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# Corrigendum to Middle Holocene hunter–gatherers of Cis-Baikal, Eastern Siberia: Combined impacts of the boreal forest, bow-and-arrow, and fishing, Archaeological Research in Asia Volume 24 (2020) 100222

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The author regrets to inform that the entries on the "Subject to intensification" line in Table 6 are incorrect and the correct version of Table 6 has been provided below.

The author apologises for any confusion and inconvenience caused.

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**Table 6**
Comparison between game hunting with bow and fishing.

| Variable | Game hunting with bow | Fishing |
|---|---|---|
| Territory | Larger | Smaller |
| Group mobility | Higher | Lower |
| Returns per capita | Higher | Lower |
| Risk of failure | Higher | Lower |
| Labour investment | Back-loaded | Front-loaded |
| Risk of resource depletion | High | Low |
| Subject to intensification | No | Yes |
| Organization | Individual hunting | Individual (non-intensive) and cooperative (intensive) fishing |

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Full length article

# Middle Holocene hunter–gatherers of Cis-Baikal, Eastern Siberia: Combined impacts of the boreal forest, bow-and-arrow, and fishing

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## 1. Introduction

It will be demonstrated in this paper that the lingering impression of prehistoric boreal hunter–gatherers (HG) as remaining relatively static and marginalized over long periods is, very likely, not quite correct. A few reasons account for this bias. Although the HG archaeological record is rich in evidence for comprehensive and relatively abrupt changes in adaptive strategies, explanatory efforts emphasize two primary drivers: major climatic shifts or competition with food producers. Consequently, explanation of HG cultural change when these two factors are not applicable is rather challenging. The inadequacies of these dominant explanations are particularly apparent when applied to the Holocene HGs of Eurasian boreal settings. The environmental paradigm, i.e., climatic fluctuations of major magnitude such as those documented for the Pleistocene and the Pleistocene–Holocene transition, is insufficient when applied on its own because the Holocene climate was relatively quiescent. The economic paradigm of direct competition with farmers or pastoralists is also only marginally useful because boreal environments have never been friendly to this type of food procurement and food producers expanded into the southern fringes of the boreal forest only late in the Holocene.

The inapplicability of these two explanatory approaches to such settings has created an important gap in the current understanding of Holocene HGs in boreal environments, by far the largest biogeographical zone in Eurasia, though continuously occupied over long periods only during the last 10,000 years after the retreat of the glaciers. Consequently, what drove the processes of culture change is arguably the most fundamental question regarding Holocene HG archaeology of the Eurasian north. This matter has been an overarching objective of the research conducted in the Baikal region of Eastern Siberia by the Baikal Archaeology Project (BAP) since the mid-1990s. The Baikal HG archaeological sequence is unique in that its Middle Holocene portion (Table 1) is dominated by materials from cemeteries (Table 2), a category of archaeological finds rare in most boreal settings. Furthermore, the sequence is unaffected directly by food producers who did not arrive in the area until its end.

The insights generated by BAP are evaluated employing a theoretical perspective derived from human behavioural ecology and cultural evolutionary theory. These related bodies of work, grounded in modern Darwinian evolutionary theory (Lewontin, 1970; Maynard, 1982), have been gaining prominence since the early 1980s through adaptations to human behavioural variation (Sugden, 1986), culture transmission, change, and ethnicity (Boyd and Richerson, 1985), and the like (Kennett and Winterhalder, 2006). The evolutionary program has proven particularly useful in understanding HG subsistence activities, while human behavioural ecology formalized the dynamic interaction between environment and technology, permitting testable predictions about resource choices and aiding in understanding patterns of long-term culture change via the modeling of adaptive strategies (Bettinger, 1991; Kelly, 2013; Smith and Winterhalder, 1992; Winterhalder and Smith, 1981; Winterhalder and Smith, 1992). A recent synthesis of California archaeology provides the most comprehensive application of this approach to past HG culture change (Bettinger, 2015).

The argument for Middle Holocene HG evolutionary history in the Baikal region advanced here is threefold:

- Gradual, perhaps even imperceptible on a generational scale, climate and environmental trends can effect cumulative changes in prehistoric HG adaptive strategies leading, in turn, to tipping points at which rapid system restructuring occurs;
- The overall impact of these gradual climate and environmental changes on HG adaptive strategies depends to a large degree on concurrent technological, economic, and social innovations; and
- Even rather simple environmental settings with limited food options can support rather diverse HG adaptations and complicated evolutionary trajectories.

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**Table 1**
A.P. Okladnikov and current models of Middle Holocene culture history in Cis-Baikal, Siberia [after 1 and 2]. Bold font denotes units in the incorrect chronological position.

| Period | Okladnikov model | Current model |
|---|---|---|
| | Mortuary traditions or groups | |
| Late Mesolithic | Khin | Khin Group |
| Early Neolithic | **Isakovo** | Kitoi, Khin Group |
| Middle Neolithic | **Serovo** | None |
| Late Neolithic | **Kitoi** | Isakovo, Serovo |
| Early Bronze Age | Glazkovo | Glazkovo |
| Late Bronze Age | Shivera | Shivera |

## 2. Recent advances in Cis-Baikal Middle Holocene hunter–gatherer archaeology

BAP was founded around the time when the culture history model developed by A.P. Okladnikov (Okladnikov, 1950; Okladnikov, 1955) collapsed under the weight of the radiocarbon evidence (Konopatskii, 1982; Mamonova and Sulerzhitskii, 1989; Weber, 1995; Weber et al., 2002; Weber et al., 2006). Three out of the four Middle Holocene mortuary traditions with good archaeological visibility (i.e., Isakovo, Serovo, Kitoi, and Glazkovo) occupied incorrect chronological positions in the model (Table 1). Furthermore, the Okladnikov sequence was continuous while the new sequence shows a long gap between the Early Neolithic (EN) and Late Neolithic (LN) mortuary traditions. Since the Okladnikov model guided archaeological research in Cis-Baikal for half a century its collapse created much confusion, well reflected in publications dating as late as the 2000s (e.g., Aseev, 2003).

This development, however, also created a “clean slate” for BAP research. In order to document afresh the spatio-temporal variation in Cis-Baikal Middle Holocene HG strategies, the focus from the very beginning was on the examination of human skeletal materials using a range of bioarchaeological methods and employing the individual life history approach (Zvelebil and Weber, 2013). Examination of ~700 individuals revealed a large number of new insights with regard to diet, subsistence, genetic structure, population size and distribution, number and size of cemeteries, health and activity patterns, individual mobility and migrations, mortuary protocols, socio-political differentiation, and inter- and intra-microregional variation (Weber et al., 2016; Weber et al., 2002; Bazaliiskii, 2010; Bazaliiskiy and Savelyev, 2003; Bronk Ramsey et al., 2014; Faccia et al., 2016; Faccia et al., 2014; Haverkort et al., 2008; Katzenberg et al., 2009; Katzenberg et al., 2012; Katzenberg and Weber, 1999; Lam, 1994; Lieverse et al., 2011; Lieverse et al., 2009; Lieverse et al., 2013; Lieverse et al., 2007; Lieverse et al., 2007; Lieverse et al., 2015; Lieverse, 2010; Lieverse et al., 2008; Lieverse et al., 2016; Lieverse et al., 2014; Lieverse et al., 2017; Lieverse et al., 2014; Link, 1999; Losey et al., 2008; Mooder et al., 2005; Mooder et al., 2006; Moussa et al., 2018; Nomokonova et al., 2013; Osipov et al., 2016; Scharlotta et al., 2016; Scharlotta et al., 2013; Scharlotta and Weber, 2014; Schulting et al., 2015; Schulting et al., 2014; Shepard et al., 2016; Temple et al., 2014; Waters-Rist et al., 2016; Waters-Rist et al., 2010; Waters-Rist et al., 2011; Waters-Rist, 2012; Waters-Rist et al., 2014; Weber et al., 2010; Weber and Bettinger, 2010; Weber and Goriunova, 2013; Weber et al., 2017; Weber et al., 2016; Weber et al., 2011; White et al., 2020; Goriunova et al., 2020; Weber et al., 2020; Bronk Ramsey et al., 2020; Goriunova et al., 2020; Waters-Rist et al., 2020; White et al., 2021; Osipov et al., 2020; Moussa et al., 2020; Temple and Lieverse, 2020). The most intriguing aspect of this variation is that the EN HG system appears to show more structural and spatial diversity than subsequent systems. Recently, this new knowledge has acquired fresh meaning due to the following developments:

**First**, we addressed the problem of direct radiocarbon dating of human skeletal remains by developing equations to correct the effect of old carbon, which transferred to the skeletons of Baikal HGs via the consumption of aquatic foods (Bronk Ramsey et al., 2014; Nomokonova et al., 2013; Schulting et al., 2015; Schulting et al., 2014; Schulting et al., 2020). Applying this method first to ~310 and then to 560 directly dated individuals, we revised the Middle Holocene culture history of the region, tied it more closely to climate history, examined chronological structure—in chronometric and relative terms—of many cemeteries including a few larger ones, and identified previously unknown dietary trends exhibited by Cis-Baikal HGs (Weber et al., 2016; Weber and Goriunova, 2013; Weber et al., 2017; Weber et al., 2016; Weber et al., 2020; Bronk Ramsey et al., 2020).

Second, assessment of faunal remains from several camp-sites hinted at a gradual transition from hunting large game (red deer) to hunting medium game (roe deer) and fishing, a trend consistent with the results from stable isotope analyses on human bones (Weber et al., 2016; Weber et al., 2016; Weber et al., 2020; Losey and Nomokonova, 2017a).

And third, chronological examination of several cemeteries uncovered variation in what was initially assumed to be a continuous pattern of cemetery usage: some indeed seem to have been used continuously, but others only sporadically, and some show long periods of disuse (Weber et al., 2016; Weber et al., 2016; Bronk Ramsey et al., 2020). Evidence has likewise been found for variation in the timing and duration of cemetery use.

