONS

The relationships outlined in the model allow us to consider the ways that changing social, geographic, and environmental conditions should influence the nature and degree of investment hunter-gatherers place in information network strategies. Figure 4.4 identifies the kinds of information strategies expected to develop under different combinations of environmental predictability and the costliness of maintaining networks at different scales.

Political Networks

In situations of high environmental predictability (low uncertainty and variability assuming sufficient average productivity) and low interaction cost, we

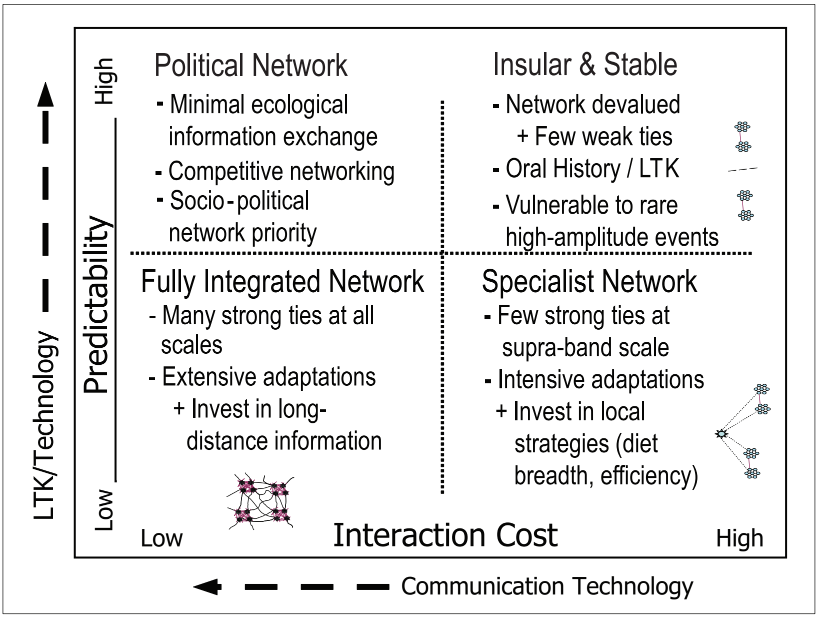

Figure 4.4. Information networks expected for different combinations of environmental predictability and costs of information network maintenance. As a simplification, this scheme ignores the third dimension of productivity and assumes that in all cases productivity on average is sufficient to support whatever population density resides on that landscape.

expect information networks to be externally focused on sociopolitical over environmental content. In these cases, because of the predictable nature of the environment, people should focus their information networking investments/interests in developing social and political relationships, either competing for opportunities to improve their situation relative to others, or attempting to limit their interactions as a defense mechanism against opportunitistic advantage takers.

Fully Integrated Networks

Where environmental predictability is low but interaction costs are also relatively low (and average productivity is sufficient), we expect egocentric networks with many strong ties to emerge. Because of the relatively low cost of interactions relative to the value of information, people would invest in a diverse range of local and regional networks, maximizing their access to information at all scales and creating a network structure of high interconnectivity and resilience. In other words, a set of nested networks at different spatial scales is produced, with many strong ties up to the supra-band level and informal regional integration (walkabouts, etc.).

Specialist Networks

By contrast, a more vulnerable situation occurs where interaction costs are high but environmental predictability is low (and productivity on average is sufficient). In these cases, fewer people can afford to invest in diverse information strategies, and the network should become increasingly specialized, with smaller numbers of interactors maintaining fewer strong ties. Others would invest more heavily in more intensive local strategies (such as expanding diet breadth, improving technological efficiency, etc.) to mitigate unpredictability. The resulting network structure would be one of low connectivity and high vulnerability. We would expect this kind of network to be more prone to failure, compared with an informal regional network, especially early in the period following initial colonization or after a major social or environmental change.

Through time and under circumstances of relative social and environmental stability, we expect a successful population to increase their local knowledge and ability to mitigate variability locally, allowing them to become less dependent on extensive networks, but perhaps rendering them more vulnerable to rare perturbations (Fitzhugh and Kennett 2010). Increased technological effectiveness can both reduce the costs of communication (e.g., by improving the safety or facility of engaging in communication networks) and increase the predictability of environmental outcomes (e.g., through development of mass harvesting and storage technologies, or better mechanisms for tracking or securing resources). Technological developments, however, also often lead to unintended consequences, such as altered system parameters (prey populations, human population densities, etc.) and dynamics, in ways that render accumulated knowledge less relevant to future variability.

Insular and Stable Networks

Where there is high environmental predictability and sufficient local productivity to support settlement but also high interaction costs in connecting settlements, we expect networks to be minimal and adaptations to be internally focused. Under these circumstances, investment in the high cost of interacting with and maintaining information networks is less warranted, given the predictable nature of the local environment. On the other hand, while this kind of insularity may be economically efficient, given short- and medium-term environmental variability, it would make communities more vulnerable to unprecedented or very infrequent negative environmental fluctuations. Communities maintaining this kind of network structure might generate archaeological signatures characterized by long periods of stability and independent cultural developments, punctuated by catastrophic loss or abandonment.

