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Parental investment as social agency and catalyst to complexity

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ABSTRACT

Re-examination of the relationships between diets as inferred isotopically and grave goods in light of new data has revealed the importance of parental investment for Early Neolithic populations in Cis-Baikal, Siberia. The Kitoi Culture developed and maintained a flexible but expensive broad-spectrum subsistence strategy. Moderately high extrinsic risk factors produced periodic famines and metabolic stress evidence in skeletons. The small-scale efforts of parents to support their offspring through increased breast milk and plant food provisioning led to a restructuring of subsistence priorities with ramifications for group structuring over the course of centuries.

1. Introduction

Hunter-gatherer societies evaluated in terms of intergenerational wealth transmission have been found to display more inequality than is widely appreciated (Smith et al., 2010). Archaeological records in areas like Early Neolithic (EN) Cis-Baikal, Siberia, poorly reflect conventional portrayals of foragers as highly egalitarian and unconcerned with wealth. Initial observations of spatial structuring and uneven distributions of grave goods within the EN Shamanka II cemetery have been augmented by additional behavioral observations relating to parental investment, the focus of this paper.

Portions of EN society have proven more effective at creating and collecting material goods during life to such an extent that they can afford to, or choose to, inter more grave goods. There is not enough information contained in the mortuary record to clearly infer if the sum total of an individual's material possessions were being buried or destroyed upon their death. Modern ideas of intergenerational wealth center on material goods, properties, privileges, and liquid assets that can be held and transferred to offspring. If these goods were to be buried, then they arguably leave the society as a whole, although hunter-gatherers may evidence different behaviors.

Active interaction with the dead creates multiple reasons to expect different types of behaviors related to how material wealth relates to living and dead members of EN society. By physically interacting with the grave, the individual's bones and associated grave goods remain as part of the living world, with ongoing potential for revisiting, additions, or removals.

Ethnographic accounts of wealth being accumulated and gifted during mortuary ceremonies (cf., potlatch or bigman ceremonies) as being important to social standing within living memory (e.g., Carr, 1995; Clay, 1992; Jopling, 1989; Lincoln, 1989; Letham and Coupland, 2018; Ucko, 1969). Whether these goods are subsequently consumed or destroyed is immaterial to the status acquired through their ceremonial presentation. Living members of society may remember, or have stronger associated concerns for the mortuary ceremony itself and how relatives acted in regard to the dead, coloring ascribed social standing and subsequent interactions related to material possessions.

If these figures or families are periodically the recipients, or organizers/controllers, of larger labor organizations and material goods, then they may well be interred with a portion of those goods, or comparable prestige items to recognize their actions. If the entirety of material goods were indeed interred, then even though the material goods will have left living society, the status and associated privileges associated with those goods will be retained by living members of society. Their privileged or materially enriched lives may directly relate to the investment in prior mortuary ceremonies.

Identifying the underlying behaviors that convert privileged societal standing to different life history outcomes, or social hierarchy denoted by differential access to material goods in life and mortuary treatment in death, is more challenging. Outside of structured societal roles (e.g., shaman or hunting/war party leader), the pathways to gain standing may relate to either individual accomplishments or to parental efforts.

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Parents may have focused energy on getting their children opportunities or information that would help them individually achieve success, or more directly attempted to ensure their survival through nutritional provisioning.

Such provisioning could take the form of breastfeeding and weaning decisions, or greater provisioning during childhood until the juvenile is old enough to join group hunting or fishing efforts.

Parental behavior related to breastfeeding is an important element in understanding cultural aspects of investment in children and population level fertility (Bentley, 1985; Borgerhoff Mulder, 1992, 2000; Dettwyler, 2004; Hill, 1993; Tsutaya and Yoneda, 2015). Looking at changes in breastfeeding decisions at the group level at Shamanka II, parental investment seems to be divided, as there is a bimodal pattern of weaning (Scharlotta et al., 2018). This is reflective of parental investment decisions in light of interpretations of extrinsic risks (Greenwald et al., 2016; Kaplan, 1996). The relative costs will be correlated to the prevalence of disease, risks of resource shortfalls, and other environmental hazards, thus, the length of weaning has been hypothesized to fluctuate with changing circumstances throughout the EN in Cis-Baikal (Scharlotta et al., 2018).

Investigating the context in which hunter-gatherers created Shamanka II has yielded some intriguing clues. Building on the concept of scalar stress (Johnson, 1982), group fissioning and the emergence of organization complexity are predicted as mechanisms to dissipate social tension and maximize information processing capacity. The emergence of hierarchical social organization(s) rely on the interplay of foraging resource constraints, life-history constraints and the density dependent effects of competition for energy, materials and information in finite environments in the emergence of a complex social structure (Hamilton et al., 2007).

The establishment and use of EN cemeteries distributed throughout Cis-Baikal may evidence group fissioning (Okladnikov, 1950, 1955; Weber, 1995; Weber et al., 2002). EN population expansion may also have led to the development of special use cemeteries related to changing social structure. Changing technologies, diets, and mortuary practices (Bazaliiskii, 2010; Scharlotta et al., 2016; Weber et al., 2016a) in EN Cis-Baikal suggest that we are witnessing the evolution of hierarchical social organization at Shamanka II.

Trends of increasing fish consumption through time and increasingly disparate mortuary treatment raise the questions of the societal context. Portions of EN society managing to build and bury differential wealth suggest variability in individual success or unequal familial dynamics. How this success impacts their ability to extend these benefits to their offspring is less clear. The point at which differentiation within social structures create hierarchies of specialist or kin groups, and develop further into social complexity is rarely clear. Once hierarchical structures are clear enough in archaeological manifestation to evidence social complexity, any differences in diet, weaning, or mortuary treatment are likely attributable to the function and continuation of extant systems. What social agency started the process may no longer visible in the archaeological record, or sufficiently distinct as to have unequivocally played a causal role in creating the complexity. The catalyst to this progression is hypothesized to lie in this initial differentiation in parental investment and how larger-scale ramifications follow as ripple effects for seemingly minor variations in behavior.

Investigating the links between dietary and mortuary variability, Scharlotta et al. (2016) hypothesized that intensified fishing was a critical activity driving social stratification through labor organization or species targeting. Attempts to identify mass harvesting techniques for fishing, directly through tools to create nets, weirs, or boats, or indirectly through dietary differences for individual buried with prestige items, failed to support this hypothesis. There was no evidence of species targeting in the faunal or isotopic data, or evidence of tools for mass harvesting. The variable weaning time suggests greater risks which is the opposite of what would be expected if effective mass harvesting were provisioning more people, or the same people more reliably. Results suggested instead that this dietary staple was sourced through extensification using a broad-spectrum technological package. Maintaining multiple technologies for the same task expanded opportunities for fishing success at the cost of reduced efficiency (cf. Bright et al., 2002; Ugan et al., 2003). This type of technological package also challenges the hypothesis that fishing was an activity around which labor organization could have occurred.

Increasing numbers of grave goods were correlated with extended weaning times, increasing extrinsic risk(s), and increased parental investment in offspring (Scharlotta et al., 2018). Greater fish consumption was not reducing risk factors for the population, or specifically rewarding individuals with recognition of fishing prowess (i.e., buried with more prestigious items). Individuals, who benefited from additional breast milk frequently, saw greater grave good allocation, but not exclusively. The goal of this study is to investigate the links between differential provisioning, parental investment, information resources and social structure on the persistence of a broad-spectrum technological package.

2. Materials

2.1. Shamanka II

The Shamanka II cemetery is located on the southwestern coast of Lake Baikal (Fig. 1; 103°42′11″E, 51°41′54″N) (Bazaliiski and Weber, 2004, 2006; Bazaliiskii, 2010). The Early Neolithic (EN) component of this cemetery consists of 97 graves, containing the remains of a total of 155 individuals. Many of the EN graves at Shamanka II were extensively disturbed in prehistory and a large number of burials have substantial parts of their skeletons missing (Bazaliiskii, 2010). Many EN graves at Shamanka II contained single bones of individuals other than the main burials. Such skeletal elements are not considered separate interments and they are not included in the tally of EN burials.

The EN graves display characteristics of the Kitoi mortuary tradition, including the extended supine body position, N–S/NE–SW orientation, multiple interments, toe-to-head arrangements, the use of red ochre, composite fishhooks, and items of zoomorphic art. The distribution of grave goods is quite variable both between graves and through time (Bazaliiskii, 2010; Scharlotta et al., 2016), ranging from no objects, or very few, to interments with hundreds of items.

The EN graves present a few discernible spatial arrangements (Fig. 2). The most obvious are the two groups of graves in the north and south of the cemetery, referred to as the North and South Sectors. The North Sector is further divided into the Northwest and Southeast Clusters. Spatially these two units are not as distinct as the sectors but the distances separating the two clusters do appear somewhat greater than between the graves within each cluster. The apparent void in grave distribution around the State Topographic Datum within the Northwest Cluster is the result of a fenced off area with prohibited access. Fieldwork confirmed the presence of graves around this part of the cemetery, which were left unexcavated. Therefore, the graves east of the Datum are considered part of the Northwest Cluster. Lastly, some graves are arranged side-by-side and these formations are referred to as rows. Rows are defined as a minimum of three graves arranged into one line with grave long axes roughly parallel one to another. Graves constructed outside of row formations are referred to as scattered. Twelve such rows have been identified and all, with one exception in the South Sector, run along the NW/SE axis.

There are two separate phases of cemetery use during the EN at Shamanka II: Phase 1 from approximately 7756 to 7052 corrected years BP, and Phase 2 from 6893 to 6577 corrected years BP, following correction of a freshwater reservoir offset in radiocarbon age between terrestrial and aquatic fauna (Schulting et al., 2014; Weber et al., 2016b). Three clusters of graves used concurrently through these phases suggested the use of Shamanka by multiple groups, or a single socially complex group.

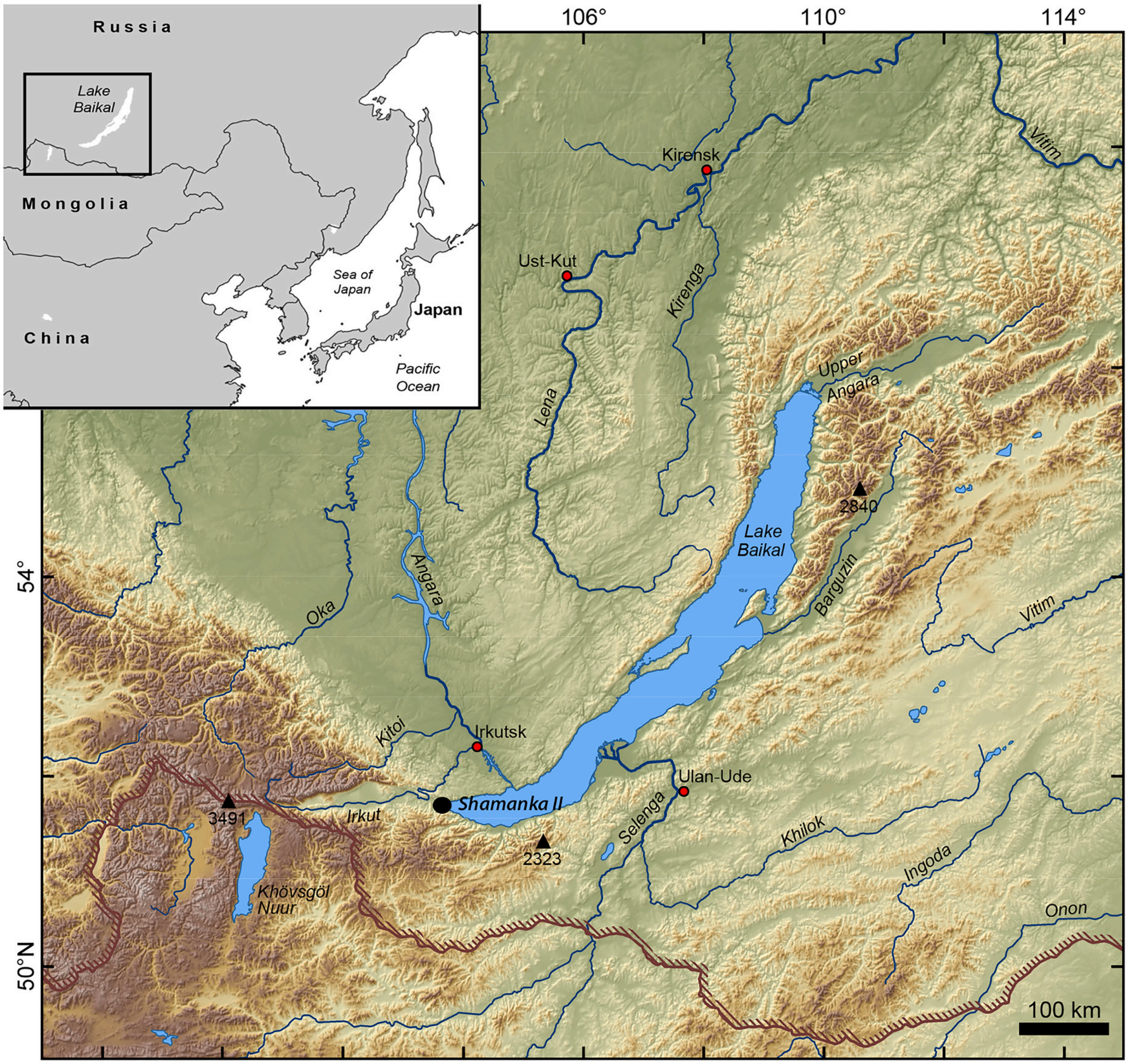

Fig. 1. Location map of Cis-Baikal region, Siberia, within northern Asia. Topography is based on elevation Shuttle Radar Topography Mission (SRTM) v4.1 data (Jarvis et al., 2008) produced by Christian Leipe (FU Berlin).

3. Methods

3.1. Classification of grave goods

A total of 2949 grave goods was recovered from Shamanka II. Artifacts were organized into 17 functional classes (function, means of manufacture, and material) with grave goods identified to grave and burial number.