The above describes Cis-Baikal Middle Holocene HGs as far from static, monolithic, or marginal to the shaping of their own destiny. These groups display degrees of spatio-temporal variation in many aspects of their adaptive strategies rarely seen not only in the boreal world but in other environmental settings too. Importantly, these results allow us to see changes in HG behaviour not only at period boundaries but also within periods. The new insights show that Cis-Baikal HGs experienced periods of continuity and discontinuity as well as stability and change. Some changes were gradual, some rapid, but together resulting in several important transitions:

Transition 1: Formation of the Late Mesolithic (LM) cultural pattern with incipient cemeteries and undifferentiated mortuary protocols around *8630* [1] *calibrated years before present* (*cal. BP)*;
Transition 2: Replacement of the LM system on the Angara and in Southwest Baikal by the EN Kitoi pattern with its large cemeteries around *7560 cal. BP*;
Transition 3: Collapse of the Kitoi by *6660 cal. BP* followed by establishment of the MN pattern with no cemeteries;
Transition 4: Re-appearance of cemeteries around *6050 cal. BP*, or somewhat earlier, and the formation of the LN pattern;
Transition 5: Establishment of the EBA system around *4970 cal. BP*; and lastly
Transition 6: The end of the EBA socio-economic pattern by *3470 cal. BP*.

Fresh assessment of this variation and the patterns of temporal change is the primary objective of this paper, paying attention to the following questions:

- Why did all these cultural transitions happen when they did, and not earlier or later?
- What kind of barriers—environmental or cultural—affected the spatial distribution of the different HG patterns across Cis-Baikal?
- What was the significance of the undifferentiated LM mortuary practices?

[1] By convention, the dates presented in italics are modelled, all other dates are not. Detailed information on Bayesian analysis and modelling of radiocarbon dates is provided in a separate paper included in this special issue (Weber et al., 2020).

**Table 2**
Geographic and cultural distribution of Cis-Baikal Middle Holocene cemeteries documented archaeologically. In cases where more than one mortuary tradition was represented at a given location, each was counted as a separate cemetery.

| Period & mortuary | Category | Microregion | | | | |
|---|---|---|---|---|---|---|
| tradition or group | | Angara | Baikal SW | Upper Lena | Little Sea | Total |
| Late Mesolithic to | Cemeteries | 6 | | 6 | 10 | 22 |
| Early Neolithic, Khin | Graves | 8 | | 12 | 38 | 58 |
| | Individuals | 8 | | 14 | 44 | 66 |
| Early Neolithic | Cemeteries | 13 | 1 | | | 14 |
| Kitoi | Graves | 147 | 99 | | | 246 |
| | Individuals | 215 | 159 | | | 374 |
| Middle Neolithic | | Lack of documented formal cemeteries | | | | |
| Late Neolithic | Cemeteries | 23 | | 1 | | 24 |
| Isakovo | Graves | 94 | | 1 | | 95 |
| | Individuals | 124 | | 1 | | 125 |
| Late Neolithic | Cemeteries | 4 | | 5 | 10 | 19 |
| Serovo | Graves | 19 | | 30 | 42 | 91 |
| | Individuals | 20 | | 51 | 70 | 141 |
| Early Bronze Age | Cemeteries | 47 | 1 | 12 | 16 | 76 |
| Glazkovo | Graves | 193 | 12 | 65 | 200 | 470 |
| | Individuals | 211 | 14 | 77 | 230 | 532 |
| Total | Cemeteries | 93 | 2 | 24 | 36 | 155 |
| | Graves | 461 | 111 | 108 | 280 | 960 |
| | Individuals | 578 | 173 | 143 | 344 | 1238 |

- What was the significance of the MN break in the use of formal cemeteries?

The proposed evolutionary approach is especially well suited to this exercise because evolutionary forces act at different levels: from artifact to pan-regional techno-complex, from individual to population, and from decades to millennia. New methods and findings make assessment of these different scales possible, while the evolutionary framework offers the most promising avenue to understanding the cumulative patterns of culture change.

## 3. Environment

Since several good recent accounts of the modern environment and climate in Cis-Baikal, as relevant to HG archaeology, already exist [e.g., 18, 64, Fraser-Shapiro, 2012; Losey and Nomokonova, 2017b; Mckenzie, 2006; Nomokonova, 2011; Weber, 2003; White, 2006, and further references therein], only the most important points will be mentioned here.

Cis-Baikal (the area of about 200,000–250,000 km$^2$ immediately west of Lake Baikal—between its northwest coast and Ust'-Ilimsk on the Angara; Fig. 1) features a markedly continental climate with Bailey's effective temperatures consistently around 11°C (Bailey, 1960; Breken, 1966). Topography, geology, hydrography, precipitation, vegetation, and terrestrial and aquatic fauna are all variable across the region. These, in combination with archaeological criteria, define four main microregions: (1) The Angara River Valley; (2) The Upper Lena River Valley; (3) The Little Sea (or Ol'khon) area; and (4) Southwest Baikal (Fig. 2). Of these, the Little Sea stands out due to its aridity, with annual precipitation of only 160–190 mm, roughly less than a half of what the other microregions receive (Kozhov, 1963; Breken, 1968).

With the exception of the four archaeological microregions, which all feature at least some open landscapes (steppe and forest-steppe), the region is covered by thick taiga. Historically, only the Angara and the Upper Lena have been connected by a stretch of open landscape along the Kuda and Manzurka rivers. The distribution and abundance of terrestrial game varies with vegetation (Shvetsov et al., 1984), and more precisely with the balance between boreal forest on the one side and open landscape (forest-steppe and steppe) on the other. Red and roe deer favour open and ecotonal landscapes and thus are available in all microregions, while moose, boar, and musk deer prefer more densely forested parts. Red deer and roe deer form large herds and are migratory whereas the boreal forest moose and musk-deer are not and are solitary. The boar either forms small sounders or is solitary. The aridity of the Little Sea would have made its red and roe deer smaller in body size and probably less abundant than in places with more precipitation. Hare and marmot are small game potentially also available for hunting but their diminutive size, like the musk-deer, would not make them high rank game. Ethnographically confirmed plant foods include pine nuts, inner bark (pine, birch or willow), young shoots and buds, roots, bulbs (onion, garlic, Siberian lily, and Martagon lily), berries, mushrooms, moss, lichen, etc., most available seasonally (Okladnikov, 1950; Okladnikov, 1955).

Although fish are available in all four microregions, the fisheries differ much in abundance, diversity, accessibility, and reliability (Table 3). Historically, the Angara fishery has been very rich and diverse, much more so than its large western tributaries (Irkut, Kitoi, and Belaia) and an order of magnitude more abundant than the Upper Lena (Kozhov, 1950). The Baikal fishery has been diverse overall with several distinct habitats each preferred by a different assortment of fishes (Kozhov, 1963; Kozhov, 1972). The Little Sea fishery is patchy in distribution, with a number of shallow and quiet coves in the south end, most separated from one another by stretches of inaccessible cliffs. In contrast, the Kultuk Bay fishery in Southwest Baikal, with an open coastline and direct access to the shallows running uninterrupted for about 15–20 km, is linear and thus similar to the riverine fisheries although not nearly as stretched out. It is safe to assume inter-annual variability in fish abundance would be higher in the small coves and rivers, due to their lower species diversity, compared to the more diverse fisheries in large rivers and expansive shallows. The Baikal seal is another aquatic resource available from the lake, but also of seasonally limited HG procurement to late winter and early spring.

In sum, the Middle Holocene HGs in Cis-Baikal would not have had that many food choices. Large and medium game (moose, red deer, roe deer, and boar) would have been the primary choice, small game (musk deer, hare, and marmot) would have been less important, and fish would be a viable option too. Due to their narrow seasonal availability, scarcity, or low caloric content, plant foods and Baikal seal are expected to have been minor dietary elements.

## 4. Main factors of Middle Holocene hunter–gatherer culture change in Cis-Baikal

The evolutionary approach to explaining Middle Holocene


**Fig. 1.** Eastern Siberia and the Baikal region.

hunter–gatherer culture change in Cis-Baikal requires that environmental and cultural factors (e.g., technology, subsistence, demography, and social organization) are examined from the perspective of the costs, benefits, and risks involved in the actions taken by these people. Of particular interest are the interactions between factors that produce gradual changes in HG behaviour, the accumulation of which can lead, in turn, to rapid shifts in adaptive strategies. A good place to begin is to assess the effects of changes in the distribution of the boreal forest, technological innovations, and intensification of fishing, as well as their combined impacts on subsistence and social structure.

### *4.1. Distribution of the boreal forest*

The changes in the distribution of the boreal forest during the Holocene are singularly important because they control the distribution of terrestrial game, the most critical resource for all inland North Eurasian HGs. Large, medium, and to some extent small game provide not only food but also hides and furs for clothes and shelter, as well as bone, antler, and sinew to make a range of essential tools, weapons, utensils, and ornaments. That Cis-Baikal offers only a few species of large and medium game underscores the importance of this resource. In this regard, the Baikal seal, with its short limbs and seasonally restricted accessibility, would not be a practical substitution for the resources provided by red and roe deer and moose. Seal meat could be stored, however, and the fur would likely have been quite useful.

Following the dynamic climatic oscillations associated with the Pleistocene–Holocene transition, Siberia experienced a long trend towards warmer temperatures and increased precipitation. On a subcontinental scale the boreal forest expanded from a relatively narrow zone at the end of the Late Pleistocene, replacing tundra to the north and steppe to the south (Khotinskii, 1984a; Khotinskii, 1984b). In places with complex topography, such as Eastern Siberia, the southward expansion of the boreal forest also took on longitudinal and altitudinal dimensions. In Cis-Baikal, additional variation to forest distribution was related to the size and volume of Lake Baikal acting as a barrier to both the southeast Asian monsoon and North Atlantic weather and climate impacts.

The expansion of coniferous forests in Cis-Baikal, already well on its way around 9500 cal. BP, reached its maximum extent around 7000–6500 cal. BP. It was associated with thicker and longer-lasting snow cover, resulting in generally deteriorating conditions for HG game hunting (Bezrukova et al., 2014; Bezrukova et al., 2013; Tarasov et al., 2015; White and Bush, 2010; Kobe et al., 2020). What was initially, very likely, a vast expanse of open landscape connecting all different areas of Cis-Baikal and beyond, turned at the time of maximum forest distribution into small patches isolated from one another by dense taiga. From 7000–6500 cal. BP the climate stabilized and then, slowly, the trend began to reverse. Gradually drier and cooler conditions across the region meant thinner snow cover and shrinking forests. Such an environment was potentially able to support larger deer populations which, particularly in places with forest-steppe and steppe landscape, were also much easier to procure. This trend ended ~3000 cal. BP when the modern climatic regime was established (Bezrukova et al., 2013; Tarasov et al., 2015; White and Bush, 2010; Kobe et al., 2020). Patches of open landscape expanded again, though never to their Preboreal distribution. This scenario is a product of work on environmental proxies with large catchment (e.g., Lake Baikal cores) and variation in local conditions and timing is expected although not yet well documented (Bezrukova et al., 2013; Kobe et al., 2020).