THE KURIL ISLANDS

The Kuril Islands in the northwest Pacific Ocean provide an interesting case for exploring the adaptive imperative for information sharing at different places and points in time throughout the island chain. The Kuril archipelago (Figure 4.5) is an active volcanic island arc spanning the Okhotsk Sea–Pacific Ocean boundary from Hokkaido to southern Kamchatka. The Kuril Islands comprise 160 Quaternary terrestrial and 89 submarine volcanoes, with 32 of the volcanoes known to have erupted in the past 300 years (Ishizuka 2001). Tephra layers present throughout the islands indicate that prehistoric volcanic activity was a regular occurrence.

The Kurils become more geographically isolated toward the center of the island chain, and vary in size from 5 km^2 to 3,200 km^2, with the northernmost and southernmost islands generally much larger than those in the central region. For the purposes of this paper, we divide the Kurils into three geographical zones: southern (Kunashir, Iturup, and Urup), central (Chirpoi to Matua), and northern (Shiashkotan to Shumshu). In spite of their midlatitude location, the Kuril Islands experience subpolar conditions in winter due to strong northwesterly winds (Leonov 1990). Sea ice covers up to one-third of the Sea of Okhotsk by the end of the winter season and typically reaches the southern Kuril Islands from the west. With partial ice-free ocean upwind, heavy snow is common from November to March. Summers are characterized by dense fog and mild southerly winds (Rostov et al. 2001).

Marine and anadromous fish, marine mammals, and birds are common throughout the Kuril Islands. Sea otter (*Enhydra lutris*), northern fur seal (*Callorhinus ursinus*), and sea lion (*Eumetopias jubatus*) frequent the shores and bays of the islands. As of the mid-twentieth century, few land mammals were present in the Kurils, with most concentrated on the larger islands close to Hokkaido and Kamchatka (Hacker 1951). Recent biogeographic surveys of the Kuril Islands have found that southern-source land mammals and freshwater fish extend north only to Iturup, while freshwater fish and mollusks from the north have made it south only to Paramushir, rendering the majority of islands in the center of the island chain relatively impoverished in these taxa and lowest in overall species richness (Pietsch et al. 2003).

Today the marine food webs in this region are supported by Arctic Ocean nutrients carried into the region from the Bering Sea by the cold Oyashio current. These nutrient-rich waters are supplemented by dissolved iron from the Amur River outflow into the western Sea of Okhotsk. These ingredients converge especially off the southern Kurils and northeast Hokkaido and lead to high primary productivity in the spring, following the melting of Okhotsk sea ice (Chiba et al. 2008; Heileman and Belkin 2008; Kasai et al. 2009; Mustapha et al. 2009; Qiu 2001). Farther north up the Kurils, the primary productivity is today much more limited than in the southern islands, and we can expect this relative pattern to have persisted in the past, despite possible fluctuations in the overall productivity of the system, tied to changes in the

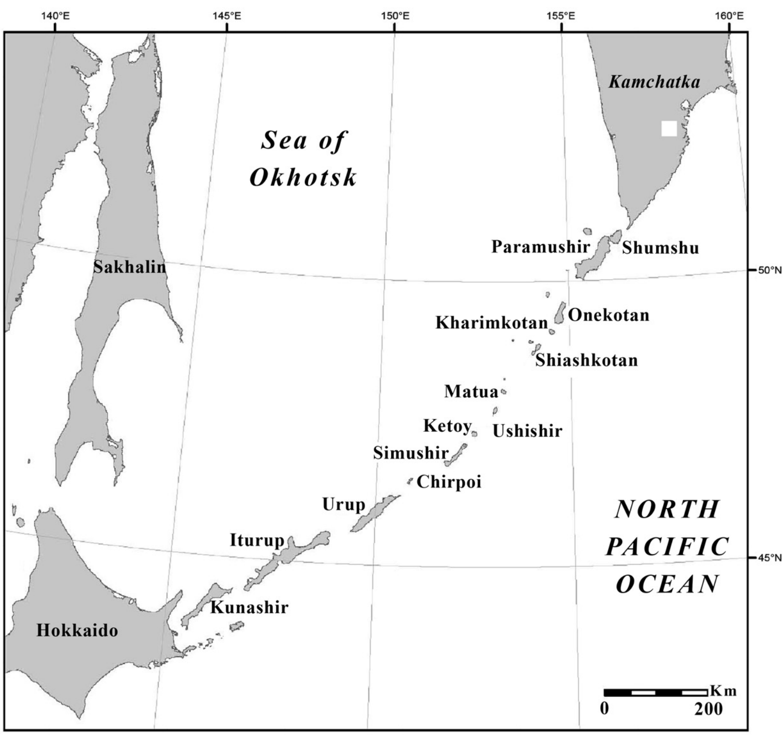

Figure 4.5. Map of the Kuril Islands.

North Pacific low pressure system and the corresponding strength of the Oyashio current. Only upon reaching the eastern and western coasts of Kamchatka do we again see predictable hotspots of primary productivity. As a result, the marine ecology of the Kurils can be characterized as having an abundant and diverse southern zone and a relatively deplete central and northern zone. Terrestrially, the south is also the most productive and ecologically diverse, followed by the northern islands of Paramushir and Simushir, which have small numbers of Kamchatkan fauna.