- *Stone Projectiles* includes all arrow and spear points
- *Knives, Axes, and Blades* includes polished and retouched stone adzes, axes, knives, and prismatic blades including materials on nephrite, slate, and argillite
- *Miscellaneous Lithic Tools* includes hammers, non-specific bifaces, scrapers, push-planes, perforators, burins, borers, abraders, shaft straighteners, pestles, cores, drills, saws (serrated or denticulate edges), and retouched flakes
- *Debitage* includes traditional debitage and raw lithic materials that were not modified (where mode of production was not specified as flaking or grinding)
- *Shell Ornaments* includes shell and mother-of-pearl beads, pendants, bracelets, rings, and disks
- *Stone Ornaments* includes stone (nephrite, agalmatolite, calcite, etc.) beads, pendants, bracelets, rings, and disks
- *Bone Projectiles* includes flat, awl-like, needle-like, extended triangular, and barbed points, non-specific arrow and dart points
- *Bone Fishing Tools* includes harpoons, pikes, simple and complex fish hooks (composed solely of bone)
- *Modified Bones and Miscellaneous Tools* includes polishers, adze-like flattened antler tools, daggers, needles, needle-boxes, pointed and knife-like objects with handles, spoons, curved blades and shanks, pipes, flakers, bow planks, hammers, shovels, split bones and antlers, notched or fluted handles, combs, and non-specified bone and antler objects
- *Predator Bones and Teeth* includes unmodified bones, teeth, and claws of predators
- *Herbivore Bones and Teeth* includes unmodified bones, teeth, and antlers or herbivores
- *Aquatic Bones and Teeth* includes unmodified bones, teeth, beaks, and scales of water-related animals (e.g., fish, beaver, swan)
- *Bone and Tooth Ornaments* includes all modified bone, antler, and tooth pendants, beads, and bracelets
- *Stone and Bone Sculpture* includes all zoomorphic and anthropomorphic objects

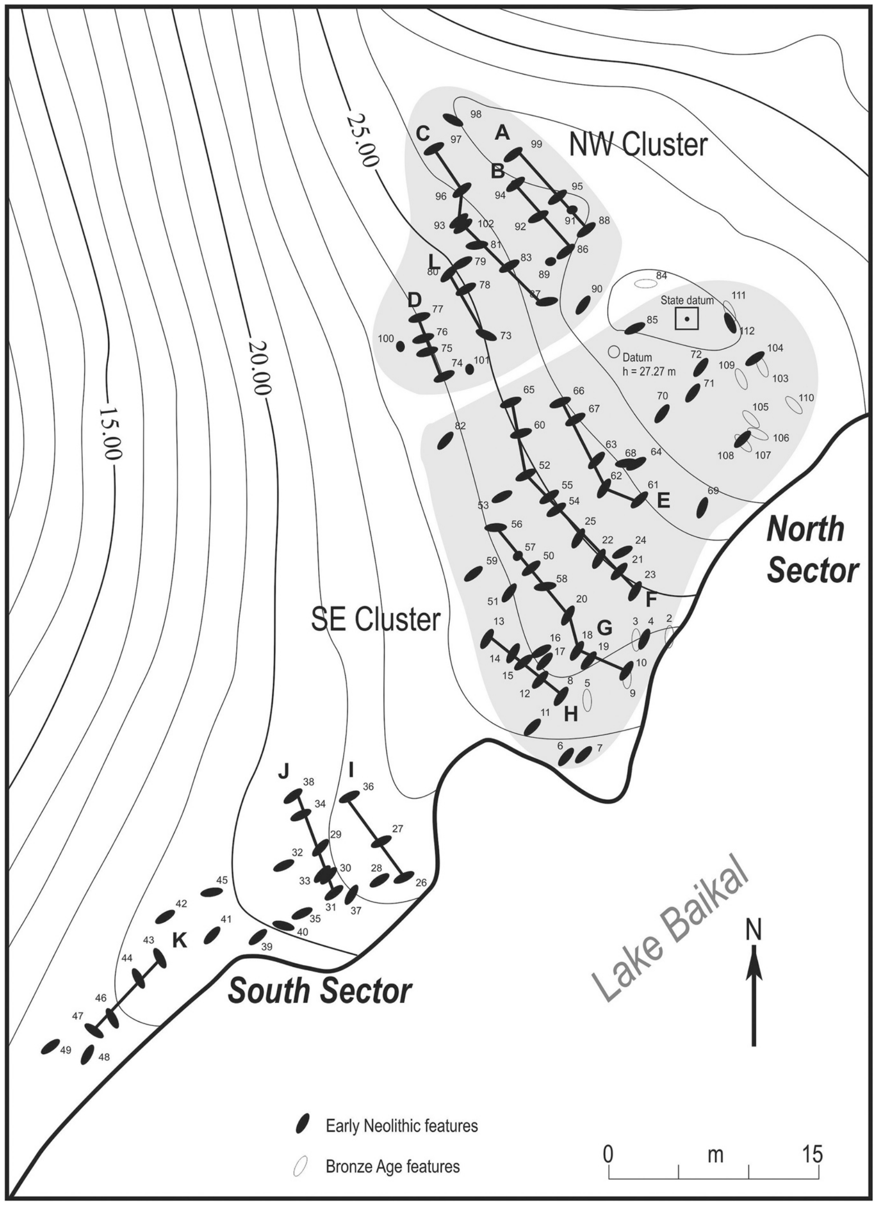

Fig. 2. Map of Shamanka II showing Sectors and Clusters.

- *Composite Fishing Tools* includes composite fishhooks of Kitoi and Baikal (barrel) types, as well as shanks, and barbs of composite untyped fishhooks
- *Composite Cutting and Multipurpose Tools* includes composite insert points, shafts, and cutting blades, grooved knives, handled tools
- *Pottery* includes all vessel types and fragments of EN pottery

3.2. Data groups

A total of 92 EN graves with 143 individuals interred at Shamanka II are included in this analysis. This sample includes all individuals with bone collagen stable isotopic data (Weber et al., 2016a; Weber et al., 2011), 121 adults with calibrated radiocarbon dates, and 22 subadults lacking radiocarbon dates. Most individuals ($n = 122$) contained one or more grave goods comprising a variety of artifact classes. Twenty-one (21) individuals, including 11 adults and 10 subadults, were interred without grave goods.

A previous analysis of the relationships between grave goods and dietary patterns (Scharlotta et al., 2016) focused on grave goods that were hypothesized to relate to fishing, construction of boats, and prestige items like exotic nephrite. Individual selection within the cemetery was therefore limited to adult individuals who had securely associated radiocarbon dates, carbon and nitrogen stable isotope results, and one or more of 16 classes of grave goods. There were three groups of individuals who were excluded from the Scharlotta et al. (2016) analysis (Table 1): 1) *Individuals* lacking grave goods hypothesized as prestigious or relating to fishing; 2) *Subadults*; and 3) *Divided Multiple Graves* for which grave goods could not be confidently attributed solely to one individual. The goal was to investigate if fishing intensification could be correlated with diets or artifacts. Excluding individuals without confident grave goods associations, or lacking classes of grave goods, removed individuals that would have made no contribution to explaining the variability within the selected artifact groups. Unfortunately, this approach may have unintentionally biased subsequent efforts to link observed trends with larger spatial and temporal patterns in the cemetery.

In order to mitigate potential biases, three working data groups have been included: *Divided Multiple Graves, Individuals,* and *Subadults*

Table 1
Average artifact-per-individual and total artifact counts for different data groups.

	n	Avg Artifacts/Ind	Total Artifacts
Basic Data Groups			
Juvenile	22	6.14	135
Individual	73	29.13	2177
Divided Multiples	121	24.37	2949
Data Groups by Phase			
Individual (phase 1)	60	28.52	1711
Individual (phase 2)	13	35.85	466
Divided Multiples (phase 1)	104	23.58	2453
Divided Multiples (phase 2)	17	29.16	496
Weaning by Phase			
Weaning Phase 1	20	40.80	816
Weaning Phase 2	8	37.50	300

(Table 2). *Divided Multiple Graves* group represents the main group of 121 adult individuals with isotopic and radiocarbon data. Multiple interments where grave goods could not be clearly attributed to a single individual were divided equally between all members. There are 11 graves in this group that have no grave goods. *Individuals* (n = 73) are restricted to graves with isotopic and radiocarbon data as well as clearly attributable grave goods (Table 3). This was the dataset primarily used in the previous analysis of diet and artifacts, as well as the source of subsets used for incremental dentin studies of parental investment (n = 28) and FRUITS dietary modeling (n = 23) (Scharlotta et al., 2018, 2021). These subsets were drawn from the main group based on which individuals had complete sets of molars available for incremental dentin studies and then also had strontium data for the FRUITS modeling. All of these individuals are included in the Divided Multiples group as well. The third group (n = 22), *Subadults*, is composed of individuals either lacking radiocarbon dates, or lacking correction for the freshwater reservoir effect due to the complication introduced by nursing on the δ^{15}N values used in the correction equation (Weber et al., 2016b) who died under the age of 5 years along with one individual who died around age nine years (Table 4). Nine of the subadults were recovered from multiple burials. The remaining 13 subadults were interred as individuals, but were excluded from previous analyses due to concerns over their δ^{15}N values. There were six individuals aged between six and nine years (average estimated age) included in the divided multiples group because they had calibrated radiocarbon dates available. Temporal trends including phase distinctions were only applied to the *Individuals* and *Divided Multiples* groups.

3.3. Conventions

This study uses a combination of data exploration through comparison of grave good distributions, broad temporal trends, and principal components analysis to investigate the underlying drivers of observed variability. In the principal components analysis (Baxter, 1994; Baxter and Heyworth, 1989), the length of individual eigenvectors corresponds to the amount of variance within the data that the variable explains with longer vectors having a greater influence on the projected data points than shorter vectors. Correlation refers to any of a broad class of statistical relationships involving dependence. In this case, this would refer to how dependent the frequency of one artifact class is upon another. That is, for example, how likely the number of fishhooks is to be dependent upon the number of stone ornaments or axes. Variance is the measure of how far a set of numbers is spread out, in terms of their similarity in multivariate space. The direction of the vector corresponds to the correlation between variables within the principal components matrix with the angles indicating the closeness of the relationship between different variables. Vectors with acute angles are closely correlated in a positive fashion; vectors that are close to 180-degree angles (inversely acute) are closely correlated in a negative fashion, while perpendicular vectors are not correlated. Results are discussed in terms of the visualization of the data using the following guidelines: strong (<20° difference between vector angles), moderate (20–50°), weak (50–70°), or not correlated (70–90°). Negative correlations would comprise the same degree of offset from the inverse of the original vector.

Another way to look at the relationship between artifact classes is to use a variance-covariance matrix instead of a correlation matrix when conducting principal components analysis. Covariance is the measure of how much two variables change together, that is, the degree to which greater values in one variable correspond with greater values of another variable, the same holding for smaller values. In the opposite case, when the greater values of one variable mainly correspond to the smaller values of other variables, the covariance is negative. This approach is often used in analyses of chemical composition because each element represents a portion of the total and so will vary proportionally to other elements within the matrix. Similarly, if non-perishable artifact classes are closely related, then they should co-vary together within the sum of grave goods, that is, they should represent a larger portion of the total number of grave goods. The total number of grave goods should not bias the analysis as preservation is generally good throughout the cemetery. The raw numbers of grave goods or artifact classes are less important than the proportion of total grave goods that each class represents in determining the significance of each class.

3.4. Age-specific dietary stable isotope analysis and FRUITS modeling

Dietary reconstruction efforts have progressed rapidly in recent years (e.g., Bocherens et al., 2005; Drucker and Bocherens, 2004; Drucker and Henry-Gambier, 2005; Hopkins et al., 2012; Newsome et al., 2004; Richards et al., 2001; Tykot et al., 2009). Observations of increased fish consumption through time were based on adult bone collagen δ^{13}C and δ^{15}N values that could not be readily explained by non-fish dietary sources. In order to parse out dietary contributions from different sources, there were multiple interrelated problems to solve.

Attempts at using modern reference materials initially had limited success in providing an isotopic baseline for Cis-Baikal (Katzenberg and Weber, 1999; Weber et al., 2002, 2011). Anthropogenic influences rendered many samples unusable and hinted that there may have been significant changes to aquatic ecosystems as a result of both pollution and dam construction. Creating reference groups specific to aquatic habitats (Weber et al., 2016a; Weber et al., 2011) improved results, but showed substantial overlaps in potential reference groups. Fishing was clearly an important dietary contributor, but where and which fish were being targeted remained elusive. Bayesian modeling of the relative contributions from different groups was sought through Food Reconstruction Using Isotopic Transferred Signals (FRUITS) to clarify matters. Dietary modeling based on the relative contributions of *Plant Foods, Riverine Fish (River Irkut), Lake Baikal Fish (Kultuk Bay), Seal, and Terrestrial Game*, showed differences between grave clusters, the beginning and ends of each phase, and between the two phases of cemetery use at Shamanka II (Scharlotta et al., *This issue*).

Second, the efficacy of long-term dietary averages is limited for hunter-gatherers. The underlying assumption is that isotope measurements on bone provide a long-term average of all the foods consumed (biased towards protein) and that shifts in diet are averaged out, even if they vary wildly. Food representing a stable balance of options available on the landscape do not have to be consumed in consistent proportions year on year, making it more challenging to identify routine habits such as seasonal rounds. If there was a directional shift that was maintained for some years, it should become visible in bone collagen isotopes, particularly when compared with dental isotopic records. Given the overlap in aquatic reference groups and variety of terrestrial ecological niches, there were concerns that long-term averaging may not clearly show shifting fishing preferences. Attempts at identifying a preferred method of fishing that could target specific waterways (e.g., near-shore

Lake Baikal, or small rivers) or species yielded evidence for the long-term persistence of a broad-spectrum toolkit. This is intriguing as the economic payoff for specialization frequently leads to the abandonment of less efficient technologies over time (Ugan et al., 2003). In order to investigate either opportunistic or broad-spectrum subsistence approaches, greater temporal resolution was accomplished through incremental dentin collagen studies (Scharlotta et al., 2018). These sub-annual blocks of time represent approximately 30 points of subsistence behavior, for the first 20 years of life. Compared with a single bone collagen point representing a similar amount time, there is greater opportunity to observe and analyze both routine and exceptional changes in diet.

Third, was to ensure that proxy data yielded realistic dietary reconstructions. Models are only as good as their proxy and reference data. If the inputs include two very large overlapping groups, or the proxies used only represent a portion of the real diet, then any reconstructed diet will have large uncertainties (Bocherens et al., 2005; Drucker and Bocherens, 2004; Newsome et al., 2004; Richards et al., 2001).

Diet reconstruction studies depend on the specific dietary proxy (e.g. $\delta^{13}C_{collagen}$, $\delta^{15}N_{collagen}$, $\delta^{13}C_{bioapatite}$) and on which food fractions (e.g. bulk, protein, lipids) determine the isotopic proxy signal (Ambrose and Norr, 1993; Tieszen and Fagre, 1993). Siberian hunter-gatherers, anticipated to have protein-rich diets (Katzenberg and Weber, 1999; Weber et al., 2002, 2011), should be excellent candidates for collagen-based studies such as incremental dentin analysis. Plant foods high enough in protein to impact collagen studies were thought to be available in only small quantities; however, recent modeling efforts on agrarian populations in Europe (Bickle, 2018), have underestimated contributions from low-protein sources. Inner bark in particular has been ethnographically noted as an important food source in Scandinavia (Bergman et al., 2004; Östlund et al., 2009; Östlund et al., 2004; Zackrisson et al., 2000). More crucially, containing approximately 3–10% protein, these resources could potentially be visible in collagen-based isotopic records (Rautio et al., 2013). As a result, there were concerns that opportunistically harvest plant foods important in other subarctic forested areas (e.g., inner bark) may be missed entirely without additional proxies.

Including strontium is challenging as it is recovered from different tissues (enamel versus dentin) and reflects different dietary vectors into the body, and residence time in body tissue and requires alignment with incremental dentin collagen data. Once aligned, this additional proxy allows for dietary reconstruction of a sub-annual block of time with geographic information on foraging areas (Scharlotta et al., *This issue*). Third molar (M_3) crowns representing approx. 12.5–13.1 years were the preferred materials for multi-proxy FRUITS analysis, though second molars (M_2) representing approx. 6.6–7.1 years old were used where M_3s were not available and the $\delta^{13}C$ and $\delta^{15}N$ data showed that weaning was completed. Analysis of weaning patterns and subadult dietary patterns showed little age-specific variation in diets (Scharlotta et al., 2018). After cessation of breast milk, dietary variations through an individual's lifetime exceeded any divisions between adult and subadult diets. The results showed higher than expected contributions of *Plant Foods* and *Riverine Fish* and suggested that a logistical foraging range of 75 km (radius) could adequately explain the geochemical variability observable at Shamanka II.

4. Results

4.1. Subadults

Looking at the distribution of grave goods associated with subadult burials, there is a notable disparity between individuals buried alone and those interred with adults (Table 1). Thirteen subadults were interred buried on their own. These individuals were interred more frequently with *Herbivore Bones and Teeth* and *Knives, Axes, and Blades,* while less frequently with *Stone Ornaments* and *Modified Bones* than those buried with adults, though the sample sizes are quite small and easily skewed by individuals with clusters of these artifacts.

Nine subadults were interred with adults (Master IDs ending in 0.01–0.04). Of these nine subadults, seven were buried with one, or no grave goods. Only six subadults buried alone contained one or no grave goods. The remaining two subadults interred with adults had notable grave goods ($n = 14$ and 46). The subadult (SHA_2004.056.01) with the highest number of grave goods ($n = 46$) was interred with more than twice as many artifacts as any other subadult. This number of grave goods would place them in the 82nd percentile of Shamanka II if they had survived to adulthood. Subadults interred with adults had an average of 6.9 artifacts per individual, compared with 5.6 artifacts per individual for subadults buried alone; however, this number is skewed by the high grave good count in SHA_2004.056.01.