In the Cis-Baikal region, the four archaeological microregions would likely have been the areas into which the boreal forest expanded last and from which it retreated first. However, good empirical data on this matter are lacking. The greater ecological diversity of these ecotones would have been particularly attractive to HG groups although, with the forests closing in, the forest–steppe ecotone would have been shrinking too. All these points emphasize the importance of changes in vegetation distribution for understanding of the history of Cis-Baikal Middle Holocene HG groups. It is this shifting balance between open and forest landscapes that likely should be considered the stage for all cultural events to unfold.

The history of the boreal forest in Cis-Baikal is also important because, following the principle of ideal free distribution (IFD) (Fretwell,

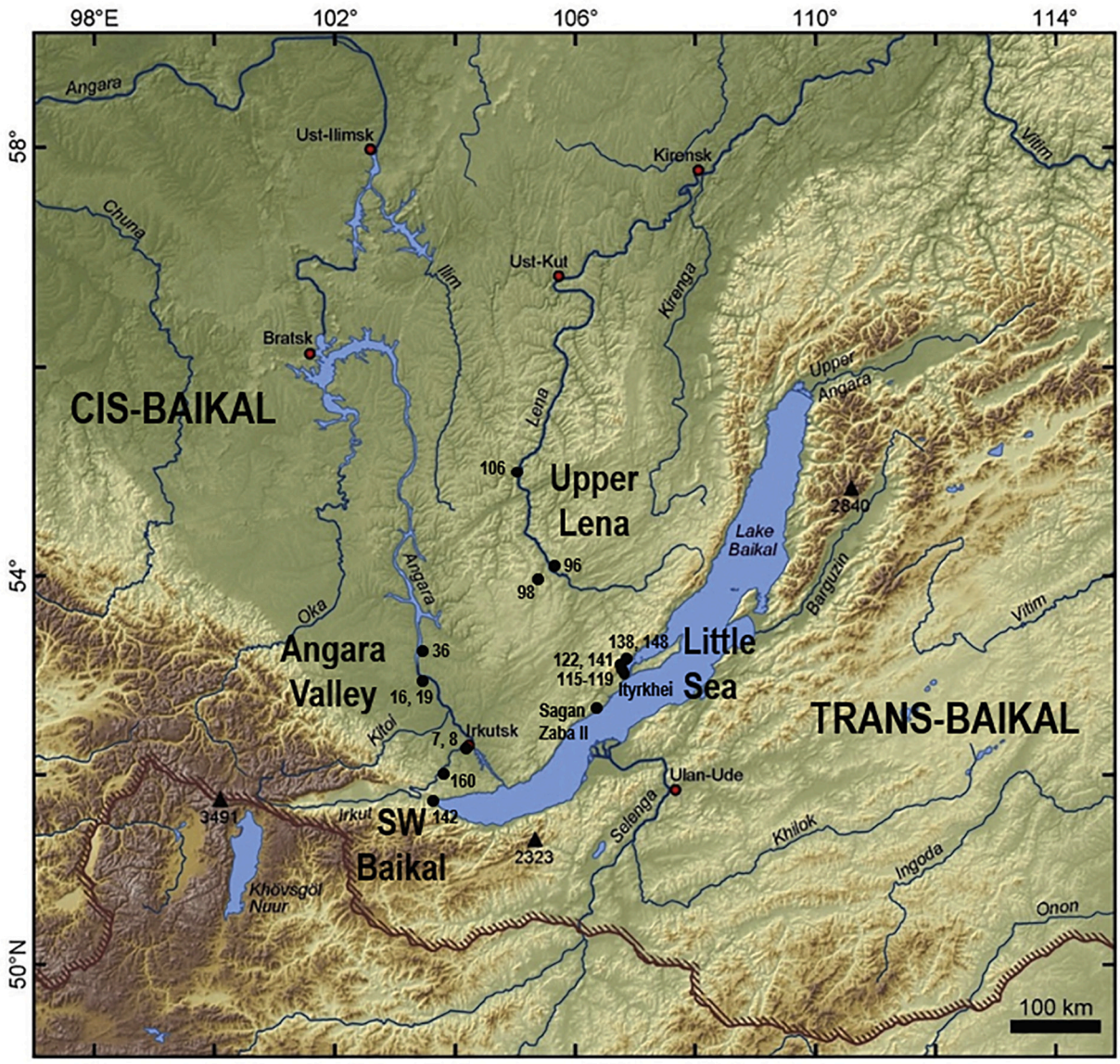


**Fig. 2.** Cis-Baikal, micro-regions, and main archaeological sites mentioned in the paper.
Angara Valley: 8–Lokomotiv, 14–Kitoi, 19–Ust'-Belaia, 16–Galashikha, 60–Serovo, 36–Ust'-Ida I, 160–Moty-Novaia Shamanka
Southwest Baikal: 142–Shamanka II
Little Sea: Ityrkhei, 141–Khuzhir-Nuge XIV, 148–Khadarta IV, Sagan–Zaba II
Upper Lena: 96–Verkholensk, 98–Obkhoi

1972), it is expected that the dispersal of HG groups across the landscape would generally reflect the distribution of available food resources. It is also expected that HG settlement patterns and movement across the landscape would tend to maximize procurement of the most important food source. For example, although the Hadza of eastern Africa depend on plant foods for ~65% of their subsistence, they still

**Table 3**
Cis-Baikal fisheries based on data published by M.M. Kozhov (Kozhov, 1950), summarized first by Weber and Bettinger (Weber and Bettinger, 2010) and modified further for this table. Data assembled by Kozhov are useful because they predate construction of the three hydroelectric power dams on the Angara River (Irkutsk, Bratsk, and Ilimsk), which effectively destroyed its fishery.

| River section | Section length [km] | Fish [kg/year] | Fish [kg/km/year] | References |
|---|---|---|---|---|
| | | Angara | | |
| Angara Section 1 (Baikal–Irkut) | 71 | 200,000 | 2817 | Kozhov 1950: 46 |
| Angara Section 2 (Irkut–Bratsk) | 680 | 500,000 | 735 | Kozhov 1950: 49 |
| Angara Section 3 (Bratsk–Ilim) | 240 | 700,000 | 2917 | Kozhov 1950: 51 |
| Angara, Baikal to Belaia | 148 | 400,000 | 2703 | |
| | | Lena | | |
| Lena (source to Vitim) | 1300 | 297,100 | 229 | Kozhov 1950: 84–85 |
| Lena (~Anga to Zhigalovo) | 160 | 18,300 | 114 | |

**Table 4**
Summary of climate and environmental history for northern Eurasia (Walker et al., 2009; Walker et al., 2012) and the Baikal region (Tarasov et al., 2015; Kobe et al., 2020), and Cis-Baikal Early and Middle Holocene hunter–gatherer culture history (Weber et al., 2020). All ages in cal. years BP.

| Eurasian climate | Climate and environment in the Baikal region | Archaeological periods and transitions |
|---|---|---|
| Preboreal–Boreal 11,700–8,200 | Cool, dry, rising temperature, expansion of the boreal forest from ~9500 | EM ~10000–8630<br>Transition 1 ~8630 |
| Atlantic 8200–5700 | Long trend towards warmer temperatures and more precipitation, expansion of coniferous forest, thicker and longer-lasting snow cover | LM 8630–7560<br>Transition 2 *~7560* |
| | Continued forest expansion reaching maximum at 7000–6500 | EN *7560–6660*<br>Transition 3 *~6660* |
| | Stabilization and reversal of the earlier trend after 7000–6500 | MN *6660–6050*<br>Transition 4 *~6050*<br>LN *6050–4970* |
| Subboreal 5700–2500 | Continued reversal: cooler, drier, shrinking forests | LN *6050–4970* cont.<br>Transition 5 *~4970* |
| | Stabilization towards modern conditions around 3000 | EBA *4970–3470*<br>Transition 6 *~3470* |

adjust their camp size, movement, and population size and density relative to hunting returns (Woodburn, 1982). In the Cis-Baikal setting, it is red and roe deer that should be considered the highest ranked resources, albeit also high risk, as most high-ranked resources are.

Comparison between the environmental and cultural histories, particularly regarding the timing of the identified cultural transitions, shows that they are not aligned (Table 4), which is not particularly surprising given the very gradual nature of the environmental trends compared to the rather rapid nature of culture change. This lack of association implies that the environmental explanation on its own, as expected, is not readily applicable here and makes the questions listed earlier even more pressing.

### 4.2. Technological innovations

Of all technological innovations characterizing the culture historical sequence examined in this paper, the introduction of the bow-and-arrow at the beginning of the EN surely is the most important, its potential impacts reaching far beyond hunting alone. While the atlatl is better than the spear, the bow-and-arrow is superior to both (Table 5) [e.g., Bettinger, 2013]. Because of their low accuracy and short range, spear and atlatl are effective from a close distance and on large targets (i.e., individual animals or compact herds). They require the cooperation of many hunters dispatching their weapons simultaneously not to miss the target to minimize risks of failure. Conversely, the bow is more accurate, has a longer range (153%), and covers a larger area (235%). It is even more silent than the atlatl, can be used from a few body positions, and is easier to master due to much simpler biomechanics. A bow hunter can dispatch many arrows in quick succession quietly with minimal body movement, thus lowering the risk of startling the prey (Okladnikov, 1950). Due to these advantages, the bow does not require cooperation and is effective on small targets and in the woods. Bettinger (Bettinger, 2013) estimates that one hunter with a self-bow (made of wood only) is as good as 2–3 atlatl hunters. Moreover, the bow can also be employed as a bow trap, with many such devices potentially installed at any given location, an additional advantage over the spear or atlatl. Overall, the bow offers much higher return rates per capita and lower risks of hunting failure.