Model Predictions for the Kuril Islands

In the Kuril Islands, two key variables will affect the vulnerability of a population to specific environmental fluctuations. The first is the inherent productivity and variability of the environment in which people live; the second is the facility through which supra-band and larger-scale networks can be maintained. These variables are largely independent of each other, but both are tied in part to geography, in part to demography, and in part to technology. Given the linear orientation of the Kuril Island chain and the regional differences in ecological diversity that are present, information network strategies should shift dynamically with cycles of island colonization, occupation, and abandonment. In the southern parts of the island chain, settlements would have been able to develop in closer proximity under conditions of greater ecological productivity and diversity, as well as greater availability of suitable settlement locations to support larger population densities. Higher ecological diversity would also have resulted in lower vulnerability to perturbations in any single resource or suite of related resources. Due to the low interaction costs between more closely spaced settlements, these groups would have been externally focused and highly interconnected. However, the more predictable and productive nature of their environment should place an emphasis on networking for sociopolitical purposes, more so than ecological information exchange (= Political Networks).

The Kuril Islands can be classified as an island environment demonstrating subpolar climate variations. The most northern latitudes of the Kuril Islands have lower ecological diversity than the southernmost islands, while also being prone to rare sea-ice incursion from the Okhotsk side of the Kamchatka Peninsula. (The southern islands get pack ice more predictably for a month or so in peak winter, due to the counterclockwise flow of the Sea of Okhotsk.) The low ecological diversity makes the northern Kurils more ecologically unpredictable than the southern islands, but probably less so than the central islands. The greater unpredictability of resources should encourage network structures that invest in access to longer-distance information in order to mitigate unpredictability. Because Kamchatkan groups would be relatively accessible to northern Kuril residents (travel costs are less than in the central islands), the information networks model suggests many strong ties between these areas. Thus, the northern regions are most likely to demonstrate a more integrated set of network relationships at all scales (= Fully Integrated Networks).

The central Kuril Islands present different challenges in colonization and maintenance of information networks. In this region, where ecological diversity is at its lowest and distances between neighboring populations would be the most costly to maintain, we would expect people living in these remote regions to invest more heavily in maintaining a few, but strong, network ties to compensate for their local vulnerability. These ties would be essential early in a colonization phase, before locally sufficient population densities and local knowledge are developed (see Fitzhugh and Kennett 2010). If information networks persist after initial colonization with no reduction in interaction costs, populations may come to depend upon specialists to maintain network relationships. In this case, network specialists link groups that are inwardly focused on adapting to local environmental conditions (= Specialist Networks).

Alternatively, in times of ecological plenty, when the local human population density is low, high interaction costs high, and productivity/predictability of resources high, residents of the central Kurils may be able to weather most unpredictable fluctuations without the support of a wide network. This outcome would be expected with an expansion in local knowledge and internally oriented investments in localized adaptations (such as expansion of diet breadth or technological efficiency). The information network model suggests that networks may be devalued in such cases, leading to only a few weak ties with other groups (= Insular/Stable Networks). While optimal in certain circumstances for short- and medium-range perturbations, this strategy would render populations most vulnerable to the very rare, high-amplitude crises that occur beyond the scope of LTK adaptation.

The Kuril Islands: Cultural History

Terrestrial Hunter-Gatherers

The earliest archaeological remains in the Kuril archipelago are found at the sites of Yankito and Kuibyshevo (Iturup Island) and Sernovodskoe (Kunashir

Island) and date to around 7000 BP (Samarin and Shubina 2007; Vasilevsky and Shubina 2006; Zaitseva et al. 1993). Archaeological materials from the Sernovodskoe show early relationships between the southern Kurils and Hokkaido, with large, cord-marked ceramics characteristic of the Early and Middle Jomon periods of Japan dating from at least 7000 to 2500 BP (Vasilevsky and Shubina 2006). While little is known about the adaptations of these earliest Kuril occupants, we assume that they lived much as their Jomon cousins did in Hokkaido. These early groups lived in small and highly mobile populations subsisting primarily by terrestrial hunting and gathering, which was supplemented by small amounts of fish and shellfish (Imamura 1996; H. Okada 1998; Y. Okada 2003).

Marine Hunter-Gatherers: Epi-Jomon

The inhabitants of Hokkaido shifted from terrestrial foraging to an increased reliance on marine mammal hunting (whale, seal, sea lion) between 5000 and 3000 BP (Niimi 1994). The Late Jomon and Epi-Jomon periods are recognized as the first consistent occupation of the Kuril islands (Fitzhugh et al. 2002; Niimi 1994; Yamaura and Ushiro 1999). The Epi-Jomon occupation of the Kurils appears to be one of the first and most expansive settlements of the region, with large numbers of sites extending north of the Bussol Strait (between Urup and Simushir) into the more remote central islands. Yamaura (1998) suggests that increased sea mammal hunting may have been related to cooler climatic conditions and increased populations of sea mammals in the area around Hokkaido and the Kuril Islands. Increased sea mammal populations, along with technological specializations, would have improved the overall return rate of sea mammals and favored population expansion into the central islands.