Circumstances with high infant mortality can lead to delayed or reduced parental interactions noted ethnographically (e.g., Tsimané) such as not naming children until after the first year of life, or reduced spoken interaction frequencies (Sear and Mace, 2008). Similar risky environmental conditions in EN Cis-Baikal could logically yield age-graded phenomena where children were given grave goods only if they survived past a certain age, and are given full mortuary treatment as adults thereafter. This does not appear to be the case. The individual with 46 grave goods died around the age of four years while the subadult with the second highest artifact count was under the age of two years. Five of the subadults interred without grave goods were under the age of two years, yet one was nine years, another four years, and three more around two and one-half years old.

Comparing subadults and adults more broadly (Fig. 3), there are clear preferences for which artifacts were to be interred with subadults. *Herbivore Bones and Teeth* followed by *Bone and Tooth Ornaments* were the most common artifacts interred with subadults. These two artifact classes were also 3–4 times more frequent in subadult than adult burials. This same pattern holds true for *Stone Ornaments* as well, though only the fifth most common grave good class. *Predator Bones and Teeth, and Knives, Axes, and Adzes* were two classes of graves good more commonly interred with subadults than adults, but only marginally as compared with adult frequencies. All remaining artifact classes were predominantly, or solely, recovered from adult burials.

Patterning in which artifacts were correlated with diets and age of death (Fig. 4) is intriguing. Estimated age-at-death is negatively correlated with $\delta^{15}N$, as expected, most likely representing the effects of children who died during the process of weaning. Estimated ages were strongly positively correlated with a clustered group that includes *Predator Bones and Teeth, and Stone Ornaments*. This cluster is also strongly positively correlated with *Modified Bones and Bone and Tooth Ornaments* though this second cluster is only moderately correlated with age.

Two artifact classes in subadult graves that differed between individuals buried alone versus with adults, *Knives, Axes, and Blades, and Herbivore Bones and Teeth* were strongly negatively correlated. The former was parallel with $\delta^{13}C$ which presents a curious return to previous hypotheses (cf. Scharlotta et al., 2016). If subadults with higher $\delta^{13}C$ were more likely to be interred with *Knives, Axes, and Blades*, then these artifacts may be related to increased fish consumption. Given the conclusions of previous grave goods analysis, this relationship is likely functional as all other ornamental and prestigious items are weakly correlated at best. Conversely, subadults with lower $\delta^{13}C$ values were more likely to be interred with *Herbivore Bones and Teeth.* These

Table 2
Age-at-death (years), sex, radiocarbon date (MeanCalDateBP), Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) bone collagen results for skeletal individuals analyzed, and grave good artifact counts for the Divided Multiples data group. Bone values, Grave Cluster, and Diet Groupings follow Weber et al. (2016a).

Master ID	Sex	Avg. Age Est. (years)	14C Date	d13C	d15N	Stone Projectiles	Knives, axes, blades	Misc. Lithic Tools	Debitage	Shell Ornament	Stone Ornament	Bone Projectile	Bone Fishing Tools	Modified Bone and Misc. Tools	Predator Bones+Teeth	Herbivore Bones+Teeth	Aquatic Bones+Teeth	Bone/Tooth Ornaments	Stone+Bone Sculpture	Composite Fishing	Composite Cutting/Misc.	Pottery	Total
SHA_2003.025.03	F	20	7756	-16	12.5	0	0.3	0.3	0.3	0.3	0	0.3	0	2.7	0.3	0	0	1	0	0	0	0	**6**
SHA_2002.021.01	M	28	7552	-16.4	12.4	0	1	0	1	0	1	3	3	13	3	0	2	2	0	4	3	0	**36**
SHA_2006.066.01	F	30	7531	-17.1	13.6	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	**2**
SHA_2007.073	F	17	7516	-16.5	14.1	0	1	1	3	0	0	0	5	7	0	23	2	1	0	0	7	0	**50**
SHA_2006.058	M	40	7515	-16.8	13.9	2	0	2	0	0	0	2	2	6	0	1	0	0	1	6	1	0	**23**
SHA_2003.027.01	M	43	7507	-16.8	13.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2002.023.03	U	20	7505	-17.2	13.4	0	0.2	0.2	0.2	0.4	0.2	1.8	0	2.6	1.6	1.4	1.4	1	0	0.2	0.2	0	**11**
SHA_2004.034	M	40	7503	-16.6	14	1	2	1	1	0	2	1	0	5	0	1	1	0	0	0	0	1	**16**
SHA_2002.020.02	U	20	7501	-16.8	13.7	0.3	0.5	0.5	1.3	0	0.3	2.5	2.3	8.5	0.3	0	0.8	0	0	0.3	1	0.3	**19**
SHA_2007.085	M	30	7500	-15.6	13.7	0	4	0	6	0	1	0	0	43	0	30	1	0	0	0	0	0	**85**
SHA_2004.043	F	35	7499	-17	14.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2002.021.02	M	28	7488	-16.5	14.1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
SHA_2006.062.03	F	20	7483	-15.8	14.6	0	0.4	0	0.4	0	0.2	0.4	0.2	3.6	0.6	1.2	0.6	0.4	0.2	0	1.4	0.4	**10**
SHA_2007.088	U	7	7483	-16.6	13.7	0	0	1	2	0	0	0	0	1	1	0	0	0	0	0	5	0	**10**
SHA_2002.023.05	M	20	7478	-15.9	14.6	0	0.2	0.2	0.2	0.4	0.2	1.8	0	2.6	1.6	1.4	1.4	1	0	0.2	0.2	0	**11**
SHA_2005.041	M	35	7478	-16.9	14.1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
SHA_2007.077	F	35	7475	-16.7	14.7	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	**4**
SHA_2005.045	M	30	7474	-16.4	13.6	2	2	2	1	0	0	4	1	4	0	0	0	0	0	0	1	0	**17**
SHA_2003.025.02	U	19	7472	-16	15.5	0	0.3	0.3	0.3	0.3	0	0.3	0	2.7	0.3	0	0	1	0	0	0	0	**6**
SHA_2007.079	F	43	7472	-15.2	15	0	0	1	2	0	0	0	0	3	0	0	0	0	0	0	0	0	**6**
SHA_2004.029.01	M	25	7469	-16.2	13.3	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
SHA_2006.065	M	50	7469	-16.4	14.4	0	0	0	0	0	0	0	0	0	1	1	0	5	0	0	0	0	**7**
SHA_2007.093.02	F	38	7468	-16.4	14.7	0	2	2	0	1	0	0	0	4	0	9	0	0	0	0	0	0	**18**
SHA_2004.050.02	M	27	7448	-16.9	13.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2002.021.03	M	17	7445	-15.6	14.4	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**3**
SHA_2005.044.02	M	20	7441	-16.9	14	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	**3**
SHA_2007.078.04	F	43	7440	-15.8	14.9	3.8	0.5	0.8	4.5	0	0	2.3	3.3	11	1	2.5	0.8	0.5	1	3.8	1	0	**37**
SHA_2004.042.02	F	50	7433	-16.4	15.1	0	0	1	2	0	0	0	0	3	0	0	0	0	0	0	4	0	**10**
SHA_2006.062.05	M	52	7432	-16.7	13.7	0	0.4	0	0.4	0	0.2	0.4	0.2	3.6	0.6	1.2	0.6	0.4	0.2	0	1.4	0.4	**10**
SHA_2004.033	M	40	7430	-16.4	14.2	1	0	0	1	0	0	1	0	2	0	11	0	0	0	0	1	0	**17**
SHA_2006.062.04	M	27	7428	-15.7	14.9	0	0.4	0	0.4	0	0.2	0.4	0.2	3.6	0.6	1.2	0.6	0.4	0.2	0	1.4	0.4	**10**
SHA_2006.061.02	M	40	7421	-15.9	14.3	1	1	0	0	0	3	0	0	1	0	0	0	6	0	0	0	0	**12**
SHA_2007.074	M	19	7421	-16	14.5	0	1	0	0	0	0	0	1	3	0	1	0	0	0	0	0	0	**6**
SHA_2002.022.01	M	21	7420	-15.9	15.6	2	3	0	2	4	0	4	2	13	2	8	0	2	0	2	2	0	**46**
SHA_2000.010	M	30	7415	-16.8	13.9	0	0	0	0	0	0	0	0	2	1	0	1	0	0	0	0	0	**4**
SHA_1998.004	M	40	7413	-15.9	14.3	0	0	0	2	0	0	1	0	3	0	0	0	0	0	0	0	0	**6**
SHA_2006.062.01	F	20	7412	-16	13.9	0	0.4	0	0.4	0	0.2	0.4	0.2	3.6	0.6	1.2	0.6	0.4	0.2	0	1.4	0.4	**10**
SHA_2003.027.02	M	28	7410	-16.7	14.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2006.067	U	8	7408	-17.6	14.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2004.039	M	42	7405	-16.4	14.2	0	2	1	1	0	0	0	0	2	4	5	0	0	0	0	0	0	**15**
SHA_2004.032	M	40	7399	-16.1	14.5	1	1	0	1	0	0	0	0	2	0	0	0	0	0	0	0	1	**6**
SHA_2002.023.02	F	20	7396	-15.4	16.2	0	0.2	0.2	0.2	0.4	0.2	1.8	0	2.6	1.6	1.4	1.4	1	0	0.2	0.2	0	**11**
SHA_2006.069.02	F	23	7392	-14.7	14.8	0	1	0	0	3	0	0	0	5	0	7	2	0	0	0	0	0	**18**
SHA_2002.024.02	U	14	7387	-15.4	14.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2006.063.02	M	30	7382	-15	14.5	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	**2**
SHA_2006.055.02	U	6	7381	-16	15.4	0	0	0	0	0	0	0.5	0.5	3.5	0	2	0	0	0	0	0	0	**7**
SHA_2001.013.03	M	19	7376	-15	14	0	0	0	0	0	0	0	0.7	1	0.3	0	0	0	0	0.3	0	0	**2**
SHA_2005.048.01	M	50	7375	-16.4	14.8	0	0	0	0	0	1	0	0	0	0	6	0	2	0	0	2	0	**11**
SHA_2001.017.02	M	21	7370	-14.8	15.4	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	**3**
SHA_2006.060.02	F	42	7370	-15.9	15.1	0	0	0	0.5	0	0.5	0.5	0	0	0.5	0	0	0	0	0	0	0	**2**
SHA_2001.017.01	M	35	7368	-15.4	14.7	1	1	4	4	0	1	2	9	16	16	4	0	7	2	22	2	0	**91**
SHA_2007.092	U	11	7367	-15.5	14.4	0	3	1	0	0	0	0	0	0	0	2	0	1	0	0	2	0	**9**
SHA_2002.023.04	M	20	7363	-16.3	14.2	0	0.2	0.2	0.2	0.4	0.2	1.8	0	2.6	1.6	1.4	1.4	1	0	0.2	0.2	0	**11**
SHA_2007.090	F	19	7363	-15.6	15.5	0	0	3	3	4	0	0	0	7	1	0	0	0	0	0	0	0	**18**
SHA_2007.075	M	27	7357	-16.3	16.1	0	1	0	0	0	0	1	0	1	3	2	0	0	0	7	0	0	**15**
SHA_2004.050.03	M	35	7356	-15.9	14.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2006.055.01	M	37	7356	-15.9	14.6	0	0	0	0	0	0	0.5	0.5	3.5	0	2	0	0	0	0	0	0	**7**
SHA_2005.047	F	23	7355	-16.2	15.8	0	0	1	1	0	1	0	0	4	1	2	0	0	0	0	0	0	**10**
SHA_2006.056.02	U	9	7352	-15.7	15.5	0	0	4	0	0	0	0	0	6	3	6	1	3	0	1	0	0	**24**
SHA_2007.076	M	45	7351	-15.8	15.8	0	0	0	0	0	1	0	0	0	0	14	1	0	0	0	0	0	**16**
SHA_2006.069.01	F	28	7350	-15.8	14.8	0	0	1	0	5	0	1	0	18	0	6	1	1	0	0	1	0	**34**
SHA_2003.025.01	F	21	7349	-15.5	14.8	0	0.3	0.3	0.3	0.3	0	0.3	0	2.7	0.3	0	0	1	0	0	0	0	**5.67**
SHA_2005.046	M	27	7343	-15.8	16.4	0	1	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	**12**
SHA_2006.054	F	19	7340	-15.2	15.2	0	0	0	0	0	0	0	1	0	0	7	0	2	0	0	0	0	**10**