**Table 5**
Comparison between hunting with atlatl and bow-and-arrow (Okladnikov, 1950; Bettinger, 2013).

| Variable | Atlatl | Bow-and-arrow |
|---|---|---|
| Biomechanics & learning | Complex & difficult to master | Simple & easier to master |
| Accuracy | Lower | Higher |
| Target distance | Shorter | Longer (by 153%) |
| Target area | Smaller | Larger (by 235%) |
| Repetition rate | Lower | Higher |
| Risk of startling prey | Higher | Lower |
| Unattended use | Not suitable for traps | Suitable for traps |
| Target size | Effective on large targets | Effective on large to small targets |
| Hunting environment | Effective in open area | Effective also in woods |
| Returns per capita | Lower | Higher |
| Overall risk of failure | Higher | Lower |
| Effect on group size | Favours large groups | Favours large and small groups |
| Effect on group mobility | Favours higher mobility | Favours lower mobility |

The social and demographic consequences of the bow-and-arrow are important too. While the atlatl requires large groups, the bow makes small groups viable too on the account of its better returns per hunter and risk reduction, thus also reducing the need to move as frequently as before. Which of these two group size options would prevail after adoption of the bow, or whether both would prove to be equally practical, would depend on other circumstances such as the requirements of other forms of food procurement. The important point is that while the spear and atlatl favour large groups only, the bow-and-arrow makes room for units from small to large. Lastly, better returns from hunting with the bow-and-arrow also create opportunities for: (1) Population growth by a combination of such demographic factors as higher birth and infant survival rates, higher fecundity and fertility, and lower morbidity etc., all relative to the times prior to the adoption of the bow; and (2) Changes in population distribution by crowding defined as the combined effects of individuals and families forming larger groups and the tendency of such groups to live relatively nearby, thus leading to higher variability in microregional and regional population densities.

While the role of fishing gear is introduced in the next section and assessed in more detail below, the socio-economic impacts of the other Neolithic innovations (e.g., ceramic pots, and new forms and kinds of tools) are expected to be only minor and, thus, are discussed only as necessary. Copper and bronze objects (e.g., knives, rings, needles, and fishhooks) represent the only truly new technology of the EBA but their role in food procurement was almost certainly minimal. Still, the potential impacts of metals on social organization are useful to consider.

### 4.3. Intensification of fishing

The critical difference between game and fish resources in most HG settings, including Cis-Baikal, is that fish lends itself to both non-intensive and intensive procurement, but large game only to non-intensive—otherwise resulting quickly in overhunting (Winterhalder and Goland, 1993). Of all the resources in Cis-Baikal, only the fisheries are amendable to intensification, though differences in abundance, distribution, access, and reliability mean that not all are equally suited to this practice. The Angara and the shallows of Kultuk Bay in the

**Table 6**
Comparison between game hunting with bow and fishing.

| Variable | Game hunting with bow | Fishing |
|---|---|---|
| Territory | Larger | Smaller |
| Group mobility | Higher | Lower |
| Returns per capita | Higher | Lower |
| Risk of failure | Higher | Lower |
| Labour investment | Back-loaded | Front-loaded |
| Risk of resource depletion | High | Low |
| Subject to intensification | Yes | No |
| Organization | Individual hunting | Individual (non-intensive) and cooperative (intensive) |

southwest corner of Lake Baikal offer the best opportunities for intensification, while the Upper Lena is the least suitable, and the coves of the Little Sea only with difficulty, mostly due to their patchy and unpredictable nature. Ice cover is another important aspect of accessibility and only the Angara fishery remains unfrozen during long winters while the ice on the others can easily be 1 m thick [e.g., Kozhov, 1963].

The numerous differences between game and fish resources are outlined in Table 6. Relative to game hunting, fishing— particularly its intensive from—is heavily front-loaded, requiring a major cooperative investment of labour in the manufacture and maintenance of fishing gear, in procurement itself, and in post-harvest handling for consumption and storage (Lindström, 1996; Tushingham and Bettinger, 2013). Post-harvest handling is particularly relevant where large amounts of fish can be procured with relatively simple, less intensive, methods. Additionally, small fish can be a very cost-effective resource when mass harvested whereas small game (e.g., hare) cannot (Lindström, 1996).

In Cis-Baikal, fish lends itself to storage by freezing in winter and drying and smoking in summer, the latter requiring considerable cooperation in order to be done quickly to avoid spoilage. The easily distributable food packages would also help solve a problem inherent to sharing game meat: no need to haggle over who gets what or how much because each unit is relatively the same. Lastly, intensive fishing requires much higher levels of cooperation than game hunting, especially with the bow. While bow hunting would probably work equally well for groups of any size, intensive and, to some extent, non-intensive fishing would need the cooperation of large social units to work properly.

As in many other HG settings [e.g., Fitzhugh, 2003; Kennett, 2005; Prentiss et al., 2007; Prentiss et al., 2014; Tushingham et al., 2016], there is no reason to believe that Middle Holocene Cis-Baikal HGs were on an inevitable course to develop intensive fishing sooner or later simply because there was fish just about everywhere around the region. Therefore, When, Where, and Why the intensification of fishing took place around Cis-Baikal, are all good questions to ask. Moreover, Bettinger [Bettinger 2015: 30, 38] notes that HG intensification is as much a social and political problem as it is a subsistence and technological problem. A shift to more intensive fishing can be facilitated by a change in the mode of hunting to one that is more efficient and frees up the labour required by the heavily front-loaded intensive fishing. In sum, an understanding of fishing is as critical to the understanding of HG evolution in Cis-Baikal as is the history of boreal forest distribution and the socio-economic effects of hunting with the bow.

## 5. Discussion

The following argument focuses on the interactions between the main factors identified above: changes in the distribution of the boreal forest and approaches to game hunting and fishing, as well as their combined impacts on HG adaptive strategies, together leading to gradual changes within each cultural pattern and the transitions between them. Other factors are brought into the discussion as necessary. Since the materials from camp-sites in this region do not correlate well with mortuary groupings, the empirical foundations for this assessment are provided mainly by the recent archaeological and bioarchaeological studies of materials from cemeteries.

The narrative is presented within the traditional culture historical units and deliberately emphasizes regional patterns. Microregional or local particularities are invoked when necessary, not to divert attention from meaningful generalizations and mechanisms, but to suggest future research directions. The chronological ranges for each analytical unit (mortuary tradition or archaeological period) have been updated based on the recent analysis of 560 radiocarbon dates (Weber et al., 2020). On a regional scale, most of the boundaries are considered relatively firm with the exception of the start of the LN—still defined by a rather small number of dates—which is likely to shift slightly earlier. More revisions are expected on a microregional scale, where a few samples of radiocarbon dates (e.g., the LN and EBA in the Angara and the Upper Lena valleys) are still relatively small. New fieldwork, as well as the dating of materials excavated in the past but not yet analyzed, will expand the radiocarbon dataset further. Continued research may bring microregional differences in the timing of relevant mortuary traditions into sharper focus, but is not expected to move their boundaries enough to make much difference for this analysis. Lastly, the Late Bronze Age is not discussed because bioarchaeological data for this period are nonexistent and the few radiocarbon dates available for burials suggest a gap of ~1000 years separating them from the EBA (Losey et al., 2017).

### 5.1. Mesolithic: Early (~10000–8630 cal. BP) and Late (8630–7560 cal. BP [2])

The Mesolithic can further be divided into Early Mesolithic (EM) and LM, differentiated by the appearance of individual graves, sometimes forming very small cemeteries, in the latter. The Mesolithic Khin mortuary group was represented in the Okladnikov sequence by only two graves from the Angara valley and subsequent fieldwork identified two more: one on the Angara and one on the Upper Lena. Recently, a dozen or so graves from several locations across Cis-Baikal have been assigned to the latter half of the Mesolithic based on a combination of typological and radiocarbon criteria, thus defining the LM (Weber et al., 2016; Bazaliiskii, 2010). In cultural terms, the EM is essentially the LM without the mortuary component. It is possible that other differences in cultural characteristics exist but these are currently difficult to identify.

The LM mortuary record appears highly variable with regard to body position, orientation, use of red ochre or rocks, and grave goods (Weber et al., 2016; Bazaliiskii, 2010; Goriunova et al., 2020). Thus, the term mortuary tradition is not fully applicable and a more neutral concept of *mortuary group* seems more appropriate. In this paper, to keep the matter simple, the label of *Khin Group* is used in reference to all graves of this kind from the entire region (Table 1 and 2). Grave goods are generally small in number but relatively diverse and show similarities with the EM (prismatic blades and points on prismatic blades, known from camp-sites) and the EN (fishing tackle including fishhooks—some composite—and leisters, known mostly from cemeteries). Ornaments are rare and include beads, red deer canine pendants, and boar tusk pendants—all also known from numerous EN, LN, and EBA graves. Bazaliiskii (Bazaliiskii, 2010) underscores the absence of pottery and bifacially formed arrowheads, but many other categories relatively common in EN, LN, and EBA graves are lacking too: nephrite tools and ornaments, composite tools, bone points, etc. (Weber et al., 2016).

The stable isotope data in this group imply at least some consumption of aquatic resources across Cis-Baikal and, on the Angara specifically, the start of a dietary trend towards increased reliance on the local fishery (Weber et al., 2016; Weber et al., 2020). For the Little Sea and the Upper Lena, radiocarbon dates show sometimes sporadic

[2] All period boundaries are from Weber et al. submitted.

and sometimes clustered use of cemeteries continuing well into the EN without significant changes in mortuary characteristics (Goriunova et al., 2020; Bronk Ramsey et al., 2020).

As mentioned, at the beginning of the Holocene Cis-Baikal was essentially a vast and continuous expanse of steppe and forest-steppe with ample large game roaming around. The available hunting technology, the atlatl and the spear, required that HG groups were relatively large in order to have enough hunters to cooperate: the only way to compensate for the inherent deficiencies of this technology, to provide enough food, and to satisfy needs for clothes, shelter, etc. Consequently, these groups allocated much of their time to searching for and pursuing large game. The EM groups were very mobile and their transient camps were scattered in a pattern dictated as much by hunting success as by a preference for specific locations. Discard rates of archaeological materials at these locations were low and their archaeological visibility today is equally low. These groups also subsisted on plant foods and fish, the latter harvested employing a range of techniques for individual capture. Hunting with spear and atlatl and high group (i.e., residential) mobility would have accommodated only non-intensive fishing, which could be practiced on many rivers and along lake shallows whenever the opportunity arose. Controlled and sustained access to such fisheries, including by legitimizing it via formal cemeteries, was neither necessary nor practical due to the high level of group mobility.