Marine Hunter-Gatherers: Okhotsk

The Okhotsk culture flourished during a time of significant social and economic change across East Asia (Hudson 2004). The Okhotsk period is usually divided into three distinctive stages (Amano 1979 in Hudson 2004:294). The first stage identifies the initial expansion from south Sakhalin Island into the islands of the Japanese archipelago, including Rishiri, Rebun, and northern Hokkaido. This stage is characterized by a heavy reliance on marine resources as well as breeding of pigs (Yamaura 1998). The second stage is identified as an eastern movement of Okhotsk culture to the northeastern corner of Hokkaido and into the southern Kuril Islands (Hudson 2004:294). During this stage, the Okhotsk culture, similar to its Epi-Jomon predecessor, expanded from the southern islands through the central islands and to the northernmost Kuril island of Shumshu. The third stage is identified by high population pressure on Hokkaido, leading to the assimilation of the eastern Hokkaido Okhotsk with their Satsumon neighbors and increasing the separation of northern Okhotsk groups into the Kuril Islands. After 800 BP, the Okhotsk culture is replaced or assimilated on Hokkaido and, perhaps later, on the Kuril Islands by or into Ainu cultural groups (Yamaura and Ushiro 1999).

Ethnographic Hunter-Gatherers: Ainu

The Ainu presence in the Kuril Islands is first noted in ethnohistorical accounts where distinct Kuril Ainu cultural and linguistic groups are distinguished (Kono and Fitzhugh 1999). The Kuril Ainu are said to have lived throughout the island chain in relatively large pit-house villages as well as smaller seasonal camps (Fitzhugh 1999). Kikuchi (1999) suggests that the Ainu movement from Hokkaido into the Kuril Islands would have likely taken place during the fourteenth or fifteenth century AD; these tentative dates seem to coincide with radiocarbon dates obtained by the Kuril Biocomplexity Project (Fitzhugh et al. 2008). During the early eighteenth century and into the nineteenth century, the Russian-American Company settled the Kurils with transplanted Alaskan and Siberian sea mammal hunters (Shubin 1994). The Japanese occupation of the Kurils during the twentieth century forcefully displaced a number of Ainu populations, and World War II saw the fortification of the islands by the Japanese and then Soviet military and the complete removal of remaining Kuril Ainu to Hokkaido (Stephan 1974).

Refinements in Culture History: Initial Results of the Kuril Biocomplexity Project (KBP)

KBP teams documented occupations from each of the culture historical phases that are known to have been present in the Kuril Islands. Based on existing radiocarbon dates (Fitzhugh et al. 2002; Zaitseva et al. 1993) and new dates generated by the KBP (Fitzhugh et al. 2008), several dates between 4250 and 2300 BP suggest a small but persistent occupation of the southern Kurils during the Middle to Final Jomon periods of Japan. Earlier occupation is suggested by Early and Middle Jomon diagnostic ceramics found at various locations on Kunashir and Iturup (Samarin and Shubina 2007). Numerous radiocarbon dates from the northern and central islands range from 3450 BP to 2450 BP and suggest persistent activity on these islands for the first time within these dates. Through diagnostic ceramics found in the central island of Rasshu, the earliest colonization of these islands seems to be directly linked to Final or Epi-Jomon cultures from Hokkaido. In the northern islands, we are so far unable to resolve whether the earliest occupation of Shumshu Island occurred from a culture of the Kamchatka Peninsula to the north or from a culture from the Japanese islands to the south.

A surge of occupation of the Kuril Islands begins in the Epi-Jomon period and is represented by a significant increase in the number of radiocarbon dates for this period and the distribution of Epi-Jomon ceramics through much of the island chain. Diagnostic Epi-Jomon ceramics are common in many archaeological sites from Kunashir to Shiashkotan, and Epi-Jomon pottery is tentatively reported from the northern Kuril Islands of Paramushir and Shumshu (V. O. Shubin, personal communication).

The Okhotsk-period occupation of the Kuril Islands is well represented throughout the island chain. Okhotsk-type materials are found as far north as the southern tip of Kamchatka (Dikova 1983), and the Okhotsk-period presence in the Kuril Islands suggests that these people were prepared to adapt to the environmental and ecological variability they would have experienced across the length of the island chain. Based on KBP radiocarbon dates, the end of the Okhotsk period falls around 700 BP, roughly coeval with the time when Okhotsk populations are replaced by the Ainu on Hokkaido.

Evidence of Ainu-period occupations is relatively scarce throughout the Kuril Islands. Ethnohistoric accounts (Krasheninnikov 1972) and earlier archaeological research (Baba 1937, 1939; Baba and Oka 1938) documented Ainu settlements across the length of the island chain, while systematic survey over three field seasons of KBP have found very few Ainu sites relative to the earlier periods. While historical accounts suggest significant Ainu occupations, we are evaluating the possibility that Ainu colonization of the central and northern Kurils occurred late in the Ainu period and may have been less substantial and more mobile than earlier occupations (Fitzhugh et al. 2008).