SHA_2002.024.01	M	30	7337	-15.5	14.9	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	**2**
SHA_2006.053.02	M	50	7337	-16	15.8	2.5	2.5	13	12	0	0	4.5	11	20	3	1.5	9	0	0	7	2.5	0	**88**
SHA_2001.014.02	F	23	7333	-15.3	15.3	3	1	0	1	0	1	2	0	2	0	4	1	3	0	0	0	0	**18**
SHA_2007.083.02	F	25	7330	-16.6	16.6	4	3.5	4	6.5	0	0	10	2	22	5.5	4	1.5	1.5	1	2.5	2.5	0	**70**
SHA_2007.078.02	F	30	7326	-16.6	13.99	3.8	0.5	0.8	4.5	0	0	2.3	3.3	11	1	2.5	0.8	0.5	1	3.8	1	0	**37**
SHA_2006.061.01	F	27	7324	-15	14.9	0	0	0	0	0	1	0	0	1	0	0	0	3	0	0	1	0	**6**
SHA_2006.062.02	U	20	7321	-15.8	15.1	0	0.4	0	0.4	0	0.2	0.4	0.2	3.6	0.6	1.2	0.6	0.4	0.2	0	1.4	0.4	**10**
SHA_2006.071	M	40	7317	-16.3	14.7	0	3	1	5	0	0	0	0	4	1	20	0	2	0	0	0	0	**36**
SHA_2001.013.02	M	43	7309	-16	14.8	0	0	0	0	0	0	0	0.7	1	0.3	0	0	0	0	0.3	0	0	**2**
SHA_2006.070	M	45	7308	-15.8	14.6	1	0	1	0	0	0	0	0	8	0	0	0	0	0	0	6	0	**16**
SHA_2004.026.02	M	20	7306	-17.4	12	0	0.2	0	0.6	0.8	0.6	0.4	0	3.8	0.6	1	0.6	0.6	0	0	0	0	**9**
SHA_2006.068	M	47	7300	-16	15.2	1	0	2	0	0	0	0	0	3	0	0	2	0	0	0	0	0	**8**
SHA_2002.020.01	F	28	7293	-16	14.6	0.3	0.5	0.5	1.3	0	0.3	2.5	2.3	8.5	0.3	0	0.8	0	0	0.3	1	0.3	**19**
SHA_2004.051	M	23	7288	-16.6	15.1	22	2	16	43	2	4	16	15	23	7	18	4	1	0	19	4	0	**196**
SHA_2006.053.01	M	23	7279	-16.2	15.7	2.5	2.5	13	12	0	0	4.5	11	20	3	1.5	9	0	0	7	2.5	0	**88**
SHA_2006.057.01	F	27	7259	-15.4	16	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
SHA_2001.013.01	F	30	7255	-16.3	15	0	0	0	0	0	0	0	0.7	1	0.3	0	0	0	0	0.3	0	0	**2**
SHA_2006.052.01	M	22	7244	-14.7	15.3	3	3	2	3	0	1	1	2	19	2	6	0	19	0	9	3	0	**73**
SHA_2002.020.04	U	20	7233	-16	16.1	0.3	0.5	0.5	1.3	0	0.3	2.5	2.3	8.5	0.3	0	0.8	0	0	0.3	1	0.3	**19**
SHA_2007.078.03	M	23	7224	-18	14.4	3.8	0.5	0.8	4.5	0	0	2.3	3.3	11	1	2.5	0.8	0.5	1	3.8	1	0	**37**
SHA_2006.059.02	F	17	7214	-17.7	14.2	0	2	10	17	0	0	4	2	28	1	6	6	1	2	1	2	0	**82**
SHA_2001.016	F	23	7209	-15.7	15.3	0	1	5	4	0	0	4	6	7	3	7	2	2	0	2	0	0	**43**
SHA_2007.096.02	F	33	7196	-16.1	14.3	0	12	15	20	0	0	3	1	14	1	3	4	0	0	0	3	0	**76**
SHA_2006.057.02	F	30	7186	-15.3	15.9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
SHA_2006.063.01	M	27	7186	-15.6	15.4	0	1	0	1	0	0	0	0	8	1	2	0	0	0	0	1	0	**14**
SHA_2008.112	M	30	7180	-16.3	15.1	3	5	5	8	0	1	3	3	18	12	10	3	3	0	3	6	0	**83**
SHA_2001.011.02	M	35	7165	-16.9	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2001.018	M	27	7155	-15.4	16.2	9	1	1	6	1	0	13	1	16	5	2	4	0	1	4	9	0	**73**
SHA_2000.008	M	38	7154	-16.8	16	1	1	3	4	0	0	4	1	16	8	3	1	0	0	2	2	0	**46**
SHA_2007.086.02	U	20	7146	-17	15.6	0	3.5	4.5	8	0	0	1	7	15	9	0.5	1	1	0.5	1.5	1	0	**53**
SHA_2001.015	M	30	7144	-15.3	15.6	7	5	16	40	0	0	11	19	37	3	6	9	0	1	15	11	0	**180**
SHA_2002.020.03	U	20	7140	-16	16.3	0.3	0.5	0.5	1.3	0	0.3	2.5	2.3	8.5	0.3	0	0.8	0	0	0.3	1	0.3	**19**
SHA_2007.083.01	M	21	7136	-17.1	14.1	4	3.5	4	6.5	0	0	10	2	22	5.5	4	1.5	1.5	1	2.5	2.5	0	**70**
SHA_2007.078.01	F	17	7131	-17.5	14.3	3.8	0.5	0.8	4.5	0	0	2.3	3.3	11	1	2.5	0.8	0.5	1	3.8	1	0	**37**
SHA_2001.011.01	F	19	7128	-17.5	14.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2006.060.01	M	50	7106	-16.9	15.9	0	0	0	0.5	0	0.5	0.5	0	0	0.5	0	0	0	0	0	0	0	**2**
SHA_2007.086.01	M	19	7101	-16.5	14.1	0	3.5	4.5	8	0	0	1	7	15	9	0.5	1	1	0.5	1.5	1	0	**53**
SHA_2001.019	M	28	7100	-15	16.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2001.014.01	M	28	7082	-15.3	16.8	0	1	0	1	0	0	0	0	2	2	3	0	2	1	1	0	0	**13**
SHA_2001.012	M	28	7052	-16.2	15.7	0	0	1	1	1	0	1	0	8	1	2	2	0	0	1	0	0	**18**
SHA_2005.049.01	M	19	6893	-16.2	13.5	1	1	0	4	0	6	0	1	5	3	0	1	1	0	0	3	0	**26**
SHA_2008.104	F	30	6865	-16.3	13.7	2	1	5	6	1	8	0	0	16	0	2	4	1	0	0	0	0	**46**
SHA_1999.007	F	25	6850	-16.4	13.7	0	1	0	4	0	0	0	0	2	15	1	0	0	0	0	0	0	**23**
SHA_2006.050.01	M	30	6825	-16.5	14.5	0	0	1	2	1	0	1	0	2	0	0	2	0	0	0	1	0	**10**
SHA_2004.026.01	F	20	6821	-17	14.2	0	0.2	0	0.6	0.8	0.6	0.4	0	3.8	0.6	1	0.6	0.6	0	0	0	0	**9**
SHA_2008.108.01	M	43	6796	-16.3	14.6	0	4	0	8	0	0	0	2	17	0	2	4	13	0	1	0	3	**54**
SHA_2008.108.03	M	30	6795	-16.3	14.4	0	6	1	3	0	0	0	0	3	0	3	2	20	0	1	0	0	**39**
SHA_2004.030	M	43	6792	-16.8	14.1	0	0	1	1	0	0	0	0	4	0	1	0	0	0	0	1	0	**8**
SHA_2005.044.01	M	50	6787	-15.3	15.3	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	**3**
SHA_2006.064.02	U	9	6758	-16.8	14.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2004.042.01	F	43	6753	-16.7	14.8	0	1	1	4	0	0	2	0	1	1	4	4	0	0	0	2	0	**20**
SHA_2006.064.01	M	35	6733	-16.5	14.9	7	6	5	8	2	23	4	2	18	12	4	4	29	0	2	7	0	**133**
SHA_2004.035.01	U	20	6695	-15.3	15.21	0	5	0	5	0	3	1	0	4	1	0	0	1	0	2	0	0	**22**
SHA_1998.006	M	17	6692	-16.2	15.9	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	**3**
SHA_2002.023.01	M	40	6646	-15.9	16.3	0	0.2	0.2	0.2	0.4	0.2	1.8	0	2.6	1.6	1.4	1.4	1	0	0.2	0.2	0	**11**
SHA_2006.059.01	M	37	6637	-16	16	2	2	5	3	0	0	5	1	33	5	11	6	2	0	0	4	0	**79**
SHA_2004.026.03	U	7	6577	-16.6	15.5	0	0.2	0	0.6	0.8	0.6	0.4	0	3.8	0.6	1	0.6	0.6	0	0	0	0	**9**
Grand Total						**103**	**124**	**173**	**321**	**31**	**66**	**162**	**145**	**763**	**177**	**311**	**120**	**158**	**16**	**145**	**126**	**8**	**2949**

relationships suggest that parental diets and status played a role in the burial items of their offspring. *Herbivore Bones and Teeth* were strongly negatively correlated with *Pottery, Aquatic Bones and Teeth, and Bone Projectiles*.

Values for $\delta^{15}N$ correlate strongly to moderately negatively with remaining grave goods.

The primary inference would be that increased age yielded more grave goods, as they themselves collected objects (e.g., *Debitage, Predator Bones*) and produced tools like *Modified Bones*, or were given ornaments by adults. With the negative correlation, the extrapolation of these $\delta^{15}N$ values would be that reduced dietary intake of aquatic resources and increased terrestrial resources led to more grave goods, suggesting that subadults were more able to participate in foraging and hunting game than in fishing or sealing activities. If weaning ages were consistent then such a pattern would likely reflect a pre/post-weaning pattern. Weaning ages at Shamanka II were bimodal and included an additional staged pattern (Scharlotta et al., 2018), so this relationship is explored further below.

4.2. Data groups and phase trends

Comparing the artifact class frequencies between *Individual* and *Divided Multiples* data groups, subtle differences are apparent (Fig. 5, Table 1). The average number of grave goods is lower for *Divided Multiples* (n = 24) than for *Individuals* (n = 29) as a combined result of including individuals lacking grave goods (n = 10), and the disparities between individual burials within multiple graves. The *Divided Multiples* group includes additional individuals (n = 48) and numerous grave goods (n = 772) excluded from previous analyses; however, the average number of artifacts for these additions equates to approximately 16 artifacts per individual, roughly 13 artifacts per individual lower than members of the *Individuals* group.

Differences between Phases mirror these groups; however, are not independently significant (*Divided Multiples*: $t = -0.626$, $p = 0.532$; $H(1) = 1.389$, $p = 0.238$; *Individuals:* $t = -0.625$, $p = 0.533$; $H(1) = 1.703$, $p = 0.192$). Approximately seven more grave goods on average were recovered from each Phase 2 burial than Phase 1 (Table 1). Including temporal information, the concentration of artifacts with *Individual* burials becomes more apparent (Fig. 6). While grave goods become more common through both phases, there is greater division between *Individuals* and *Divided Multiples* in Phase 2. The average age-at-death decreases through each phase as well, suggesting that as the population faced greater extrinsic risks and thus shorter lives, grave goods became more common and less evenly distributed. This effect was more strongly evident during Phase 2. The caveat to this inference is that age-at-death estimates for adults are rather broad outside of specific age markers, making this variable susceptible to the effects of both uncertainties in the age determinations and outlier effects from including younger individuals.

Projecting the frequencies of each class through time to clarify what artifact classes are driving these general trends, it is clear that relatively few classes experience substantial changes (Figs. 7 & 8). The majority of grave goods exhibit moderate increases or remain stable through each phase. During Phase 1, *Modified Bones, Lithic Tools, and Debitage* are the only classes that show notable change through time, becoming markedly more common by the end of the phase. During Phase 2, most artifact classes remain stable or even decline (*Predator Bones and Teeth, and Debitage*). *Herbivore Bones and Teeth, Bone and Tooth Ornaments,* and *Modified Bones* increased more than other artifact classes. *Modified Bones* increase in frequency in both phases, *Debitage* increases in Phase 1 but decreases in Phase 2, and remaining classes driving the variance in total graves goods are different, with *Lithic Tools* in Phase 1 and *Herbivore Bones and Teeth*, and *Bone and Tooth Ornaments* in Phase 2.

These temporal trends are not equitably reflected in principal components analysis. Looking at variance-covariances for *Divided Multiples* (Figs. 9 & 10) we can see that radiocarbon dates are perpendicular to the artifact classes in both phases. During Phase 1, *Modified Bones and Miscellaneous Tools* and *Debitage* are strongly negatively correlated with average age-at-death. During Phase 2, two of these three classes (age-at-death and *Modified Bones*) dominated the variability in the data, joined by *Bone and Tooth Ornaments. Modified Bones* and age-at-death were positively correlated during Phase 2, a reversal from earlier centuries.

4.3. Weaning duration

Previous analyses suggested relationships between the duration of weaning and the total number of grave goods (Scharlotta et al., 2018). Incorporating this information into the current analysis (Fig. 11), the duration of weaning and dietary isotopic data themselves vary between phases (Table 5).

Dietary inferences are expanded using FRUITS modeling results rather than δ^{13}C and δ^{15}N data alone (Fig. 12). The weaning duration is a minor variable in explaining total variance and is negatively correlated with age-at-death estimates. Duration of weaning is strongly positively correlated with *Seal* consumption and *Riverine Fish*, while negatively correlated with *Plant Foods* and *Terrestrial Game*. *Plant Foods* are moderately positively correlated with age-at-death and negatively correlated with many grave goods, suggesting that *Plant Foods* may have contributed to longer lives, but are more likely to have resulted in burial with fewer grave goods. Looking at the vectors for between-group separations (Fig. 13) there are two dominant patterns. *Lake Baikal Fish* are strongly negatively correlated with *Riverine Fish* and *Plant Foods*. The second pattern shows *Bone and Tooth Ornaments* and *Stone Ornaments* strongly negatively correlated with *Modified Bones and Miscellaneous Tools, Herbivore Bones and Teeth,* and *Bone Fishing Tools*, suggesting functional differences between phased grave good assemblages.

4.4. Cemetery sectors and clusters

Dividing the cemetery by spatial groups rather than temporal groups yields interesting, though not significant ($H(2) = 4.858$, $p = 0.085$) patterning (Table 5). The South Sector had an average age-at-death of nearly 32.5 years (n = 22, representing 1 subadult and 21 adults) and radiocarbon age of 7146 B.P., compared with 28.2 years (representing 1 subadult and 21 adults) and radiocarbon age of 7251 B.P. in the Northwest Cluster, and 28.6 years and radiocarbon age of 7131 B.P. for the Southeast Cluster (representing 3 subadults and 62 adults). The average radiocarbon dates for spatial groups that have weaning and dietary information represent a subset of the cemetery population. The weaning duration also varied, though not significantly ($H(2) = 2.035$, $p = 0.36$) with the South Sector averaging just above two years, compared with three or more years for the rest of the cemetery. Dietary variability between these clusters was evident in both δ^{13}C and δ^{15}N data and modeled diets. In both post-weaning M_1 and adult bone collagen data, the South Sector showed lower δ^{13}C and δ^{15}N. Loading vectors for between-group differences for the grave clusters (Fig. 14) further support these inferences, with age-at-death, modeled diets, and grave goods. The South Sector was defined by more *Pottery* and *Riverine Fish*. The Northwest Cluster was discriminated by older radiocarbon dates, *Terrestrial Game*, *Herbivore Bones and Teeth,* and *Knives, Axes, and Blades*. The Southeast Cluster had lower age-at-death and increased grave goods in multiples classes relative to the Northwest Cluster and South Sector.

5. Discussion

The results of paradoxically different analyses in EN Cis-Baikal have yielded a picture of a population of hunter-gatherers that was both living on the edge of survival and thriving. Evidence of adult stature (Temple et al., 2014), limb robusticity (Osipov et al., 2016), paleopathology (Purchase, 2016), enamel hypoplasia (Lieverse et al., 2007; Waters-Rist et al., 2006), and skeletal stress (Lieverse et al., 2013, 2009) all suggest a challenging environment with routine stressors. These studies did not identify any relationship between the stress events and mortality.

The prevalence of stress events severe enough to leave evidence on the skeleton, pathologies, and overall stature consistent with malnourished ethnographic populations contrasts starkly with the presence of formal cemeteries, abundance and complexity of the artifact assemblages, and evidence for social stratification within the mortuary tradition (Bazaliiskii, 2003, 2010; Georgievskaia, 1989; Okladnikov, 1950, 1955; Shepard, 2012; Weber, 1994; Weber, 1995). The former suggests that populations were subsisting in a marginal environment, largely at the whims of opportunity and climate. The latter suggest that this was a sizeable, stable (or expanding) population of effective hunter-gatherers who had adapted to variable and difficult circumstances and developed a degree of hierarchical social organization.

Attempts to parse out specific indicators of wealth or prestige that could relate to labor organization or large-scale subsistence activities failed to identify any clear markers and suggested instead that a broad-spectrum toolkit and subsistence strategy were employed throughout the EN. This is a costly approach to subsistence as each technology employed requires time and materials to produce and maintain

Table 3

Age-at-death (years), sex, radiocarbon date (MeanCalDateBP), Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) bone collagen results for skeletal individuals analyzed, and grave good artifact counts for the Individuals data group. Bone values, Grave Cluster, and Diet Groupings follow Weber et al. (2016a).