This strategy continued through the EM and, in general approach, was not much different from that employed in the Late Pleistocene or at the Pleistocene–Holocene transition. It would likely have continued for much longer if not for the expanding forests, which had two perceptible consequences: (1) An increasingly patchy environment; and (2) Population crowding within the gradually shrinking open landscape and along the forest–steppe ecotones. Together, this resulted in increased inter-group competition for game resources and created socio-economic problems with no solution (technological or otherwise) readily available.

The appearance of the first single graves and possibly also of very small cemeteries around *8630 cal. BP* perhaps mark the earliest attempts to address these troubles, thus marking also the beginning of the LM—Transition 1 (Table 7). Crowding and competition would have created opportunities for charismatic leaders to emerge and to organize hunting and individual fishing (using the same techniques as before) into more efficient operations. There were, perhaps, even attempts to control access to some resources, leading to episodes of increased socio-political differentiation. Since the long-term wellbeing of such groups would have relied on personal leadership qualities rather than on institutionalized mechanisms, it is unlikely that such arrangements would have lasted beyond the lifetime of a leader or a few generations at most. It could be these leaders and their families that were interred in the LM graves. The fleeting nature of such arrangements and the relative rarity of leader deaths were not conducive to the development of a formalized mortuary protocol which, therefore, varied greatly from place to place across Cis-Baikal.

**Table 7**
Formation of the LM cultural pattern—Transition 1.

| Variable | Description |
|---|---|
| Environment | Warming and wetter climate; forest expansion; increasing patchiness |
| Population | Small, stable in size; crowding within open landscape and along ecotones |
| Group size | Small number of relatively large groups |
| Group mobility | Decreasing |
| New technology | No important innovations |
| Hunting | Group with atlatl and spear; large game |
| Fishing | Non-intensive |
| Social relations | Limited social differentiation; increasing inter-group competition for game resources; emerging leaders |
| Mortuary activities | Rare and unstructured formal burials; single graves, emergent small cemeteries |

Around ~8000 cal. BP, that is, at the beginning of the warming and wetter trend associated with the onset of the Atlantic period, forest expansion would have likely accelerated. Such expansion would have led to even more crowding and perhaps more competition for game, now under growing pressure from hunting. The HGs of Cis-Baikal lacked a long-term solution to the mounting problem of too many people in places with probably still enough food but no technology, time, or hands to harvest it efficiently. The intensification of fishing was still not viable due to the constraints created by inefficient game hunting with atlatl and spear as well as relatively high group mobility, and thus a lack of labour surpluses. Due to this population pressure, the overall size of the EM and LM population was unlikely to grow much. The short-lasting efforts of leaders to organize their people into economically more efficient units were also unlikely to lift this pressure for long enough to make a difference. Socially, all Mesolithic groups display essentially the same limited intra- and inter-group social differentiation.

### 5.2. Early Neolithic (~7560–6660 cal. BP)

#### 5.2.1. Formation of the Kitoi pattern

The EN started with the formation of the Kitoi cultural pattern known primarily from mortuary sites on the Angara and Southwest Baikal (Table 2) (Weber et al., 2016; Weber et al., 2002; Bazaliiskii, 2010; Bazaliiskiy and Savelyev, 2003; Bronk Ramsey et al., 2014; Faccia et al., 2016; Faccia et al., 2014; Haverkort et al., 2008; Katzenberg et al., 2009; Katzenberg et al., 2012; Katzenberg and Weber, 1999; Lam, 1994; Lieverse et al., 2011; Lieverse et al., 2009; Lieverse et al., 2013; Lieverse et al., 2007; Lieverse et al., 2007; Lieverse et al., 2015; Lieverse, 2010; Lieverse et al., 2008; Lieverse et al., 2016; Lieverse et al., 2014; Lieverse et al., 2017; Lieverse et al., 2014; Link, 1999; Losey et al., 2008; Mooder et al., 2005; Mooder et al., 2006; Moussa et al., 2018; Nomokonova et al., 2013; Osipov et al., 2016; Scharlotta et al., 2016; Scharlotta et al., 2013; Scharlotta and Weber, 2014; Schulting et al., 2015; Schulting et al., 2014; Shepard et al., 2016; Temple et al., 2014; Waters-Rist et al., 2016; Waters-Rist et al., 2010; Waters-Rist et al., 2011; Waters-Rist, 2012; Waters-Rist et al., 2014; Weber et al., 2010; Weber and Bettinger, 2010; Weber and Goriunova, 2013; Weber et al., 2017; Weber et al., 2016; Weber et al., 2011; White et al., 2020; Osipov et al., 2020). It featured many technological innovations including the bow-and-arrow and ceramic pots traditionally used to define the Neolithic in Siberian archaeology. Nets, new types of leisters and harpoons, fish lures, composite fishhooks, green nephrite tools (adzes, knives, and chisels), and a range of composite tools (e.g., spearheads, daggers, and knives) were also either novel or much more morphologically variable than during the LM. The shanks of composite fishhooks, one of the most diagnostic Kitoi objects and a common grave good, were morphologically rather stable and varied mainly in size. The pottery, with simple profile and round or pointed bottom, was rather uniform. The two types of decoration, net and cord impressions, directly imply the knowledge of weaving and cordage.

The Kitoi mortuary protocol is typically defined by grave-pits lacking rocks, the presence of red ochre, extended body position, a northern orientation, graves with mostly single but not infrequently also with multiple interments (occasionally in the head-to-toe position), and grave goods of the kind mentioned above. Many of these mortuary traits repeat with only minor deviations from grave to grave and from cemetery to cemetery. There are aspects, however, that differ between cemeteries such as perimortem removal of the head, post-mortem disturbances, and bear or fire rituals. Kitoi cemeteries in the Angara valley also vary in size from one or two graves to a hundred or more. Nonetheless, the material culture was basically the same and the highly variable distribution of grave goods, in both kind and number, suggests substantial levels of social differentiation and inequality.

Bioanthropological studies indicate a population operating under a

combination of skeletal "wear and tear" and physiological stress, as evidenced by the prevalence of joint osteoarthritis and tooth enamel hypoplasia (both higher than in LN and EBA groups), individual mobility (higher than in LN groups)[3], stature and child skeletal development rates (both lower than in LN and EBA groups), as well as infant mortality rates during breastfeeding (likely higher than in the LN). Moreover, the differential distribution of joint osteoarthritis suggests a division of labour along gender lines, a characteristic absent in LN and EBA groups. Radiocarbon dates and stable isotope data reveal that most, but not all, Kitoi groups experienced a gradual and relatively short—lasting only a few centuries—trend towards the increased contribution of local aquatic foods to their diet and most used their large cemeteries continuously. At Shamanka II on Southwest Baikal, however, a break of a few hundred years was found between the long Phase 1 and short Phase 2, though both showed similar dietary trends.

All this suggests that the evolutionary landscape for Cis-Baikal HGs changed dramatically and rapidly with the advent of the bow-and-arrow. Where the bow came from and why it arrived on the Cis-Baikal stage around *7560 cal. BP* is a different matter and inconsequential to the argument advanced here. Clearly, the quick adoption of the bow—at least on the Angara and Southwest Baikal—is a proof that, from the perspective of LM groups facing mounting problems, the timing of this innovation could not have been better. It provided exactly what was needed most at this particular time: an improved technology to harvest not only large game but also medium and small with substantially better per-capita return rates and a lower risk of failure, thus releasing enough labour to be potentially channeled towards other activities.

The archaeological evidence shows that the Kitoi people used a composite bow about 0.80–1.2 m long with bone or antler stiffeners such as those found in at least 16 graves at Shamanka II (e.g., Gr. 46, 51, and 116; BAP unpublished data [4]) and a few graves at the Glazkovo and Lokomotiv cemeteries in Irkutsk [Nomokonova et al., 2013: 7; Okladnikov, 1974: 34, 44, Plate 4: 2]. The radiocarbon dates for Shamanka II imply that bow stiffeners were employed already at the early stages of the Kitoi cultural pattern. This suggests either that the bow arrived in Cis-Baikal with the stiffeners already a part of the technology or that they were developed locally shortly after the bow arrived. Since Bettinger's assessment of bow firepower used data collected for the (less powerful) self-bow, it is not unreasonable to expect that already from the beginning of the EN, one Kitoi composite bow hunter was much better than 2–3 atlatl hunters.

Excepting the fishing gear discussed below, none of the other Kitoi technological innovations would have had an impact on subsistence or social organization similar to the bow-and-arrow. The introduction of ceramic vessels may have been important for the management of household chores as their use for cooking would have allowed people to work on other tasks at the same time (Bondetti et al., 2020) and, perhaps, would assist in preparation of weaning foods. However, since EN ceramic vessels were rather small and are generally rare at cemeteries and camp-sites, their socio-economic impact was probably minor. Green nephrite tools were probably part of the toolkit for working wood, bone, and antler to make bows, arrows, and the wide assortment of bone and antler composite tools and utensils so well-known from Kitoi graves. Nephrite tools would also have been very practical for building weirs across rivers and other hunting and fishing contraptions such as basket traps, platforms, lifting devices, and drying racks, all well documented ethnographically across Siberia (Okladnikov, 1950; Okladnikov, 1955).

The intensification of fishing was the obvious allocation of the emerging labour surpluses, particularly in places with rich, predictable, accessible, and reliable fisheries located within or nearby the patches of remaining, but continuously shrinking, open landscape. The upper section of the braided, fast flowing, and never-freezing Angara and the open shallows of Kultuk Bay on Southwest Baikal, were the obvious places for this process to set out first. The Angara fishery would also have been particularly amenable to scheduling seasonal complementarity between hunting and fishing.