EVALUATING MODEL PREDICTIONS

Ceramic Technology

The Kuril archipelago lies on the periphery of two major prehistoric ceramic producing centers. To the south lay the Jomon cultures of Japan and to the west, the cultures of the Amur River, both of which exhibit some of the oldest known pottery in the world (Jordan and Zvelebil 2010). The earliest ceramic vessels in the Kuril Islands correspond to the Early Jomon period (7000–5000 BP) and are located exclusively in the southern islands nearest to Hokkaido (Vasilevsky and Shubina 2006). The influence of Hokkaido ceramic styles is strongly evident in the Kuril Island ceramic assemblage, with a vast majority of ceramic artifacts from the Kuril Islands stylistically similar to ceramic traditions found on Hokkaido (Epi-Jomon, Okhotsk, and Ainu). The similarity of Kuril pottery to ceramic traditions on Hokkaido suggests spatial and/or temporal relationships between the cultures of the two areas. The main goal of current and future research on ceramic artifacts is to use predictions derived from the information networks model to help refine concepts of the spatial and temporal interactions between inhabitants of the Kuril Islands and Hokkaido.

Drawing from the information networks model, we expect inhabitants of the Kuril Islands to engage in various adaptive network strategies based on the (technologically mediated) interaction costs associated with geographic location and environmental predictability. Given the variability in interaction costs related to the geography of the Kuril archipelago, the information network model would predict that the manufacture and transmission of ceramic artifacts might differ in various regions based upon the network strategies employed by inhabitants of each region. For example, in regions characterized by significant inter-island distances and low environmental predictability (such as the central Kurils), we expect limited movement of ceramic artifacts outside of the local region, as groups tend to focus on local adaptations with the potential for long-distance ties through a specialized network. Alternatively, in regions characterized by lower interactions costs and moderate levels of environmental predictability (e.g., the northern Kurils), we expect movement of ceramic artifacts across multiple spatial scales (local, supra-local, regional, and long distance) related to the gathering of regional ecological information. Regions with low interaction costs and high environment predictability (most closely approximated here by the southern Kurils) would also demonstrate movement of artifacts across multiple spatial scales; however, the movement is more likely to relate to the flow of social or political information, rather than ecological information, given the high environmental predictability. Therefore, the expectation for ceramic artifacts in the southern Kurils would be the increased movement of ceramic styles associated with forms of social or political information across multiple spatial scales.

The evaluation of predictions derived from the information networks model was of central interest in pilot research focusing on the location of manufacture and the transmission of ceramics. Using ICP-MS (inductively coupled plasma-mass spectrometry) methods, 200-mg samples of 58 ceramic vessels were submitted for elemental composition analysis at the Institute of the Earth's Crust, Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia. Ceramic samples were chosen from various spatial and temporal ranges. The sample was a mixed-age assemblage, with a majority of ceramic samples not identified to a specific cultural period (41) but also including culturally identified samples from the Epi-Jomon (10), Okhotsk (5), Tobintai (1), and Ainu (1) periods. Spatially, the ceramic samples represent all three regional groups, including the southern (27), central (20), and northern (11) islands.

Using a combination of principal component analysis to identify key elements (Nb, Mo, W, Zn) and hierarchical cluster analysis to identify initial cluster groups, eight ceramic source groups were identified. Source group composition appears to be strongly related to the geographic position of sites in the island chain, as six out of eight ceramic source groups have significant affiliation to a particular geographic region. For example, ceramic source groups (CSG) 1, 4, 6, and 7 all have over 90% of sites located in the southern region, whereas CSG-3 has 100% of its sites located in the central region, and CSG-2 has 67% of sites located in the northern region. Two ceramic source groups (unidentified) do not have a significant majority of sites that are characteristic of a specific region (CSG-6: 50% southern; CSG-8: 50% central).

In order to relate ceramic sourcing data to the predictions of the information networks model, we attempted to characterize the aggregated regional source groups (southern, central, and northern) by the geographic distance between sites identified in each regional source group (Table 4.1). The identification of distances between ceramic source group sites is an attempt to understand the scale of networks (local band, supra-band, regional, interregional) in each region of the Kuril Islands. Representative distances for each type of network scale were arbitrarily chosen and set at the following: local band (< 40 miles), supra-band (40–100 miles), regional (100–200 miles), interregional (> 200 miles).

The preliminary interpretation of ceramic sourcing data from the Kuril Islands generally fits with the predictions of the information networks model. The model suggests that with the habitation of marginal ecological areas characterized by high interaction costs (central islands), network ties

Table 4.1. Distribution of Network Ties between Sites with ICP-MS Analyzed Ceramics

	Southern (14, 25) (CSG-1, 4, 5, 7)	Central (3, 6) (CSG-3)	Northern (5, 9) (CSG-2)	Unidentified (7, 12) (CSG-6, 8)
Local band	29%	100%	20%	21%
Supra-band	10%	0%	0%	6%
Regional	5%	0%	14%	9%
Interregional	48%	0%	66%	65%

NOTE: Sites are grouped by regional source group. The total number of sites represented by each regional source group and the total number of ceramic samples within each group are provided next to the regional source group headings (e.g., 14, 25). Six samples were considered outliers and did not correspond to any source groups.