Master ID	Sex	Avg. Age Est. (years)	14C Date	d13C	d15N	Stone Projectiles	Knives, axes, blades	Misc. Lithic Tools	Debitage	Shell Ornament	Stone Ornament	Bone Projectile	Bone Fishing Tools	Modified Bone and Misc. Tools	Predator Bones+Teeth	Herbivore Bones+Teeth	Aquatic Bones+Teeth	Bone/Tooth Ornaments	Stone+Bone Sculpture	Composite Fishing	Composite Cutting/Misc.	Pottery	Total
SHA_2002.021.01	M	27.5	7552	-16.4	12.4	0	1	0	1	0	1	3	3	13	3	0	2	2	0	4	3	0	**36**
SHA_2006.066.01	F	30	7531	-17.1	13.6	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	**2**
SHA_2007.073	F	17	7516	-16.5	14.1	0	1	1	3	0	0	0	5	7	0	23	2	1	0	0	7	0	**50**
SHA_2006.058	M	40	7515	-16.8	13.9	2	0	2	0	0	0	2	2	6	0	1	0	0	1	6	1	0	**23**
SHA_2004.034	M	40	7503	-16.6	14.0	1	2	1	1	0	2	1	0	5	0	1	1	0	0	0	0	1	**16**
SHA_2007.085	M	30	7500	-15.6	13.7	0	4	0	6	0	1	0	0	43	0	30	1	0	0	0	0	0	**85**
SHA_2002.021.02	M	27.5	7488	-16.5	14.1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
SHA_2007.088	U	7	7483	-16.6	13.7	0	0	1	2	0	0	0	0	1	1	0	0	0	0	0	5	0	**10**
SHA_2005.041	M	34.5	7478	-16.9	14.1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
SHA_2007.077	F	34.5	7475	-16.7	14.7	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	**4**
SHA_2005.045	M	30	7474	-16.4	13.6	2	2	2	1	0	0	4	1	4	0	0	0	0	0	0	1	0	**17**
SHA_2007.079	F	42.5	7472	-15.2	15.0	0	0	1	2	0	0	0	0	3	0	0	0	0	0	0	0	0	**6**
SHA_2004.029.01	M	25	7469	-16.2	13.3	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
SHA_2006.065	M	50	7469	-16.4	14.4	0	0	0	0	0	0	0	0	0	1	1	0	5	0	0	0	0	**7**
SHA_2007.093.02	F	37.5	7468	-16.4	14.7	0	2	2	0	1	0	0	0	4	0	9	0	0	0	0	0	0	**18**
SHA_2002.021.03	M	17	7445	-15.6	14.4	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**3**
SHA_2005.044.02	M	20	7441	-16.9	14.0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	**3**
SHA_2004.042.02	F	50	7433	-16.4	15.1	0	0	1	2	0	0	0	0	3	0	0	0	0	0	0	4	0	**10**
SHA_2004.033	M	40	7430	-16.4	14.2	1	0	0	1	0	0	1	0	2	0	11	0	0	0	0	1	0	**17**
SHA_2006.061.02	M	40	7421	-15.9	14.3	1	1	0	0	0	3	0	0	1	0	0	0	6	0	0	0	0	**12**
SHA_2007.074	M	19	7421	-16.0	14.5	0	1	0	0	0	0	0	1	3	0	1	0	0	0	0	0	0	**6**
SHA_2002.022.01	M	20.5	7420	-15.9	15.6	2	3	0	2	4	0	4	2	13	2	8	0	2	0	2	2	0	**46**
SHA_2000.010	M	30	7415	-16.8	13.9	0	0	0	0	0	0	0	0	2	1	0	1	0	0	0	0	0	**4**
SHA_1998.004	M	40	7413	-15.9	14.3	0	0	0	2	0	0	1	0	3	0	0	0	0	0	0	0	0	**6**
SHA_2004.039	M	42	7405	-16.4	14.2	0	2	1	1	0	0	0	0	2	4	5	0	0	0	0	0	0	**15**
SHA_2004.032	M	40	7399	-16.1	14.5	1	1	0	1	0	0	0	0	2	0	0	0	0	0	0	0	1	**6**
SHA_2006.069.02	F	22.5	7392	-14.7	14.8	0	1	0	0	3	0	0	0	5	0	7	2	0	0	0	0	0	**18**
SHA_2006.063.02	M	30	7382	-15.0	14.5	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	**2**
SHA_2005.048.01	M	50	7375	-16.4	14.8	0	0	0	0	0	1	0	0	0	0	6	0	2	0	0	2	0	**11**
SHA_2001.017.02	M	21	7370	-14.8	15.4	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	**3**
SHA_2001.017.01	M	35	7368	-15.4	14.7	1	1	4	4	0	1	2	9	16	16	4	0	7	2	22	2	0	**91**
SHA_2007.092	U	11	7367	-15.5	14.4	0	3	1	0	0	0	0	0	0	0	2	0	1	0	0	2	0	**9**
SHA_2007.090	F	19	7363	-15.6	15.5	0	0	3	3	4	0	0	0	7	1	0	0	0	0	0	0	0	**18**
SHA_2007.075	M	27	7357	-16.3	16.1	0	1	0	0	0	0	1	0	1	3	2	0	0	0	7	0	0	**15**
SHA_2005.047	F	22.5	7355	-16.2	15.8	0	0	1	1	0	1	0	0	4	1	2	0	0	0	0	0	0	**10**
SHA_2006.056.02	U	9	7352	-15.7	15.5	1	1	1	5	0	7	0	0	7	8	2	0	11	0	0	3	0	**46**
SHA_2007.076	M	45	7351	-15.8	15.8	0	0	0	0	0	1	0	0	0	0	14	1	0	0	0	0	0	**16**
SHA_2006.069.01	F	27.5	7350	-15.8	14.8	0	0	1	0	5	0	1	0	18	0	6	1	1	0	0	1	0	**34**
SHA_2005.046	M	27	7343	-16.3	16.4	0	1	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	**12**
SHA_2006.054	F	19	7340	-15.2	15.2	0	0	0	0	0	0	0	1	0	0	7	0	2	0	0	0	0	**10**
SHA_2002.024.01	M	30	7337	-15.5	14.9	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	**2**
SHA_2001.014.02	F	22.5	7333	-15.3	15.3	3	1	0	1	0	1	2	0	2	0	4	1	3	0	0	0	0	**18**
SHA_2006.061.01	F	27	7324	-15.0	14.9	0	0	0	0	0	1	0	0	1	0	0	0	3	0	0	1	0	**6**
SHA_2006.071	M	40	7317	-16.3	14.7	0	3	1	5	0	0	0	0	4	1	20	0	2	0	0	0	0	**36**
SHA_2006.070	M	45	7308	-15.8	14.6	1	0	1	0	0	0	0	0	8	0	0	0	0	0	0	6	0	**16**
SHA_2006.068	M	47	7300	-16.0	15.2	1	0	2	0	0	0	0	0	3	0	0	2	0	0	0	0	0	**8**
SHA_2004.051	M	22.5	7288	-16.6	15.1	22	2	16	43	2	4	16	15	23	7	18	4	1	0	19	4	0	**196**
SHA_2006.057.01	F	27	7259	-15.4	16.0	0	0	4	0	0	0	0	0	6	3	6	1	3	0	1	0	0	**24**
SHA_2006.052.01	M	22	7244	-14.7	15.3	3	3	2	3	0	1	1	2	19	2	6	0	19	0	9	3	0	**73**
SHA_2006.059.02	F	17	7214	-17.7	14.2	0	2	10	17	0	0	4	2	28	1	6	6	1	2	1	2	0	**82**
SHA_2001.016	F	22.5	7209	-15.7	15.3	0	1	5	4	0	0	4	6	7	3	7	2	2	0	2	0	0	**43**
SHA_2007.096.02	F	32.5	7196	-16.1	14.3	0	12	15	20	0	0	3	1	14	1	3	4	0	0	0	3	0	**76**
SHA_2006.057.02	F	30	7186	-15.3	15.9	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	**2**
SHA_2006.063.01	M	27	7186	-15.6	15.4	0	1	0	1	0	0	0	0	8	1	2	0	0	0	0	1	0	**14**
SHA_2008.112	M	30	7180	-16.3	15.1	3	5	5	8	0	1	3	3	18	12	10	3	3	0	3	6	0	**83**
SHA_2001.018	M	27	7155	-15.4	16.2	9	1	1	6	1	0	13	1	16	5	2	4	0	1	4	9	0	**73**
SHA_2000.008	M	37.5	7154	-16.8	16.0	1	1	3	4	0	0	4	1	16	8	3	1	0	0	2	2	0	**46**
SHA_2001.015	M	30	7144	-15.3	15.6	7	5	16	40	0	0	11	19	37	3	6	9	0	1	15	11	0	**180**
SHA_2001.014.01	M	27.5	7082	-15.3	16.8	0	1	0	1	0	0	0	0	2	2	3	0	2	1	1	0	0	**13**
SHA_2001.012	M	27.5	7052	-16.2	15.7	0	0	1	1	1	0	1	0	8	1	2	2	0	0	1	0	0	**18**
SHA_2005.049.01	M	18.5	6893	-16.2	13.5	1	1	0	4	0	6	0	1	5	3	0	1	1	0	0	3	0	**26**
SHA_2008.104	F	30	6865	-16.3	13.7	2	1	5	6	1	8	0	0	16	0	2	4	1	0	0	0	0	**46**
SHA_1999.007	F	25	6850	-16.4	13.7	0	1	0	4	0	0	0	0	2	15	1	0	0	0	0	0	0	**23**
SHA_2006.050.01	M	30	6825	-16.5	14.5	0	0	1	2	1	0	1	0	2	0	0	2	0	0	0	1	0	**10**
SHA_2008.108.01	M	42.5	6796	-16.3	14.6	0	4	0	8	0	0	0	2	17	0	2	4	13	0	1	0	3	**54**
SHA_2008.108.03	M	30	6795	-16.3	14.4	0	6	1	3	0	0	0	0	3	0	3	2	20	0	1	0	0	**39**
SHA_2004.030	M	42.5	6792	-16.8	14.1	0	0	1	1	0	0	0	0	4	0	1	0	0	0	0	1	0	**8**
SHA_2005.044.01	M	50	6787	-15.3	15.3	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	**3**
SHA_2004.042.01	F	42.5	6753	-16.7	14.8	0	1	1	4	0	0	2	0	1	1	4	4	0	0	0	2	0	**20**
SHA_2006.064.01	M	34.5	6733	-16.5	14.9	7	6	5	8	2	23	4	2	18	12	4	4	29	0	2	7	0	**133**
SHA_2004.035.01	U	20	6695	-15.3	15.2	0	5	0	5	0	3	1	0	4	1	0	0	1	0	2	0	0	**22**
SHA_1998.006	M	17	6692	-16.2	15.9	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	**3**
SHA_2006.059.01	M	37	6637	-16.0	16.0	2	2	5	3	0	0	5	1	33	5	11	6	2	0	0	4	0	**79**
Grand Total						75	97	125	243	26	67	97	80	519	129	271	79	150	8	105	101	5	2177

Table 4
Age-at-death (years), sex, radiocarbon date (MeanCalDateBP), Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) bone collagen results for skeletal individuals analyzed, and grave good artifact counts for the Subadults data group. Bone values, Grave Cluster, and Diet Groupings follow Weber et al. (2016a).

Master ID	Avg. Age Est. (years)	d13C	d15N	Stone Projectiles	Knives, axes, blades	Misc. Lithic Tools	Debitage	Shell Ornament	Stone Ornament	Bone Projectile	Bone Fishing Tools	Modified Bone and Misc. Tools	Predator Bones+Teeth	Herbivore Bones+Teeth	Aquatic Bones+Teeth	Bone/Tooth Ornaments	Stone+Bone Sculpture	Composite Fishing	Composite Cutting/Misc.	Pottery	Total
SHA_2003.027.0	2.5	-16.3	14.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2003.027.0	0.5	-17.8	16.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2003.028	2.0	-15.1	15.7	0	4	0	1	0	0	1	0	2	0	0	1	5	0	0	0	0	**14**
SHA_2003.031	4.0	-15.5	14.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2003.038	2.5	-16.4	14.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2004.040	0.8	-15.8	16.1	0	0	0	1	0	0	0	0	2	0	0	1	0	0	0	0	1	**5**
SHA_2004.048.0	2.5	-17.2	14.4	0	1.7	0.3	1.3	0.0	2.3	0.0	0.0	3.3	0.7	3.0	0.0	0.0	0.0	1.3	0	0	**14**
SHA_2004.056.0	4.0	-15.5	15.4	1	1	1	5	0	7	0	0	7	8	2	0	11	0	0	3	0	**46**
SHA_2005.061.0	0.5	-15.6	17.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2005.063.0	0.3	-16.3	17.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2005.064.0	9.0	-16.8	14.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2005.066.0	1.125	-17.6	16.9	0	0	0	0.5	0	0	0	0	0.5	0	0	0	0	0	0	0	0	**1**
SHA_2006.069.0	1.125	-14.7	17.9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
SHA_2006.072	1.5	-16.7	15.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2006.080	1.125	-16	16.3	0	0	0	1	0	1	0	0	0	0	4	0	7	0	0	0	0	**13**
SHA_2006.081	0.5	-16.8	14.7	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	**2**
SHA_2006.082	1.5	-18.4	15.3	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	**19**
SHA_2007.087	1.125	-15.8	16.8	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	**11**
SHA_2007.089	2.5	-14.8	15.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2007.091	1.125	-16.8	16.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
SHA_2007.094	3.5	-15.7	13.8	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
SHA_2007.095	1.5	-15.9	15.7	0	1	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	**8**
Grand Total				**1**	**7.7**	**1.3**	**10.8**	**0.0**	**10.3**	**1.0**	**0.0**	**15.8**	**8.7**	**47.0**	**2.0**	**24.0**	**0.0**	**1.3**	**3**	**1**	**135**

additional knowledge to effectively use, and variable, often low, efficiency. More efficient technologies are expected to supplant less efficient technologies to accomplish the same task, especially considering stabilized, or increasing, population densities that require greater subsistence returns. Some details remain elusive to explain the contrasting, or contradictory, evidence for struggles and success in EN Cis-Baikal.

5.1. Shared use of Shamanka II

Outstanding questions about the EN component of Shamanka II include its role as a landmark, indicator of territorial ownership, or potential cultural nexus. Burial demographics indicate that this is not a natural population (Duering et al., *n.d.*). Dietary patterns linked with grave clusters and to a lesser degree artifact distributions, suggest that there were material and behavioral differences between groups making use of the cemetery. The grave architecture may have mirrored differences in life as groups with different foraging ranges employed different subsistence approaches, or simply operated in their own territories with shared access to Shamanka II. All three clusters were initiated during Phase 1, and following a gap of some centuries, continued to be added to throughout Phase 2. Diachronic shifts in grave goods are present in all three clusters, ruling out the possibility that the cemetery's clusters reflect cultural evolution through time.

Mooder et al. (2005) noted biological affinity-related structuring among Kitoi graves at the EN Lokomotiv cemetery in Irkutsk, suggestive of related elites as compared with other sections of the cemetery; the Kitoi mortuary ritual may have been used to denote power, status and community membership. Similar differences between grave goods and spatial clusters at Shamanka II were previously noted (Scharlotta et al., 2016) and supported by this analysis; however, dietary and demographic differences were also important factors. With less clarity in the spatial placement of potentially wealthy or prestigious individuals or markers of "elite" status, the function of, and relationship between, spatial groups at Shamanka II remains unclear.

The overall Kitoi technological and cultural package persisted for several centuries and produced numerous cemeteries through the Angara Valley and southern Lake Baikal. Differential provisioning between groups sharing a cemetery and overlapping foraging ranges suggests that social structure and information resources were variable. The scale at which these groups operated is uncertain. A larger, centralized population separating out into logistical foraging groups over decadal and generational scales could produce groups or lineages of subsistence specialists (e.g., seal hunters), traders, information brokers, or those able to organize clan activities. Such specialists are often evident in mortuary treatment (Chapman et al., 1981; Pearson and Pearson, 1999); however, evidence suggests the persistence of a broad-spectrum technological package, being highly flexible in terms of ability to exploit variable opportunities, at the cost of efficiency. Flexible opportunistic subsistence makes it unlikely that multi-generation specialists were present and differentially rewarded in life or death. Groups making use of the same resources, only in different proportions, are more consistent with multiple smaller independent groups employing their own subsistence priorities or different foraging ranges.

Maintenance of a "high-cost" broad spectrum technological package

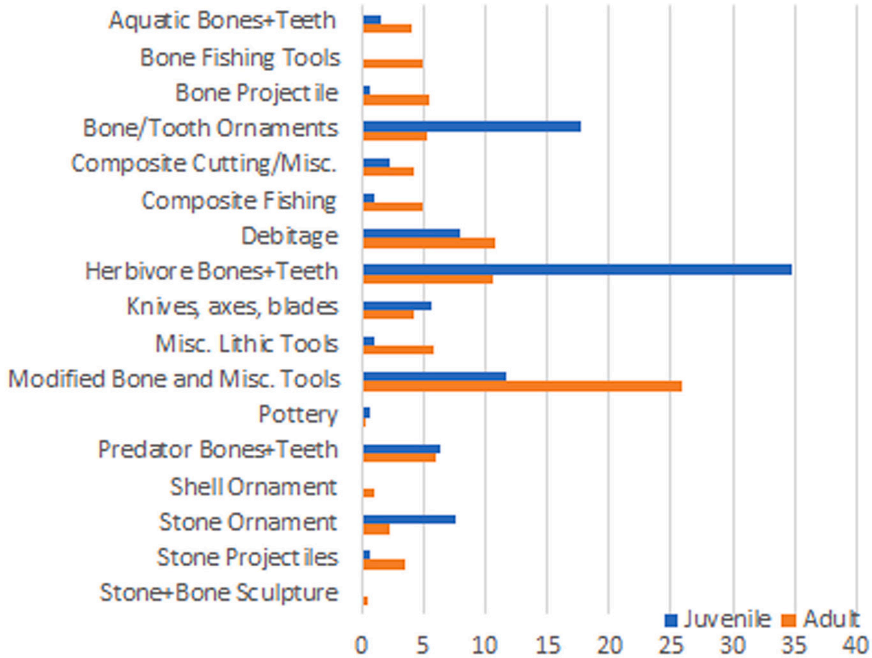

Fig. 3. Comparison of artifact class frequencies between Subadult and Divided Multiple adult graves.

requires greater labor investment in building and maintaining multiple technologies for the same subsistence task (i.e., fishing) along with the training and information upkeep costs (e.g., maintaining knowledge of regional conditions for myriad resources and conditions) (Ugan et al., 2003). If people maintained personal or cached toolkits for varied possibilities, then specialization will only occur at the group scale. Small family groups, as operative sub-groups of a clan likely retained substantial autonomy and may have created tiered allegiances, primarily to the immediate group, and secondarily to the larger clan. Groups with the best information would have advantages in survival.