Although Bettinger notes that the distinction between non-intensive and intensive hunting–gathering is quantitative, thus subtle, and difficult to measure archaeologically [Bettinger, 2015: 29], the archaeological evidence is unequivocal. Many of the methods described by Lindström (Lindström, 1996) in her three main groups of fishing techniques, were likely part of Kitoi fishing: (1) Attended techniques for individual fish capture (single fishhook lines, leisters, and harpoons); (2) Attended techniques for mass capture (lift nets, seines, and dragnets); and (3) Unattended techniques for mass capture (trot lines, gill nets, weirs, and basket traps). The last two groups support intensive fishing, while the first—non-intensive. Nettle, hemp, willow bark, and wild flax were all broadly available providing fibers for cordage and net making (Okladnikov, 1950; Okladnikov, 1955). Furthermore, chronological analysis of grave goods and isotopic evidence from the Shamanka II cemetery shows that all new fishing techniques were introduced at the beginning of the EN and then used without any major improvements or additions while reliance on fish in the diet gradually increased (Scharlotta et al., 2016). Evidently, these EN groups allocated more and more time to fishing.

These developments quickly led to the formation of the Kitoi pattern—**Transition 2** (Table 8) (Bazaliiskii, 2010)—simultaneously on the Angara and in Southwest Baikal (Weber et al., 2020; Bronk Ramsey et al., 2020). The recent discovery of a Kitoi cemetery in Moty-Novaia Shamanka on the lower Irkut River, about 40 km upstream from its confluence with the Angara (Bazaliiskii et al., 2016), suggests that the fisheries of the lower sections of the Angara's left tributaries were also suitable for intensive fishing. Unfortunately, the cemetery has been entirely destroyed by a modern housing project and details of its size and use are unknown.

Introduction of the bow, quickly followed by the intensification of fishing, also had important demographic and social consequences reflected in the Kitoi pattern. First, improved return rates from bow hunting lifted the pressure that had long been keeping the Mesolithic population in check, thus allowing Kitoi groups to grow and crowd further. Groups that were large enough engaged in intensive fishing. Chances are that the overall Kitoi population grew rapidly at the beginning of the EN and then stabilized. Second, both bow hunting and non-intensive fishing can be practiced by bands of any size but, as mentioned, intensive fishing requires large groups. This combination creates room for an array of socio-economic arrangements.

While an alliance of large cooperating units—perhaps on an intermittent basis—appears to have established itself as the dominant Kitoi socio-economic model, the structure was flexible enough to accommodate much smaller social units, able to eke out a living thanks to the advantages offered by the bow as well as the variety of fishing techniques now available. The variable size of Kitoi cemeteries was perhaps thus linked to the equally variable size of the social units using them. Well-defined home ranges were likely based along the Irkut, Kitoi, and Belaia rivers and adjoining sections of the Angara, each with a cemetery located at its respective confluence—perhaps the symbolic centre of each unit and its home range. Likely, it is these cooperating units that are behind the dietary trend towards an increased reliance on fish discovered at Shamanka II and Lokomotiv, whereas smaller units are behind the groups of burials there (Weber et al., 2016; Weber et al., 2020) and Kitoi cemeteries further downstream on the Angara (Galashikha and Ust'-Belaia) which show no dietary change over time.

By favoring cooperation, this new evolutionary HG landscape also created opportunities for leaders to coordinate such team efforts as well

[3] The differences in individual mobility between EN Kitoi and LN Isakovo are discussed further by Osipov et al.

[4] A monograph of the Shamanka II cemetery is in its final stages of preparation for publication.

**Table 8**
Formation of the EN Kitoi cultural pattern—Transition 2.

| Variable | Description |
|---|---|
| Environment | Warming and wetter climate; forest expansion; decreasing patchiness |
| Population | Growth in size; crowding within open landscape and along ecotones |
| Group size | Few very large, and some medium to small groups |
| Group mobility | Low |
| New technology | Bow-and-arrow; new methods of fish mass capture; ceramic pots |
| Hunting | Individual with bow; large, medium, and small game; pressure on large game |
| Fishing | All forms, from non-intensive through to intensive |
| Social relations | Substantial social differentiation; increasing inter- and intra-group competition for access to resources; strong leaders; craft specialization |
| Mortuary activities | Structured formal burials; large and small cemeteries |

as room for specialization and competition within and between groups. All new toolmaking, including bow-and-arrow and fishing gear, would likely have been subject to at least some craft specialization and, perhaps, the division of labour along gender lines, although this is difficult to see in the archaeological record. Competition would have focused not only on the accumulation of personal wealth, prestige, political influence, and access to resources, but likely would have also involved a search for capable marriage partners and the recruitment of skilled craftsmen and talented individuals to lead cooperative activities. This, in sum, would have resulted in much intra- and inter-group social differentiation, with small groups being potentially less differentiated than large ones.

Together, these points suggest that life at the beginning of the EN was essentially quite good—certainly much better than any time before—but the situation likely changed quickly, particularly under the persistent pressure of the forest closing in on the open landscape. Returns from game hunting also probably levelled off relatively quickly, later perhaps even decreased while the risk of hunting failure increased once again, both due to the combined effects of a large HG population, bow efficiency resulting in overhunting, and habitat loss for game. All this put Kitoi groups under renewed population pressure and halted further growth. Crowding, competition, and the need for cooperation likely increased, potentially leading to even more social differentiation. From this point on, life was no longer so good, as demonstrated by the ample evidence for physical, physiological, and developmental stress experienced by these people as mentioned above. Sources of this stress are easy to imagine: extended search and pursuit times (i.e., increased individual mobility) while game-hunting meant bringing home heavy loads of meat from further and further afield or food shortages if returning empty-handed, as well as all the heavy lifting and pulling required to handle the attended and unattended devices used for mass fish capture.

The Kitoi pattern continued until it collapsed no later than *6660 cal. BP*, roughly the time the boreal forest reached its maximum expansion around 7000–6500 cal. BP (Table 9). The substantial radiocarbon evidence suggests a relatively quick breakdown, although not as quick as its formation (Weber et al., 2020). More cooperation to increase returns from fishing was an insufficient solution to the mounting range of problems as fish was not a viable substitute for the resources that only game could provide. The system lacked the capacity to counteract the negative impacts of growing competition, population crowding, environmental changes, and diminishing returns from game hunting. At this point, ironically perhaps, the bow also facilitated a solution that the atlatl and spear could not: dispersal of the Kitoi groups into the forest.

**Table 9**
Formation of the MN cultural pattern—Transition 3.

| Variable | Description |
|---|---|
| Environment | Still warming and wetter climate; forest expansion; decreasing patchiness |
| Population | Dispersal of the Kitoi population into the forest |
| Group size | Many small groups |
| Group mobility | High |
| New technology | No important innovations |
| Hunting | Individual with bow; large, medium, and small game |
| Fishing | Non-intensive |
| Social relations | Low social differentiation; low intra- and inter-group competition for access to resources |
| Mortuary activities | No or rare formal burials |

The same radiocarbon evidence suggests variable tempo and timing of the breakdown, implying a rather complicated process [see Weber et al., 2020; Bronk Ramsey et al., 2020 for chronological details]. First, Shamanka II on Southwest Baikal shows two phases of use. Such discontinuity is lacking on the Angara as a whole and specifically at Lokomotiv, the largest cemetery with enough radiocarbon dates (n = 80) to document such break, if present. Second, Phase 1 at Shamanka II starts at the same time as the Kitoi on the Angara but it ends earlier. Third, Phase 2 begins after a long break, but ends even more quickly than Phase 1. And fourth, the dietary trend documented for Phase 2 repeats exactly the main dietary trend from Phase 1 (Weber et al., 2016; Weber et al., 2020). Overall, then, the Kitoi pattern began to vanish with the end of Shamanka II Phase 1, followed by the end of Lokomotiv, then of the smaller groups associated with the other Kitoi cemeteries on the Angara, and disappeared for good at the end of Shamanka II Phase 2.

While it can be argued that some of these chronological offsets are within the statistical confidence intervals of Bayesian analysis (Weber et al., 2020), they may yet be real. Already, evidence shows many similar temporal offsets (Bronk Ramsey et al., 2020) across Middle Holocene Cis-Baikal. Furthermore, there is no reason to expect that the end of the Kitoi should be chronologically the same everywhere. If these temporal differences are genuine, the argument advanced here helps make sense of them. The Kitoi pattern required bow technology, an open landscape with sufficient game, and fisheries suitable for intensification—the latter two in close proximity to one another—otherwise the Kitoi pattern could neither form nor function properly. The technology being the same everywhere, differences in the timing of the Kitoi dissolution must then be related to the other two factors.

In the Angara valley, good fisheries coincided spatially with open landscape along much of the first 200–300 km of the river and along the lower sections of its tributaries (Irkut, Kitoi, Belaia, and Kuda). Such a setting likely provided some socio-economic flexibility to the Kitoi pattern, making room for groups of different sizes to function side-by-side: the small ones more flexible, or resilient, than larger ones. But the ecological setting of Kultuk Bay was more restricted. Here, the fishery was limited to a relatively short stretch of lake coast, frozen for about 4–5 months every winter, and the open landscape extended westward from the lake (away from the fishery), into the middle Irkut valley where fisheries were inadequate for intensification. The result was that in Kultuk Bay, the Kitoi pattern could only develop and function within a much smaller area than on the Angara, making the arrangement less stable overall.

The expansion of the boreal forest could also have contributed to the earlier collapse of the Kitoi pattern in Kultuk Bay. The area immediately

west of the bay and along the middle Irkut lies between two high mountain ranges: Eastern Sayan to the north and Khamar-Daban to the south, both with much higher precipitation (two to threefold) than the rest of Cis-Baikal (Breken, 1968). This would have translated into a much faster advance of the forest into the valley and the concomitant reduction of the open landscape and its game resources.

Given these limitations, it seems reasonable to suggest that Phase 2 at Shamanka II represents an attempt to reintroduce the Kitoi strategy into the area at a time when it was still functioning on the Angara, although already with much difficulty. The abandonment of the Kultuk Bay area at the end of Phase 1 would have allowed game resources to rebound somewhat, depending on how long it was before the Kitoi groups returned, but it would not have stopped the forest expansion. That the diet of Phase 1 was more diverse than that of Phase 2, where all individuals neatly fit into a single trend (Weber et al., 2016), suggests that Phase 2 likely relied on a narrower range of fishing techniques. Since Phase 2 repeats the trend of the SE Cluster row burials from Phase 1, it is possible that Phase 2 represents the direct descendants of these Phase 1 individuals returning to Shamanka II and employing the same strategy for fishing intensification.