will tend to focus toward local and supra-band scales, with primary investment in adaptations to local conditions and potential for various long-distance ties to maintain flows of ecological information. Alternatively, areas with more predictable environments and lower interaction costs (larger island size) will tend toward multiple-scale networks, emphasizing either the flow of social and political information or ecological information, depending upon environmental predictability. As identified in Table 4.1, ceramic sourcing data suggests multiple-scale network interactions among sites in the southern and northern regions, with insular ties characterizing sites in the central region (Figure 4.6). Further, qualitative analysis suggests that the southern ceramics were more highly decorated and had a greater diversity of design styles, suggesting more sociopolitical significance. While the current data is not sufficient to highlight specific contexts of colonization, isolation, or political networking, the integration of ceramic sourcing data with lithic data (see below) provides suggestive insights within the context of the information networks model, which will be pursued further in future research. The next step in our ceramic studies will focus on increasing the spatial and temporal resolution of regional ceramic source groups, with analyses of larger sample sizes and improvements in the chronological control over ceramic proveniences through radiocarbon dating and directly through luminescence dating.

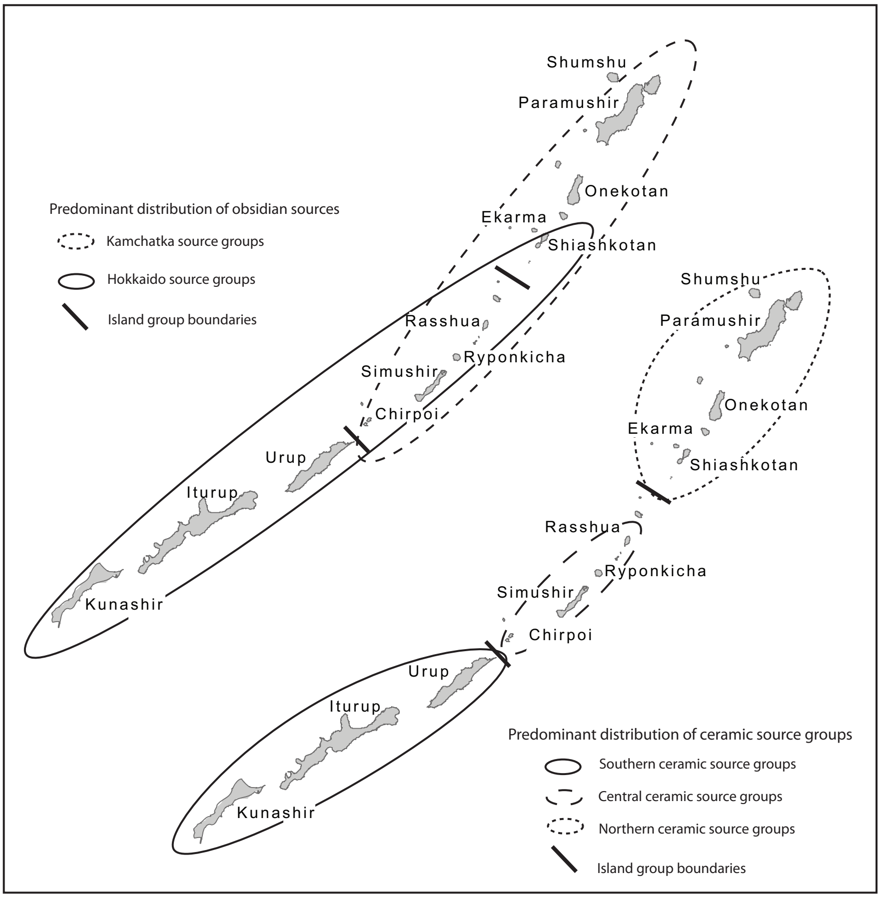

Figure 4.6. Maps of the Kuril Islands showing the general distributions of obsidian from Hokkaido and Kamchatka sources, and zones of shared ceramic geochemical similarity.

Lithic Technology

Lithic artifacts recovered through KBP excavations include a number of tool types (projectile points, knives, scrapers, and drills), but there are currently no culturally diagnostic tool forms or typologies. Lithic raw materials represented among the tools types and tool production debitage include obsidian, basalt, chalcedony, and a variety of different colors of chert (Fitzhugh et al. 2004). Although lithic artifact assemblages from across the Kuril Islands include tools and flakes made from obsidian, there are no geologic sources of obsidian in the Kuril Islands that are known to have been used prehistorically (Phillips and Speakman 2009). Nonlocal obsidian brought to the central Kuril Islands may initially have come through migration and colonization events as groups moved through the islands in search of marine resources and/or group fission sequences. We tentatively accept the discovery of local ceramic manufacture in different island regions as an indication that the Kurils were occupied more or less year-round, at least in the Epi-Jomon and Okhotsk periods (from which the majority of archaeological deposits were found). If this conclusion holds, then we can treat the long-term presence of nonlocal obsidian in Kuril archaeological sites as material traces of social connections that enabled obsidian trade.