Ethnographic research supports the importance of clan and family-scale organization including exogamous marriage ties which will influence subsistence and information networks (Anderson, 2019; Czaplicka, 1914; Hitchcock et al., 2011; Ives, 1990; Levin and Potapov, 1964; Lovis and Donahue, 2011; Shirokogoroff, 1933; Whallon, 2006). Clan membership is typically recognized through regular participation in clan-based activities and not limited to blood relations. Family groups identified primarily with clan-membership and retained this identity even when family groups separate out to search for new hunting and foraging territories. This clan-organization and the importance of exogamous marriage creates geographically extended kinship networks that can provide critical landscape and subsistence information, act as a bulwark in difficult times, and can foster trade both through direct material exchange and dowry customs. The process that led to differentiation in mortuary treatment and social stratification within a single clan, or the possible presence of multiple extended family groups, warrants further investigation.

5.2. *Parental investment*

Identifying measures of parental investment in archaeological populations can be challenging. As noted above, some of the subadult burials contain sizeable grave good assemblages. It is possible that the material offerings are reflective of parental investment but do not provide a clear means of discriminating between success and failures of parental investment. Variability in grave good abundance and composition suggests this to be a poor estimate of parental investments. Lactation is energetically expensive and lowers female fertility. Breastfeeding is often regarded as an important marker of parental investment in a child (Dettwyler, 2004; Kaplan, 1996).

Measuring parental investment through breastfeeding alone is challenging in the case of EN hunter-gatherers because of variability in the adult diet. Differences between terrestrial foods and different fish species/environments are large enough that a breastfeeding mother shifting her diet between these resources could mimic isotopic signatures of the weaning process. This type of singular dietary focus for breastfeeding mothers is not anticipated, but also cannot be discounted.

The correlated measure of duration of weaning is used at Shamanka II because it helps to dispel uncertainties about the dietary variability of the breastfeeding mother and clearly represents a period where a combination of breastmilk and solid foods are being provided. While the provisions of breastmilk alone will not meet the growing child's nutritional demands, the decision to continue nursing as a supplement is entirely within the control of the mother.

Compared with other hunter-gatherer studies that include weaning age, stable isotopic, and demographic data (Clayton et al., 2006; Fogel

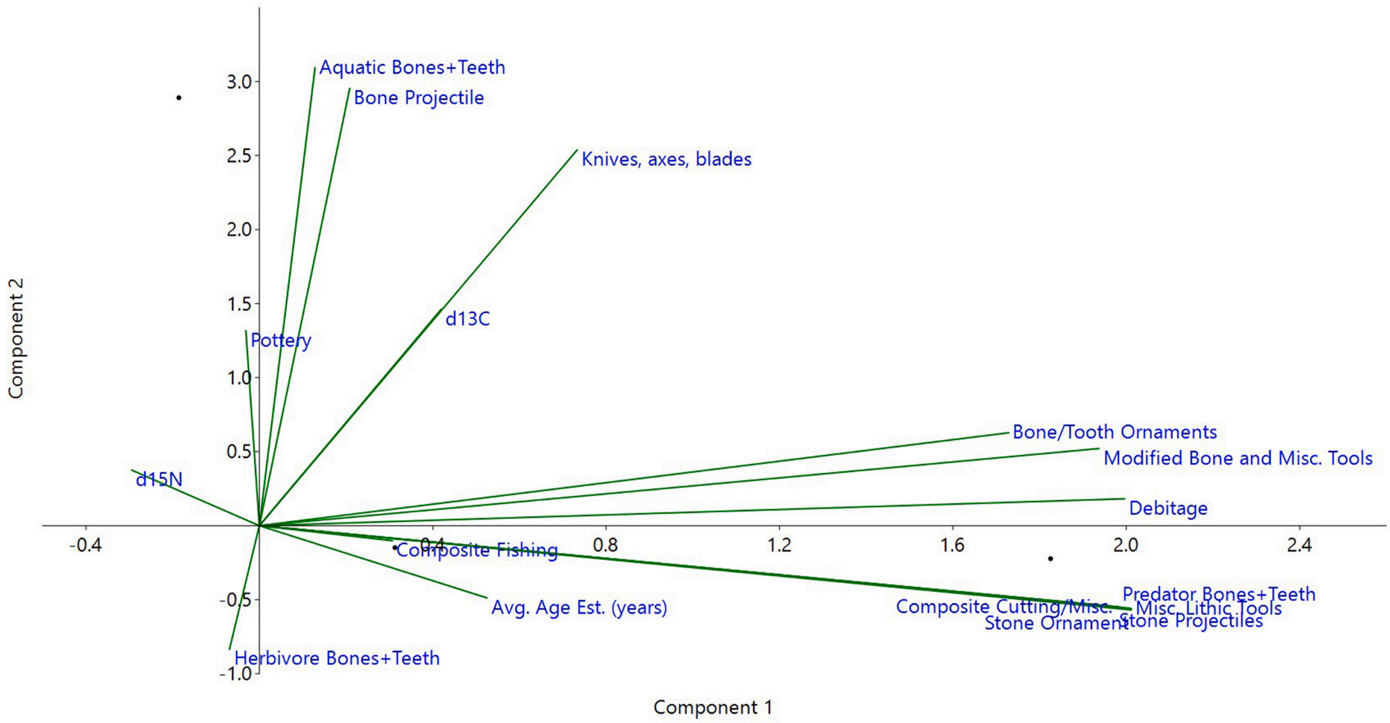

Fig. 4. Principal components analysis (correlation matrix) showing relative variance of grave goods in subadult graves.

et al., 1989; Guraieb et al., 2015; Schurr and Powell, 2005; Tessone et al., 2015), Shamanka II shows a weak correlation between adult diets and age-at-death, or differential survivorship based on the variable weaning ages; yet there is marked variability in weaning patterns (Scharlotta et al., 2016; Scharlotta et al., 2018). Some aspect of social differentiation is therefore inferred to underlay this variation. Social, gendered, or some other cultural categorization underlying social differentiation should have been evident in the material record. Patterning in the material record was thought to relate to weaning and help identify which cultural category benefited from, or required, extended weaning. For example, if prestige goods, or larger numbers of grave goods associated with fishing were interred with individuals who had longer, or

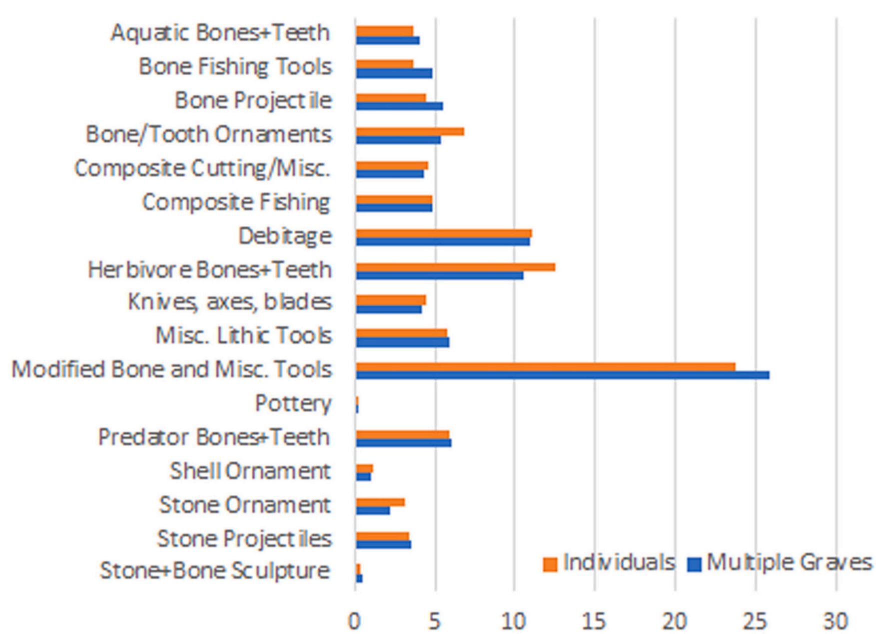

Fig. 5. Comparison of artifact class frequencies between Individual and Divided Multiple adult graves.

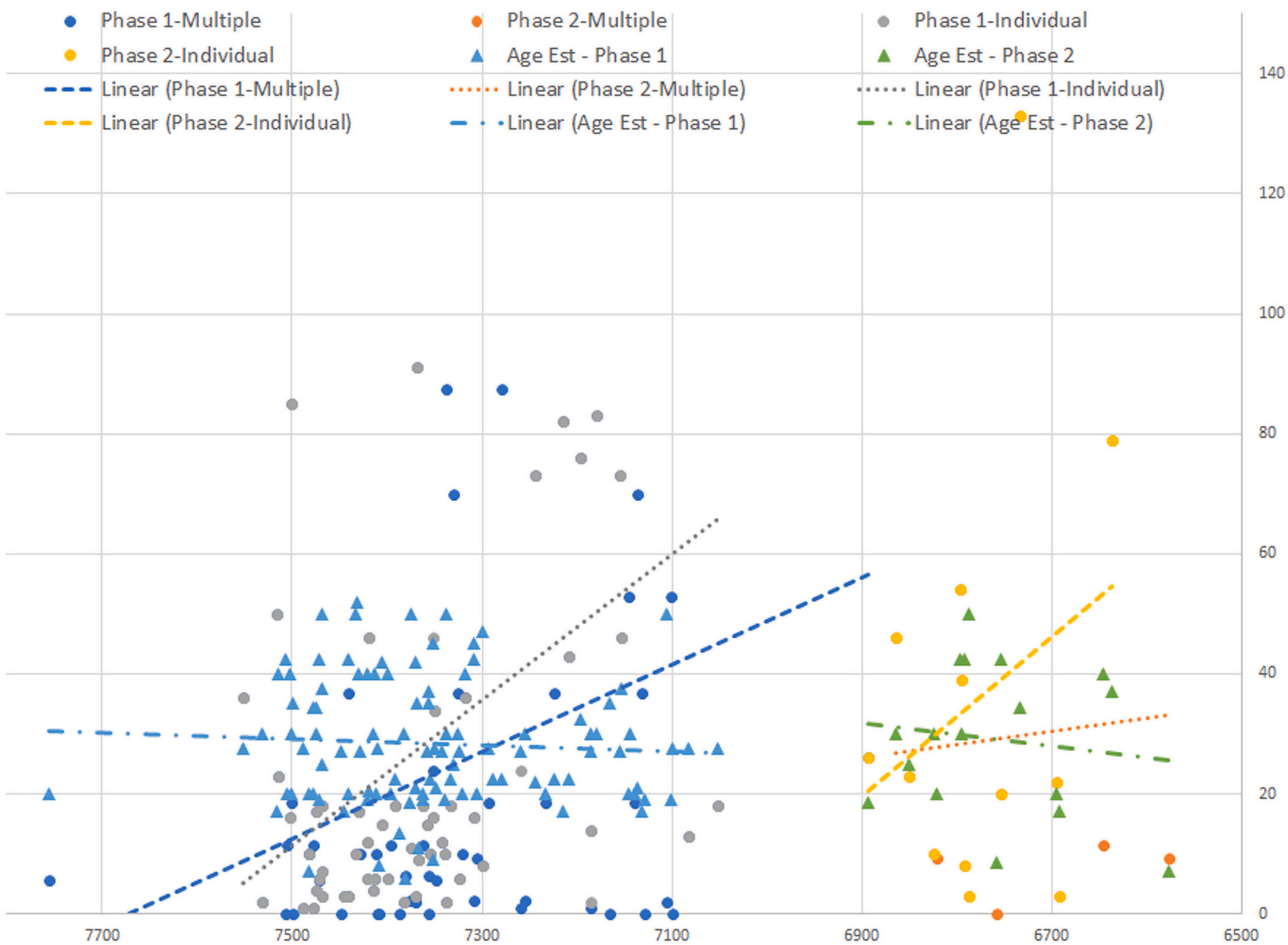

Fig. 6. Total grave goods counts and the average age-at-death during Phases 1 and 2, showing the Individual and Divided Multiples data groups.

shorter weaning durations, then this would suggest that a given social status allowed either earlier or later weaning age. If extrinsic risks are low, then earlier weaning would suggest nutritional stability and extended weaning as a response to nutritional instability. If extrinsic risks are high, the opposite is expected, with later weaning age reflecting mothers who had access to enough nutrition to risk extending breastfeeding without endangering their lives as well. Scharlotta et al. (2018) inferred that extrinsic risks were likely high during EN use of Shamanka II. Although differences in weaning patterns are present, they are not clearly attributable to any single or group or artifact classes.

Social inequality in EN Cis-Baikal was correlated with parental investment in their children through extended breastfeeding above all other apparent divisions in society (e.g., specialist hunters, fishers, tool producers, traders, etc.). Waters-Rist et al. (2011) interpret extended breastfeeding as a strategy to address food shortages, based on analyzing subadult bones for weaning age. The caveat is that these were individuals who died as subadults, and variability in their grave good assemblages could represent age-specific mortuary treatment, or the social status of the individual's parents, rather than the subadult themselves. Weaning ages used in this study represent adults whose incremental dentin from molars was analyzed. Their social status upon death directly reflects their status in life. Individuals with abundant grave goods were breastfed for extended periods of time, though not all individuals benefiting from extended breastmilk were interred with mortuary wealth. Some subsets of society were more successful in caring for their children, and these children went on to be buried with greater mortuary evidence of wealth or prestige.

This may be causative, with individuals from resource-rich groups experienced higher survival rates, or the artifact-richness in mortuary treatment could reflect individual success. This is the case especially in the context of EN Shamanka II where functional artifacts comprise the most unequally distributed artifact classes rather than exotic or labor-intensive artifacts, such as nephrite, generally hypothesized as reflecting wealth or status (e.g., Darwent, 1998; Hayden, 1995, 2001; Hayden and Schulting, 1997; Morin, 2016; Shepard, 2012; Shepard et al., 2016; Weber et al., 2002). Part of the challenge is disaggregating how resource richness could impact descendent generations and whether the appropriate context for EN mortuary treatment is the differential success of individual actions. These actions may be behavioral adaptations to a variable environment or the variable implementation of a broad-spectrum adaption to changing natural and informational environments.