After dispersal, the diet of the Phase 1 people is expected to have "reset" to what it was at the beginning of Phase 1 (a lower consumption of aquatic foods), which should also characterize the first returners of Phase 2. The direct biocultural continuity between Phase 1 and Phase 2 people at Shamanka II is supported by the spatial patterns of cemetery use. Rather than forming a new group, Phase 2 graves were added to the existing spatial units—sectors, clusters, and rows—with some burials added to graves built during Phase 1 (Weber et al., 2016). Moreover, the entire mortuary protocol of Phase 2 emulates that of Phase 1. Overall, the evidence points towards the rather short-lived Phase 2 as an attempt to re-establish the previous Kitoi pattern in Kultuk Bay that failed due to the less abundant game resources, relative to what was available at the beginning of Phase 1. The valley west of Kultuk Bay was the natural direction for Phase 2 groups to disperse.

#### 5.2.2. Early Neolithic patterns on the Upper Lena and in the Little Sea

On the Upper Lena and in the Little Sea, the EN mortuary record is confined to either individual graves or small (fewer than 10 graves) cemeteries, totalling a few dozen burials only (Table 2). It is probably significant that not a single grave comes with a set of mortuary characteristics that can be cleanly attributed to the "*classic*" Kitoi, with arrowheads conspicuously rare (Goriunova et al., 2020; Vetrov et al., 1995). Grave goods from the better documented burials in the Little Sea reveal continuity from the LM, with the rare addition of net and cord impressed ceramic pots (Goriunova et al., 2020). It seems that attempts to "transplant" the Kitoi strategy were made, as suggested by the presence in the Little Sea of a few graves with typical Kitoi composite fishhook shanks (Goriunova et al., 2020). They were unsuccessful, however, evidently because the Kitoi pattern was only viable where labour surpluses generated by bow hunting could be efficiently diverted towards the intensification of fishing. Outside of the Kitoi centers, several factors prevented such developments.

Due to its northern location, the forest on the Upper Lena would have closed in well before the Kitoi groups ran into problems in their homeland on the Angara and in Southwest Baikal. Thus, very likely, the Upper Lena was never a viable option for the Kitoi people as a fall-back or expansion area. The same factor apparently limited the northward distribution of the Kitoi pattern beyond the first 200–300 km of the Angara River, despite its rich fishery (Table 3). Evidence for use of the bow on the Upper Lena is weak, and while it would have made hunting in the forest worthwhile, it would not have affected search time, which would have been much higher than in more open landscapes. Fishing probably employed mainly single capture techniques as the more intensive approaches were not compatible with high group mobility or the poor local fisheries that were, moreover, subject to long winter freezing.

In contrast, the fisheries of the Little Sea are thought to have been rich and Middle Holocene fishing is well documented by recent excavations at Ityrkhei Cove in Kurkut Bay (Losey et al., 2008; Losey et al., 2012). Moreover, while the Little Sea's considerable aridity is expected to have slowed down the advancement of forest into the area, it likely also restricted the size and abundance of game relative to the other microregions. Whether the open landscape disappeared entirely and when the forest reached its maximum expansion is still unclear. Regardless, our current understanding implicates the combined effects of several elements as the most parsimonious reason for the absence of the Kitoi pattern in the Little Sea.

Shallow cove fisheries in the Little Sea are patchy in distribution and low in species diversity, as demonstrated by the materials from Ityrhkei where 93% of identified fish bones belonged to only 3 species: perch (65%) and dace/roach (28%) (Losey et al., 2008). This lack of diversity, coupled with the piscivorous perch's high position on the trophic ladder, would have made the abundance of these fisheries more seasonally and annually variable than that of the linear and diverse fisheries of the Angara and Kultuk Bay. The complex topography of the coastline would have resulted in an equally patchy distribution of HG groups, with travel between their homes requiring major inland detours. In contrast, the distribution of HG groups on the Angara and in Kultuk Bay was mostly linear, and travel and communication would not have been a problem, an advantage in organizing cooperative fishing. A practical solution to this problem in the Little Sea would have been effective watercraft technology, which was not as necessary on the Angara and in Kultuk Bay. Thus, that fishing in the Little Sea did not advance to the same intensification level might also be related to available watercraft technology. Lastly, the lack of rivers with substantial spawning runs in the Little Sea, as well as the annual freezing of the shallow coves from November to May, further lowered the utility of its fisheries. All these factors together would likely have made the Little Sea fisheries less amenable to intensification than they may appear at first glance.

Overall, the Kitoi strategy never collapsed on the Upper Lena and in the Little Sea, but only because it never formed there in the first place. The evidence suggests that in both areas the EN pattern, including mortuary practices (i.e., the Khin Group), continued from the LM times without much change. Hunting still relied mostly on the atlatl and spear, while fishing perhaps used some of the advanced techniques but never on a scale similar to that of the Angara and Kultuk Bay. Without much game and with fisheries inadequate for intensification, the impact of the bow on social and economic life was not as profound.

### 5.3. Formation of the Middle Neolithic pattern (~6660–6050 cal. BP)

The MN period began with the breakdown of the Kitoi culture—**Transition 3**, which took place around the time of maximum forest expansion throughout Cis-Baikal (Table 9).

Our knowledge of the MN is limited by a few factors: (1) That the period has been defined only recently (Weber et al., 2002), substantially postdating most archaeological fieldwork in the region; (2) The absence of bioarchaeological data due to a complete lack of MN cemeteries; (3) The inadequate stratigraphic resolution of most camp-sites around Cis-Baikal; and (4) The fact that past attempts to correlate cultural strata at camp-sites with mortuary traditions failed to recognize that the MN lacked cemeteries and continued to employ Okladnikov's flawed culture history sequence.

A complete depopulation of Kitoi centers, as well as of the other microregions, is highly unlikely. That people were still living in the region, and on occasion still engaging with EN burial sites, is suggested by a small number of interments (e.g., at Shamanka II in Southwest Baikal and Verkholensk on the Upper Lena) (Weber et al., 2016; White et al., 2020), as well as by archaeological strata at camp-sites (e.g., Sagan–Zaba II in the Little Sea) (Nomokonova et al., 2013; Nomokonova et al., 2015) with radiocarbon dates within MN

boundaries. Based on the data at hand, the most likely scenario seems to have been a major socio-economic reshuffling, resulting in a rather substantial decrease in HG population density, directly related to the dispersal of much of the Kitoi population into the forest. New materials from well-stratified settlements, which are challenging to find, are needed to shed fresh light on this matter.

As the MN progressed, however, the region began to see a gradual reversal of the long climatic and environmental trends that characterized the preceding periods. The first third of the MN perhaps still saw some forest expansion but the trend halted as the climate stabilized towards the middle of the period and the final third saw forests retreat. These changes to forest cover in the first and final thirds of the MN were so gradual they would have been barely perceptible on a generational scale. MN groups were likely small, making ends meet in the forest and any remaining patches of open landscape with whatever resources available, and with the bow, proving its superiority over the atlatl and spear in an environment dominated by forest. Subsistence for these groups was based on some combination of terrestrial game, aquatic resources, and plant foods, as suggested by the fauna from camp-sites and the limited stable isotope results. Emphasizing residential mobility, they traveled a great deal, allocating much of their time to search for game dispersed across the taiga. Under such conditions, the intensification of fishing made little sense and formal cemeteries, having no purpose to serve, did not form. Also, many of the Kitoi technological novelties were rare, or wholly absent, in the MN package.

The transition to the MN pattern on the Angara and in Southwest Baikal was fast, needing perhaps only a few generations to complete. Elsewhere, however, the transition was probably more gradual. Differences between EN and MN environmental conditions on the Upper Lena and in the Little Sea were not substantial, requiring only minor adjustments to existing strategies or perhaps none at all. In these microregions the EN pattern, itself still fundamentally similar to that of the LM, may have continued well into MN times.

### *5.4. Late Neolithic (6050– 4970 cal. BP) and Early Bronze Age (4970–3470 cal. BP)*

As these two periods display temporal continuity—perhaps even with some overlap (Bronk Ramsey et al., 2020)—and several well documented cultural similarities (Weber et al., 2016; Bazaliiskii, 2010; Weber and Bettinger, 2010), it is practical to present them together. The LN pattern differed from that of the MN, but less so on the Upper Lena and in the Little Sea (Weber et al., 2016; Weber et al., 2002; Bazaliiskii, 2010; Bazaliiskiy and Savelyev, 2003; Bronk Ramsey et al., 2014; Faccia et al., 2016; Faccia et al., 2014; Haverkort et al., 2008; Katzenberg et al., 2009; Katzenberg et al., 2012; Katzenberg and Weber, 1999; Lam, 1994; Lieverse et al., 2011; Lieverse et al., 2009; Lieverse et al., 2013; Lieverse et al., 2007; Lieverse et al., 2007; Lieverse et al., 2015; Lieverse, 2010; Lieverse et al., 2008; Lieverse et al., 2016; Lieverse et al., 2014; Lieverse et al., 2017; Lieverse et al., 2014; Link, 1999; Losey et al., 2008; Mooder et al., 2005; Mooder et al., 2006; Moussa et al., 2018; Nomokonova et al., 2013; Osipov et al., 2016; Scharlotta et al., 2016; Scharlotta et al., 2013; Scharlotta and Weber, 2014; Schulting et al., 2015; Schulting et al., 2014; Shepard et al., 2016; Temple et al., 2014; Waters-Rist et al., 2016; Waters-Rist et al., 2010; Waters-Rist et al., 2011; Waters-Rist, 2012; Waters-Rist et al., 2014; Weber et al., 2010; Weber and Bettinger, 2010; Weber and Goriunova, 2013; Weber et al., 2017; Weber et al., 2016; Weber et al., 2011; White et al., 2020; Goriunova et al., 2020; Goriunova et al., 2020). LN cemeteries are well documented in Cis-Baikal, the Southwest Baikal the only microregion with none so far, but future work may reveal their presence there too. EBA cemeteries occur in all four microregions. As with earlier periods, LN and EBA burial sites vary in size, but LN cemeteries are never as large as the larger EBA sites and even the largest EBA cemeteries are considerably smaller than those of the Kitoi. However, in stark contrast to the Kitoi pattern, the distribution of LN and EBA graves across Cis-Baikal is quite even. Regionally, EBA graves and burials are about twice as numerous as the LN burials and EBA cemeteries outnumber both EN and LN ones (Table 2).