Based on predictions of the model specific to the initial colonizers of the central islands, we would expect to see evidence of ties maintained to parent communities in the form of nonlocal obsidian from whichever source area people were migrating (Hokkaido or Kamchatka) in the colonization levels of excavated sites with obsidian artifacts (in the case of the Kurils, based on ceramic typologies, there appear to have been at least three separate colonization events, all from Hokkaido). An information network tied to maintaining access to long-distance, nonlocal obsidian could be classified as a specialist network, though obsidian itself may simply be an index of the degree of interactions occurring over space, in which obsidian was one of many materials circulated, along with information. As groups developed wider-ranging, more regional network connections, the diversity of different obsidian sources in obsidian assemblages should increase as people gain access to obsidian from additional sources from beyond the distal end of the island chain (in Kamchatka, in this case). The information network may transition to either the fully integrated or political network, based on the predictability of other ecological resources and the population density in those areas that are most interconnected (the ends of the islands).

Source provenance analysis of nearly 1,000 obsidian artifacts from Kuril lithic assemblages has demonstrated that obsidian from volcanic sources on Hokkaido and Kamchatka were widely used for stone tool production in the Kuril Islands (Phillips and Speakman 2009). The general pattern of obsidian source distribution indicates some geographic correlation between source area and archaeological site locations. In the southern Kurils, obsidian from four Hokkaido source groups is dominant, making up over 95% of the obsidian assemblage. Conversely, obsidian assemblages from central and northern island sites are dominated by Kamchatka obsidian source groups, which represent 71% of the central island obsidian artifacts and 97% of northern islands obsidian artifacts. In the central islands, three Hokkaido sources make up a combined 25% of the obsidian assemblage, indicating maintenance of connection to Hokkaido (though diminished, when compared with the southern island assemblage). Central island access to Hokkaido sources may have been intermittent and dependent on the ability of central island inhabitants to incur the cost of investing in the maintenance of southern-oriented relationships. However, this minimal connection appears to have been sufficient to keep updated cultural information flowing in from the south, as seen in ceramic decorations.

Given the geographic proximity of the southern and northern Kuril Islands to Hokkaido and Kamchatka obsidian sources, respectively, the extension of obsidian trade or transport networks from local source areas to adjacent islands is not surprising. Lithic assemblages from these areas should show a more even distribution of obsidian relative to other types of lithic raw materials through time. In the southern islands, the greater breadth of lithic resources available and the lower cost of access to Hokkaido obsidian sources are representative of more predictable lithic raw material resources. This is congruent with the overall characterization of the southern islands' greater ecological productivity and diversity, and their ability to support higher population densities, which would be indicative of a more politically oriented information network. In the higher latitude, subarctic northern islands, less environmental predictability and productivity and apparently lower population densities would mean a continued focus on integrated networks as an adaptive strategy. As groups of people originally from Hokkaido and the southern Kuril Islands persisted in the central islands, they may have found it too costly in terms of time and energy, and too risky in terms of boat navigation, to maintain primary access to Hokkaido obsidian sources across the Bussol Strait, the widest strait between islands in the Kuril chain and a recognized biogeographic barrier between the southern and central islands (Pietsch et al. 2003). Oddly enough, securing access to obsidian sources in Kamchatka, presumably through network exchange, may have provided a more economical and reliable alternative to Hokkaido obsidian, thus fostering social connections to the Kamchatkan mainland. Although networks related to the access and trade of obsidian from sources in Kamchatka are less well known, inhabitants of the central and northern Kurils used Kamchatka obsidian extensively (Figure 4.6). With a growth in population density in the central Kurils, the development of a down-the-line obsidian procurement system from Kamchatka into the central islands could have facilitated a locally integrated information network composed of many shorter, tighter local ties, and only connected outside of the larger region indirectly via down-the-line relationships.

DISCUSSION

Preliminary findings from ceramic and lithic geochemical analyses, taken together, suggest that geography was important to the kind of social networks created and maintained in the Kuril Islands, irrespective of chronological attribution. (Geographical patterning in ceramics and lithics in terms of deposit ages is a more involved study currently under development.) In the context of an archaeological record most closely affiliated culturally with Hokkaido (Jomon/Epi-Jomon, Okhotsk, and Ainu), the ceramic and lithic sourcing studies indicate strategic responses to degrees of geographical isolation, ecological predictability, and productivity.

As obligate maritime hunter-gatherers, Kuril settlers were primarily dependent on the ecological productivity of the marine ecosystem. While that system is buffered from the most extreme swings of climatic fluctuations by its maritime context, geographical variation in island size and inter-island distance, extent and complexity of near-shore ecozones, and the dynamics of oceanographic currents influenced the needs for and nature of networks to mitigate environmental variability. While the data sets we have explored here are small and our conclusions preliminary, the patterns in the ceramics and obsidian data complement each other.