Weaning duration was extended through the EN indicating

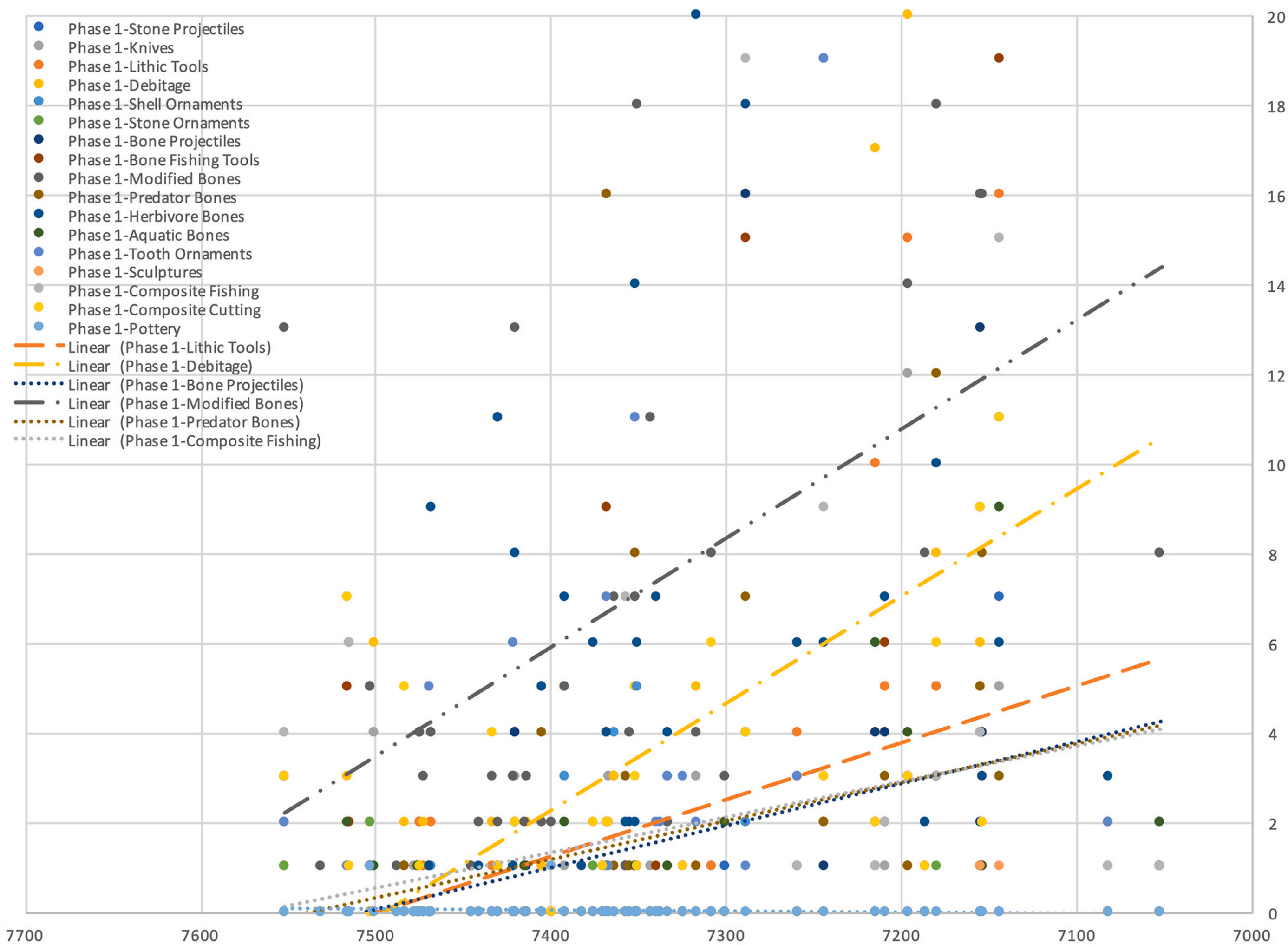

Fig. 7. Frequency distribution of each artifact class during Phase 1, showing the Individual and Divided Multiples data groups. Trend lines for more notable artifact classes.

successful parental investment. Broad-spectrum technological adaptations and periodic nutritional shortfalls evidenced in skeletal stress markers and reduced stature was also maintained, raising the question of *how* parents were capable of investing in their offspring without endangering their own lives. Using a broad-spectrum toolkit is expensive but may be more efficient in a highly unpredictable environment. Having the information on what resources are available at a given time could hold similar importance as specialized hunters pursuing herds of game, or targeting spawning fish runs. The loss of a critical resource (forest patch of Scots pine, or a river targeted for fishing during a specific season) could be disastrous. As a result, the manifestation of information network efficacy may be reflected in dietary patterns.

Information is an interesting resource for hunter-gatherers, tied to kinship, socialization, mobility, trade, and subsistence, yet often regarded as somehow different from other resources (Hitchcock et al., 2011; Ives, 1998; Whallon, 2006). In Cis-Baikal, the broad-spectrum nature of the toolkit and lack of evidence for communal hunting or fishing activities suggest a different role for information. The continued use of cemeteries suggests the presence of a broader community and some type of communal activities. Rather than targeting massed resources (cf. Scharlotta et al., 2016), information on where other groups were foraging and the current conditions of plant and riverine resources likely informed groups about which part of their toolkit to employ, where, and for how long. Resources that are scarce, patchy, low-yield resources such as inner bark and ice-fishing cannot benefit from concentrating labor efforts. Focus on these resources and a flexible toolkit may alter how information is shared and prioritization of subsistence activities.

Large lakes and rivers (e.g., Baikal and the Angara) are often targeted because their resources will be relatively stable and predictable. Variable environments, such as the smaller rivers and taiga, produce patchier resources, so even using the same strategies as peers and previous generations may yield different resource returns. Dietary changes are often examined through the lens of developing intensification, environmental changes, and demographic consequences from subsistence practices surpassing the carrying capacity of the landscape. In this case, dietary changes are smaller scale, with family groups supporting a nursing mother whose decisions impact the entire group.

The effectiveness of parental investment lies primarily in the extrinsic risk factors (predators, resource availability, difficult-to-navigate terrain, and violence) of the environment (Eerkens et al., 2017; Greenwald et al., 2016; Hill, 1993; Quinlan, 2006, 2007; Scharlotta et al., 2018). Environments with high disease loads, probability of

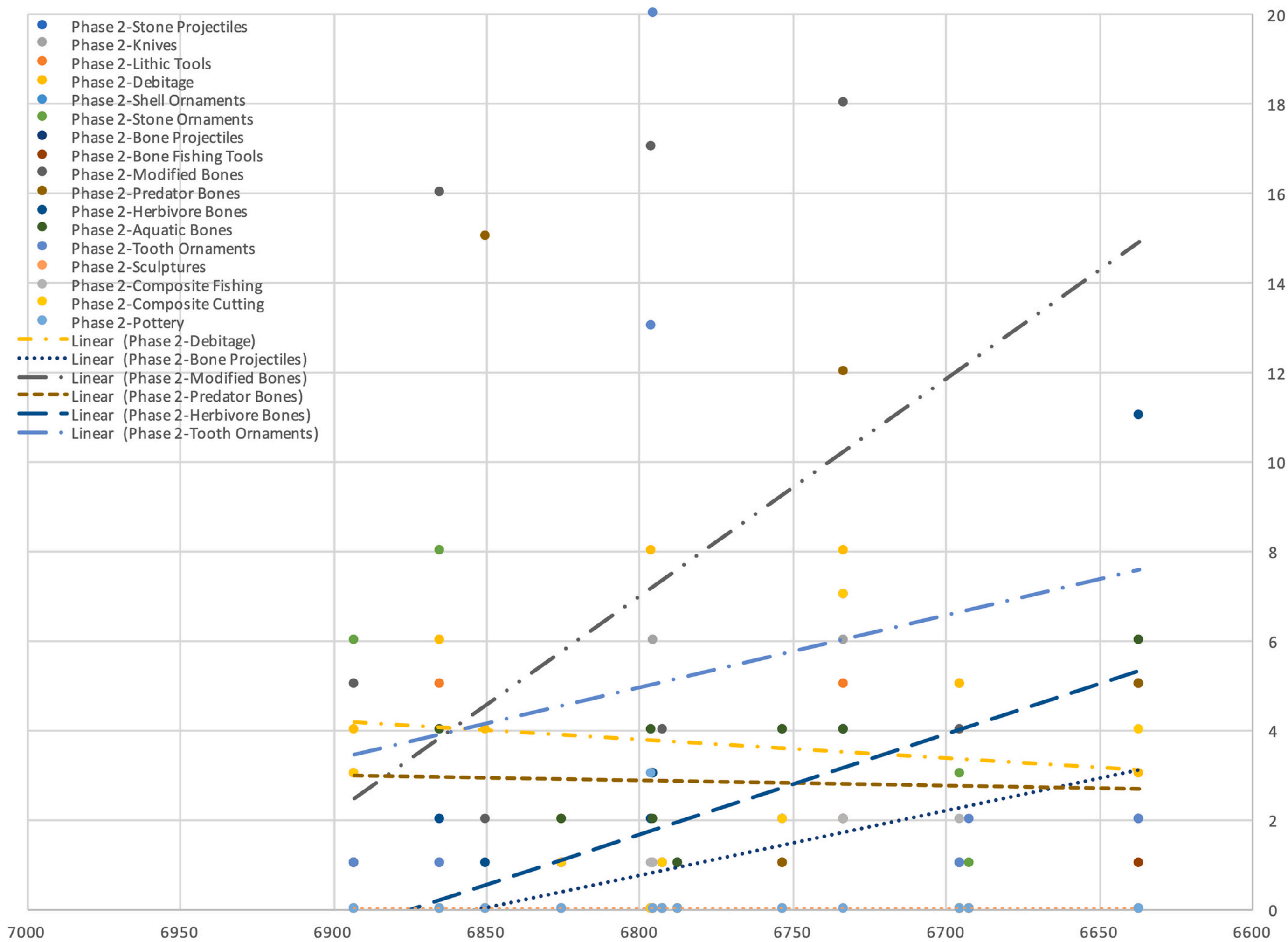

Fig. 8. Frequency distribution of each artifact class during Phase 2, showing the Individual and Divided Multiples data groups. Trend lines for more notable artifact classes.

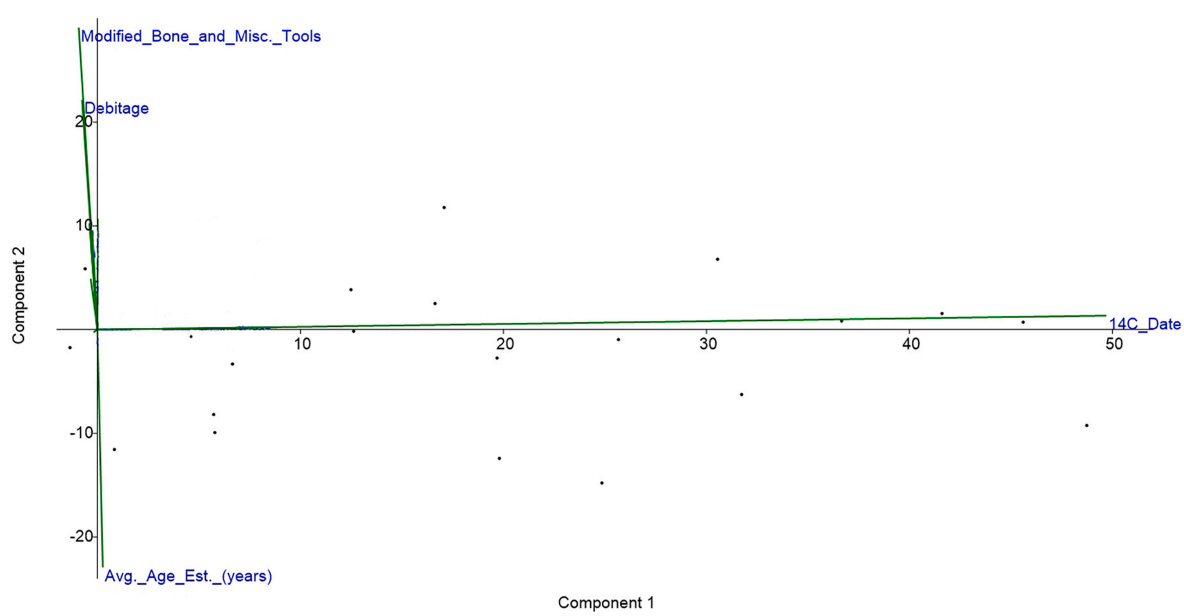

Fig. 9. Principal components analysis (variance-covariance matrix) showing relative variance of grave goods in Phase 1 Divided Multiple graves.

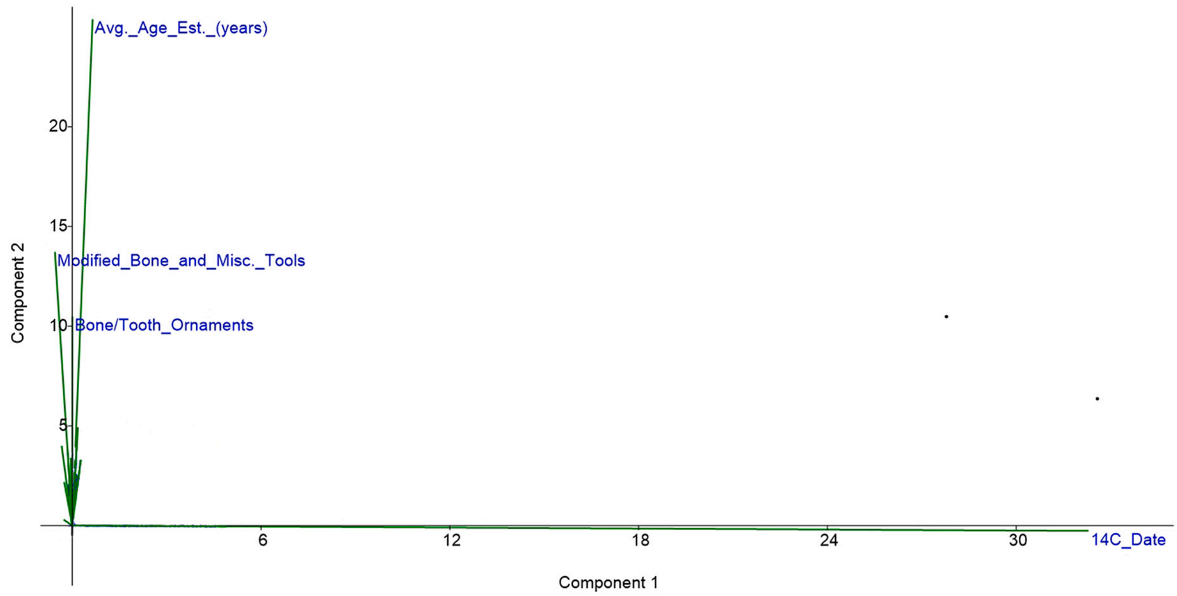

Fig. 10. Principal components analysis (variance-covariance matrix) showing relative variance of grave goods in Phase 2 Divided Multiple graves.

resource shortfall, and difficult terrain have higher mortality rates regardless of whether a mother invests heavily in breastfeeding or not. Child survivorship is similarly insensitive to duration of breastfeeding in environments with low extrinsic risks. Thus, parental investment in high- and low-risk environments will have marginal impacts on a child's chances of survival.

With moderate extrinsic risks, extended breastfeeding will directly improve a child's survival odds. Parents investing calorically in their children may produce stronger offspring who are more resilient during resource shortfalls and outcompete their peers. The degree of parental effort depends on whether environmental hazards can be avoided by increasing parental effort.

The increase in weaning times within and between phases suggests that risk factors and the trade-offs of delaying the next conception are increasing while remaining within the effectiveness of extended weaning to impact survival outcomes. There may have been a threshold where making the same parental investment decisions become detrimental. The next generation would like approach the environment as

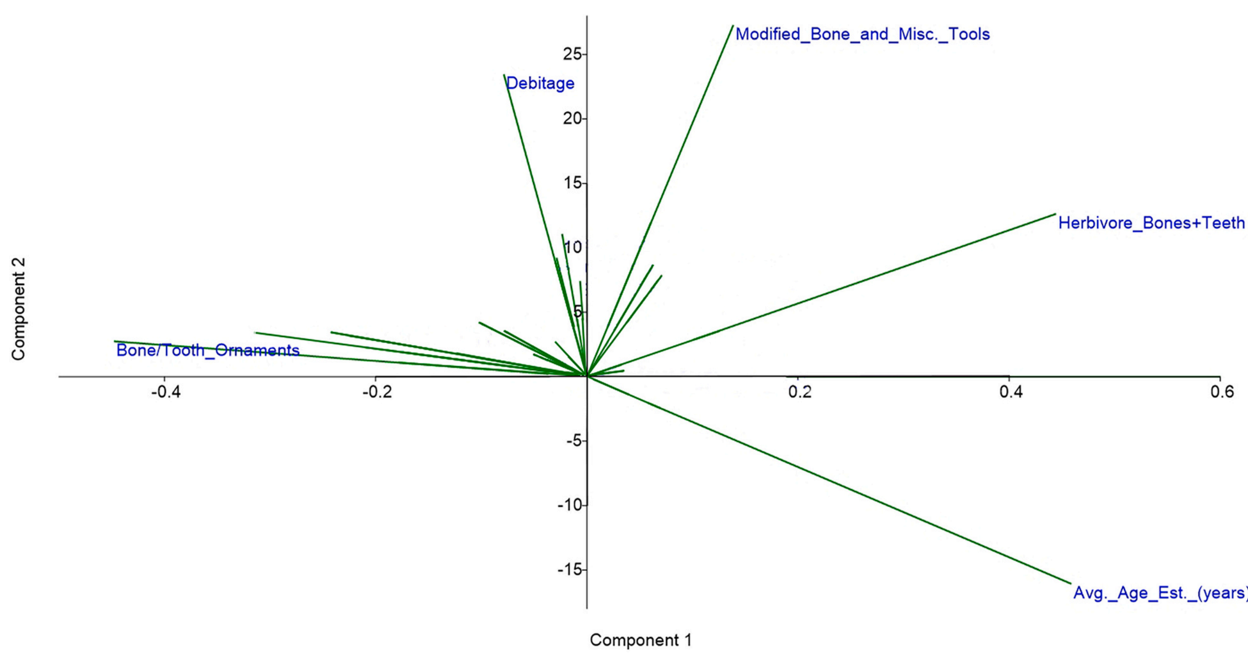

Fig. 11. Principal components analysis (correlation matrix) showing relative variance of grave goods along with weaning duration and age-at-death.