Collectively, these data indicate that the southern Kuril Islands of Kunashir, Iturup, and Urup were the most closely connected with one another and with Hokkaido in exchange of obsidian and in the manufacture of ceramics. This most closely approaches the low-cost, high-predictability cell in Figure 4.4, though we do not propose that hunter-gatherers living in the southern islands were unaffected by environmental variability. Nevertheless, it is telling that of all the Kuril Islands, only the southernmost have evidence of fortified defensive sites during Okhotsk and Ainu times (Samarin and Shubina 2007), and our finding that ceramics from this region are the most elaborated is also consistent with a more politically oriented social pattern. We suggest that this difference relates to the greater interdependence required of people living in the central and northern islands, a condition predicted based on the lower primary productivity and greater need for inter-island alliances.

The northernmost islands of Paramushir and Shumshu were also fairly well connected to the adjacent mainland, in this case Kamchatka. As already noted, the stronger material connection to the north is seen in obsidian trade despite strong cultural affinities to Hokkaido. Nevertheless, the northern islanders experienced reduced marine productivity and a less dense mainland population with which to trade. Environmental predictability would have been moderate as a result of the lower productivity, though farther north, on the east and west coasts of Kamchatka, marine productivity increases (Sea Around Us Project, n.d.). The obsidian trade with Kamchatka implies a reasonable access to network partners to the north and the facility of moving north onto Kamchatka when times were challenging (or vice versa), which supports expectations of a fully integrated network. Ceramic data further support this view of interaction in the last few centuries before Russian contact, as distinctive Ainu *naiji*, or inner-lugged pottery, was used up the east coast of Kamchatka as far north as Avacha Bay and the modern city of Petropavlovk-Kamchatsky (Dikov 2003). There is no evidence at present of the emergence of political competition in the northern islands, as there is in the south, and we expect that people in the northern Kurils and southern Kamchatka experienced predominantly mutualistic interactions.

Unsurprisingly, the central Kurils are the most insular, making pottery from local sources and obtaining obsidian from both ends of the chain. Interestingly, the vast majority of obsidian in the central islands is of northern origin, suggesting greater facility of exchange with neighbors to the north than to the south. Prior research also suggested that the central islanders utilized more conservative lithic reduction strategies, implying limited access to quality raw materials (Fitzhugh et al. 2004). This implies a significantly increased cost to interaction over distance *in both directions*. Evidence of locally manufactured ceramics in the central islands further supports this relative insularity. The central Kuril islanders seem to have most often operated somewhere between the Specialist and Insular Network modes, maintaining minimal cultural connection to related populations to the south and somewhat more significant economic interactions with people to the north, while doing as much as possible locally to minimize long-distance interaction costs. Occupation of the central Kurils at all must have been largely possible only because of the relatively abundant populations of fur seals, sea lions, and sea birds, especially in summer months. This seasonal abundance, however, is vulnerable to perturbations, and with limited ecological diversity, alternative resources are not readily available. Zooarchaeological evidence from the small central island of Chirpoi indicates that residents typically exploited the limited range of available taxa (most that would be passed over in a more diverse and productive ecosystem) as compared with taxa from Shumshu and a site in southern Sakhalin (Fitzhugh et al. 2004:107–115). Thus, despite the availability of marine mammals to support maritime hunter-gatherers in the central islands, isolation and the low ecological diversity (and overall low primary productivity) made it necessary for residents to maintain social ties to the outside world in order to have predictable access to food as well as to potential marriage partners.

Conclusion

Initial results from the Kuril Biocomplexity Project demonstrate the utility of the information network model for developing testable hypotheses about the nature of information networks across gradients in geographical isolation and environmental productivity and predictability. Kuril ceramic and lithic assemblages represent just two forms of evidence for material network interaction and exchange that can be considered evidence of information network organization. While we have hypothesized that information networks should be dynamic in the face of changing variables of cost and predictability, we have not, in this paper, attempted to evaluate dynamic changes in networks as a result of shifts in environmental conditions (e.g., climate change), developments in the facility of transportation or communication (e.g., technological improvements in boats), or changes in the content volume and quality of local knowledge and similar variables that alter the nature of interdependence among potential network partners.

As our analysis of the Kuril data proceeds, we hope to be able to address issues of chronological change in ceramic and lithic source variation, manufacturing, function, and style in the context of environmental, demographic, and cultural changes that should alter network strategies dynamically throughout the evolution of Kuril occupation history. A critical focus of this expanded effort will be the ways that network strategies changed from colonist to descendant communities and in the run-up to abandonment of part or all of the Kurils at various points in the occupational history of the island chain. The nature and status of information networks in the central Kurils may have allowed people to retreat from the center of the chain in the face of long-term ecological unpredictability or in the aftermath of a large catastrophic event; or perhaps the lack of strong networks was a factor in the potential extinction of local groups that had no safety net in times of loss.

Clearly, information is critical to the long-term sustainability of relatively insular hunter-gatherer populations. The information network model provides a framework for predicting different networking strategies that could have been pursued in response to differing degrees of isolation and environmental predictability. Expansion of this model could put more focus on issues of productivity, reproductive strategy, and other goals of social interaction that no doubt complicate many social networks, even in relatively remote and harsh conditions. The model could be expanded to consider gradations of political-ecological networking, with implications for transitions to less egalitarian societies, as implied by the short discussion of political networks in this paper. Finally, we believe that the application of social network analysis (SNA) tools to archaeological data sets holds great promise in efforts to better understand hunter-gatherer variation in the past.

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