Table 5
Average age-at-death estimates for the Scharlotta et al. (2018) weaning study, as well as the Shamanka II cemetery as a whole, weaning onset and duration, collagen stable isotopic data for post-weaning M_1 and adult bone values along with FRUITS-modeled dietary results following Scharlotta et al. (2021) (this issue).*, †

			Weaning		Post-Weaning M1		Adult Bone		FRUITS Modeled M3 Diet				
	n =	Avg. Age Est. (years)	Beginning of Weaning (yrs)	Length of Weaning Process (yrs)	13C (‰)-PW	15N (‰)-PW	13C (‰)-Bone	15N (‰)-Bone	RiverIrkut	Kultuk BayBaikal	Seal	Terrestrial	Plants
Temporal Group													
Phase 1	20	32.4	0.9	2.4	−16.6	14.5	−16.3	14.4	20.2	19.6	24.0	17.2	18.9
Phase 2	8	28.4	0.9	3.2	−16.8	13.8	−16.4	14.5	19.1	16.7	21.1	19.3	23.8
Cemetery Cluster													
NW	8	32.8	0.8	3.1	−16.4	14.3	−16.4	14.4	19.3	19.5	21.6	19.5	20.2
S	4	37.8	0.9	2.1	−17.3	14.0	−16.8	13.2	22.3	14.9	24.2	17.3	21.3
SE	11	26.6	0.9	3.0	−16.7	14.3	−16.4	14.7	19.3	19.3	23.6	17.0	20.8

* Dietary Data from Scharlotta et al. (this issue), M3 data used where available, M2s substituted where M3 absent and no lingering weaning signature evident.
† Weaning Information, Post-Weaning and Adult Isotopic Data from Scharlotta et al., 2018.

highly risky as opposed to moderately risky.

The decision to extend weaning may not be straightforward and is not taken in a vacuum. Nursing is energetically expensive, bringing inherent risks to the mother (e.g., malnutrition, increased disease susceptibility, reduced ability to travel, hunt, and defend against predators, increased reliance on group members for food, and death). Making the decision to extend nursing suggests that the mother is unlikely to starve based on her decisions. This could reflect an individual ability to forage adequate low-ranked foods, support from the immediate family and close kin, or the entire group's investment in both mother and child by ensuring their provisioning. The danger is in misjudging the risks in a variable environment where part of the risk is having removed the nutritional resilience of the mother who might otherwise have been able to survive a period of shortfall. If a mother continues nursing expecting risk factors to remain moderate and external factors change, then this could inadvertently lead to the death of both mother and child. The reduction in age-at-death during both phases suggests extrinsic risk factors were increasing for the entire population, not just for children. Three groups pursuing different subsistence priorities all experienced an insurmountable hurdle at two points during the EN (~7000 B.P. and

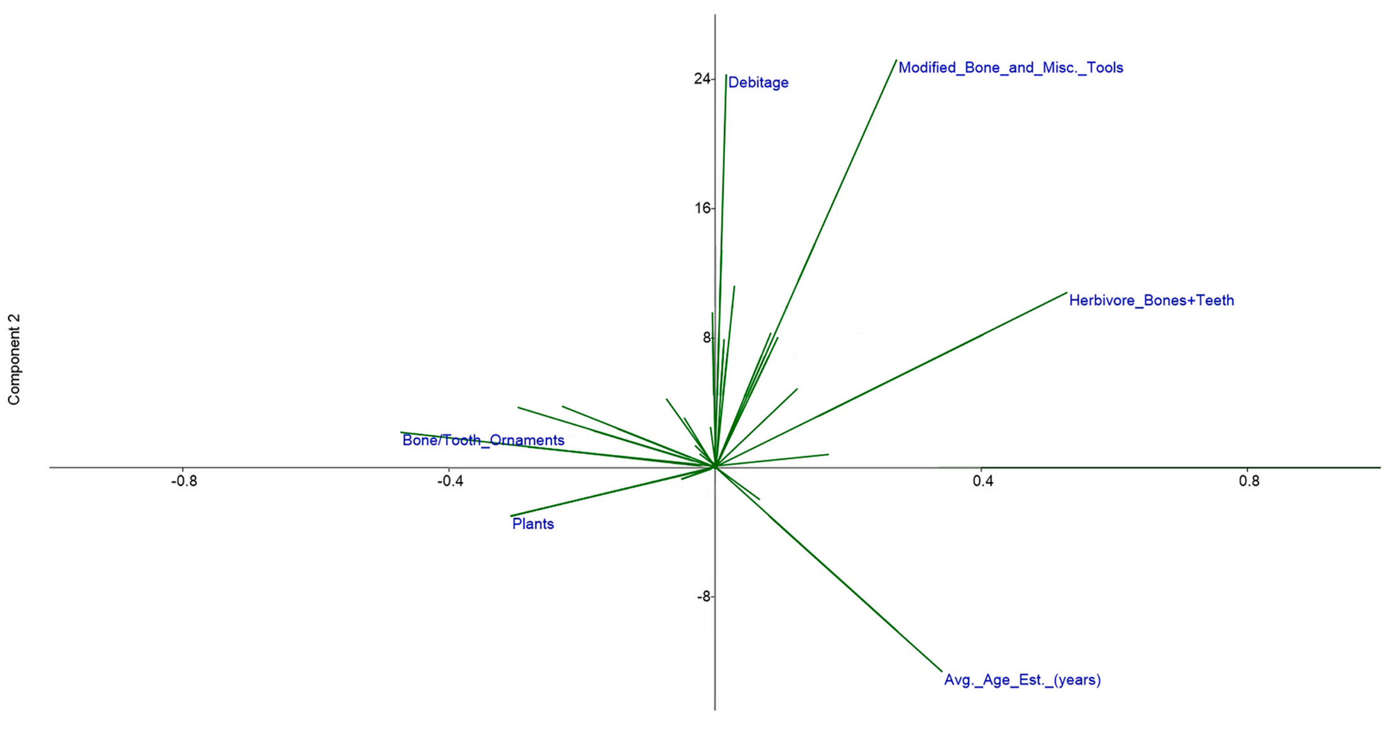

Fig. 12. Principal components analysis (correlation matrix) showing relative variance of grave goods along with weaning duration, age-at-death, and FRUITS dietary groups for cemetery phase-divisions.

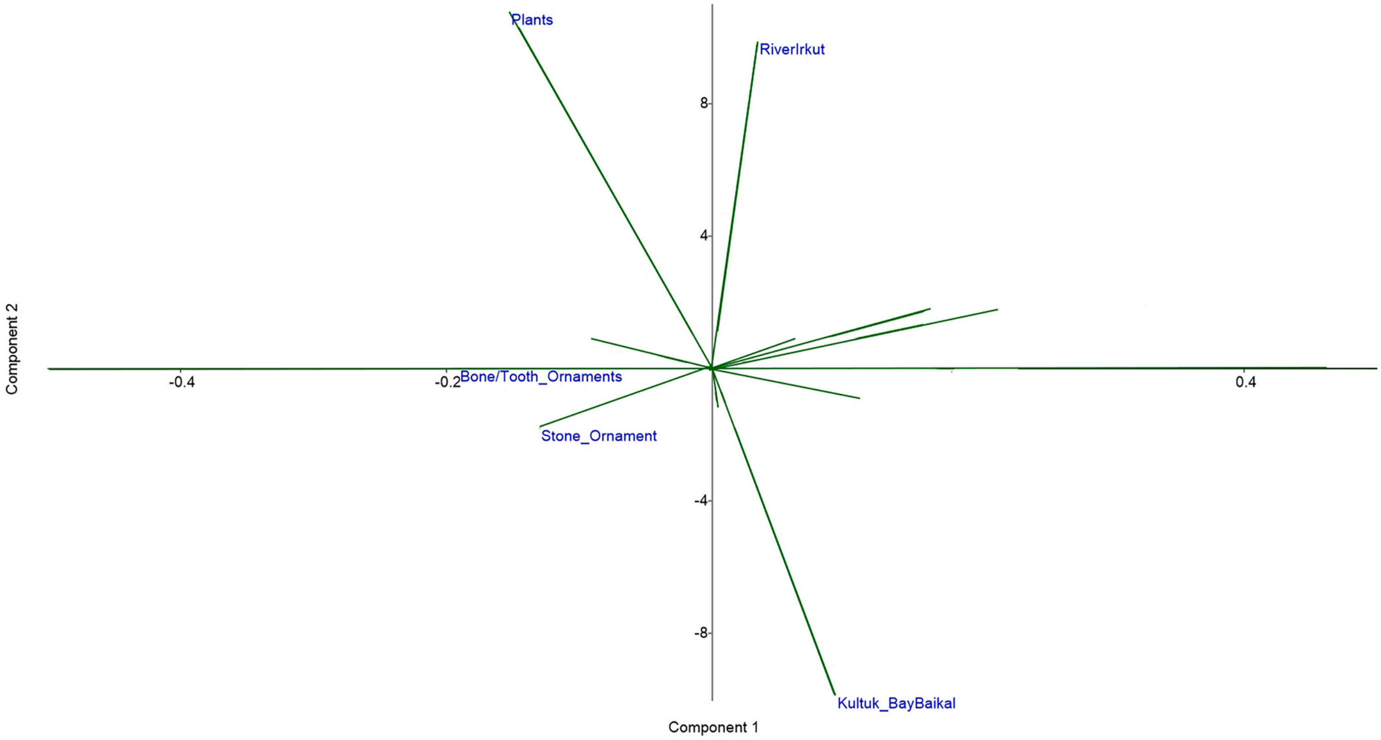

Fig. 13. Principal components analysis (correlation matrix) showing relative variance of grave goods along with weaning duration, age-at-death, and FRUITS dietary groups highlighting between-group differences between cemetery phase-divisions.

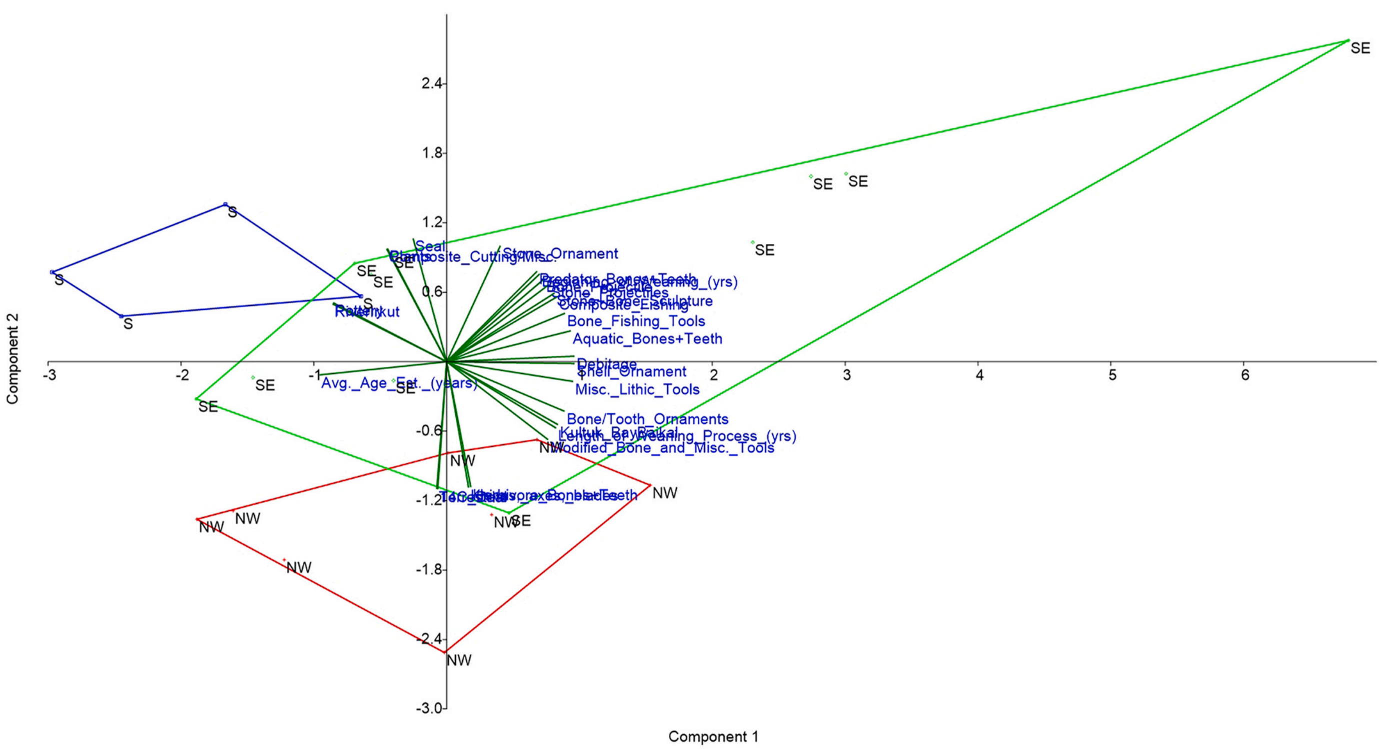

Fig. 14. Principal components analysis (correlation matrix) showing relative variance of grave goods along with weaning duration, age-at-death, and FRUITS dietary groups highlighting between-group differences between cemetery spatial clusters.

6500 B.P.), terminating cemetery phases.

6. Conclusions

Investigations of the underlying behaviors that convert privileged societal standing to different life history outcomes, or social hierarchy denoted by differential access to material goods in life and mortuary treatment in death, suggest that increased parental investment during periods of increasing extrinsic risks was an incipient source of social differentiation and mortuary assemblages. Parents attempting to keep their offspring alive led to a restructuring of subsistence priorities and resulted in social stratification.

Health indicators have shown the Cis-Baikal region to have been nutritionally stressful at times with the simultaneous operation of a subsistence-social network that allowed these extreme events to be survivable. Disparities in grave goods led to research into evidence for intensification on harvesting aquatic resources as the underlying cause for the evolution of hierarchical social organization. Weak evidence for links between dietary differences and various categories of grave goods associated with either status or fishing technologies yielded conclusions of extensification and the intentional maintenance of a "high-cost" broad-spectrum technological package.

Variations in grave good assemblages and frequencies support the increase of functional artifact classes over exotic, labor-intensive, or prestigious classes. Greater material wealth and abundant utilitarian artifacts were correlated with extended weaning periods suggesting that temporal and spatial variability at Shamanka II was the manifestation of individual or family-scale networks of sustenance and information as bulwarks to difficult times. Moderately high extrinsic risk factors produced periodic famines and metabolic stress evidence in skeletons. The small-scale efforts of parents to support their offspring through increased breast milk and plant food provisioning led to a restructuring of subsistence priorities with ramifications for group structuring over the course of centuries.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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