Based mostly on differences in burial orientation and ceramic vessel forms, two mortuary traditions have been identified for the LN: Isakovo and Serovo, but the Angara valley is the only area where they occur in good numbers, albeit never at the same location. Elsewhere in Cis-Baikal, only Serovo graves have been recorded. On the Upper Lena and in the Little Sea, areas where the Kitoi pattern was absent, differences between the LM, EN, and LN mortuary protocols can be minor, frequently leading to confusion and incorrect typochronological classification, as revealed by the latest radiocarbon dating (Weber et al., 2016; Goriunova et al., 2020; Goriunova et al., 2020). Moreover, recent reassessment of the Verkholensk cemetery on the Upper Lena suggest the presence of one Isakovo grave among many of the Serovo type (Weber et al., 2020; Goriunova et al., 2020). For the EBA, the Glazkovo mortuary tradition sufficiently accommodates the variation present in all four microregions. Microregional differences within and between the Serovo and Glazkovo mortuary protocols concern such characteristics as body position and orientation, use of fire or red ochre (the latter uncommon and never as extensive as in Kitoi graves), post-mortem disturbances, etc. (Goriunova et al., 2020). The Isakovo tradition shows much less variation, mostly on the account that it was confined spatially mainly to the Angara valley. Rocks are present in grave-pits of all three mortuary groups and in all microregions. Lastly, at many cemeteries across the region, EBA graves occur side by side with Serovo or Isakovo graves, in some cases suggesting a deliberate effort to make them fit with the existing spatial arrangements of grave rows or clusters as at Ust'-Ida I (Tiutrin and Bazaliiskii, 1996), Verkholensk (Okladnikov, 1978) or Sarminskii Mys (Goriunova, 1997; Goriunova, 2002).

The entire LN–EBA period was marked by technological stability, as nothing fundamentally new had been developed since the EN. However, most of the material culture (e.g., stone, bone, and antler objects) displayed a range of variability rather different and generally narrower than the Kitoi package. According to Bazaliiskii (Bazaliiskii, 2010), the Kitoi mortuary assemblage included 60–65 categories while the LN and EBA assemblage only 20–35. Other than the metal objects of the EBA—a convenient chronological marker—the material culture of these two periods did not need as much specialization as in the Kitoi.

Some of these differences in material culture are worth elaboration. For example, LN and EBA ceramic vessels were morphologically more variable than those of the EN (Goriunova et al., 2020; Goriunova et al., 2020; McKenzie, 2009), as well as larger and more common in graves, particularly during the LN. Pottery from camp-sites is difficult to date, but it is not impossible that some of these new forms originated in the MN. While the shape of lithic arrowheads—triangular with asymmetrical concave base—dominant during Kitoi times continued, new forms were introduced (Okladnikov, 1950; Okladnikov, 1955; Goriunova et al., 2020; Goriunova et al., 2020). LN arrowheads were about the same length as those from the EN, while EBA points tended to be shorter. Composite tools (spearheads, daggers, and knives) were also quite variable. LN and EBA fishhooks included simple bone and composite varieties, the latter varying in design much more than Kitoi specimens (Okladnikov, 1955). Fishhooks were an uncommon grave good, consistent with an overall lower incidence of objects related to the procurement of aquatic foods (fishhooks, harpoons, and lures) across the region. However, the LN component at the Verkholensk cemetery on the Upper Lena is an exception to this pattern containing a relatively large number of such objects (Goriunova et al., 2020). Nephrite tools were less frequent than in the EN, with adzes smaller than some of the Kitoi specimens and frequently made of other rock types (Okladnikov, 1950). The LN also saw the introduction of symmetrical nephrite axes. Copper and bronze knives, rings, bracelets, needles, fishhooks, etc., are rare in EBA graves. Overall, aside from metals, some elements of the Kitoi material culture were also part of the LN–EBA assemblage but in a morphologically different assortment.

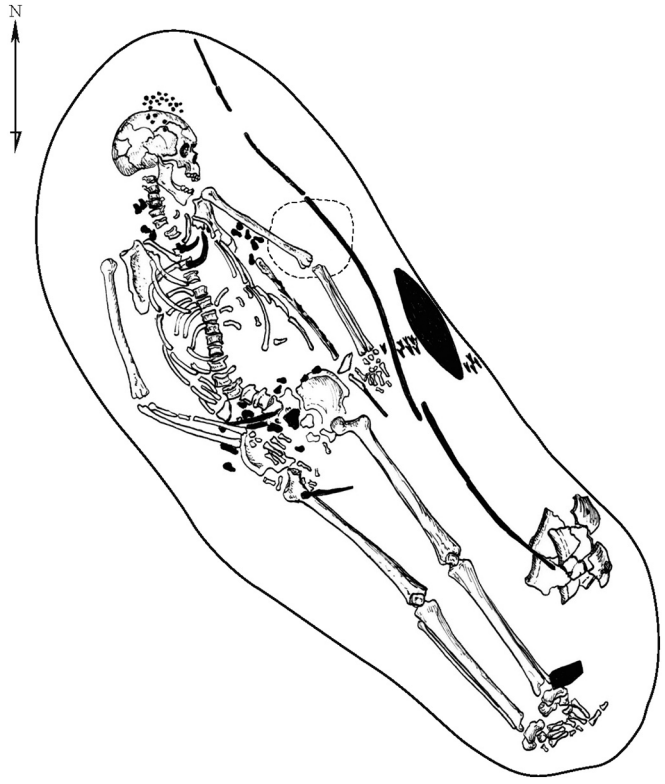


**Fig. 3.** Serovo cemetery, Grave 10 (1957) with bow stiffeners (after Okladnikov 1976: 191; prepared by A.A. Tiutrin).

The bow was also different. Already in 1950, Okladnikov (Okladnikov, 1950) described bone bow stiffeners from 16 Serovo graves (Fig. 3). Drawing on a broad range of ethnographic data from around the world, the technological superiority of the Serovo bow, not only over the atlatl and the spear, but also over the self-bow, did not escape Okladnikov's attention, although he did not quantify it in the fashion worked out by Bettinger (Bettinger, 2013). Together with specimens excavated more recently [Okladnikov 1976: 47, 51, 109, Plate 34, 45–50, 54, 56], it appears that while both were composite bows, the Serovo bow was longer than that of the Kitoi (1.5–2.0 m vs. 0.80–1.2 m, respectively) and the stiffeners were of a different kind. A few Serovo graves in the Little Sea also have bow stiffeners similar to those found on the Angara (Bazaliiskii, 2010; Goriunova et al., 2020). To date, no Isakovo graves have produced such items although arrowheads are very well documented. Likewise, the archaeological record does not tell us much about the design of the EBA bow, though the generally smaller arrowheads suggest shorter arrows and, consequently, shorter bows. No obvious bow stiffeners have been found in EBA graves so far, but a few contain bone or antler blades (e.g., Gr. 17 at Verkholensk) that could have served this purpose [Okladnikov, 1978: 161]. Regardless of differences in design, the most important point is that the bow was introduced at the beginning of the EN and remained a part of the hunting tool kit until the end of the culture–history sequence discussed here.

Bioanthropological studies indicate a population with much better overall health relative to the EN Kitoi and different dimensions of dietary variation. The stable isotope data clearly suggest at least some consumption of aquatic foods by all LN and EBA groups (Weber et al., 2016; Weber et al., 2020) and both periods show microregional differences in diet. However, additional dietary variation within the Upper Lena and Little Sea microregions is well documented, especially for the EBA. On the Lena, isotope data from cemeteries only ~20 km apart (Ust'-Ilga, Obkhoi, and Verkholensk), suggest a different balance of game and fish in the diet (White et al., 2020). In the Little Sea, the main aspect of diversity is not cemetery location, but diet type: Game–Fish–Seal (GFS) or Game–Fish (GF). The GF diet is best documented for EBA groups and only a few individuals from earlier periods fit this description and at Ulan-Khada, two such LN individuals appear to have come to the Little Sea from the Angara valley (White et al., 2020; Weber et al., 2020). During the EBA, individuals with the GFS diet outnumber those with the GF diet by a factor of ~3 and all individuals of local birth (i.e., in the Little Sea microregion) display the GFS diet, while those of non-local birth show both diets in roughly equal proportions (Weber and Goriunova, 2013; Weber et al., 2016; Weber et al., 2011; Weber et al., 2020). The GF diet, then, characterizes only people of non-local birth and at Khuzhir-Nuge XIV, the largest EBA cemetery in the area, burials with these two diets form a few spatial clusters. At the other EBA cemeteries, the GF diet is rare.

The labels assigned to these two diets suggest that the main difference is the contribution of the seal to the diet making the $\delta^{15}N$ values of the GFS group quite high (13.1–17.6‰). Removing seal from the diet would likely produce much lower $\delta^{15}N$ values, dropping them perhaps to the GF level (< 13.1%). The Baikal seal occupies the top position in the lake's aquatic food chain and its $\delta^{15}N$ signature (14.5‰ ± 1.2, n = 60) is about 8‰ higher than that of roe (6.1‰ ± 1.6, n = 29) or red deer (6.2‰ ± 1.1, n = 36). Inclusion in the diet of a relatively small amount of seal, even on a seasonally limited basis (Nomokonova et al., 2015; Weber et al., 1993), may have elevated the human values enough to create a misleading impression that all aquatic foods—fish and seal together—were a major component of the GFS diet. If EBA seal hunting emphasized young pups, easily harvestable in spring (Nomokonova, 2011; Nomokonova et al., 2015; Weber et al., 1993; Weber et al., 1998), this would have pushed human $\delta^{15}N$ values higher still, as the pups might still be subject to a nursing effect.

The Isakovo sample (n = 36) from Ust'-Ida I on the Angara shows a trend towards an increased reliance on fishing, the Verkholensk Serovo group (n = 32) shows no trend, and the Little Sea Serovo sample (n = 24, from 7 cemeteries) displays a trend towards an increased reliance on game hunting (Weber et al., 2020). For the Upper Lena EBA, the Obkhoi group shows a trend towards the increased consumption of game meat, while their close neighbors from the Verkholensk area seem to have increased their reliance on fish (Weber et al., 2017; White et al., 2020; Weber et al., 2020; Weber, 2018). In the Little Sea, the GF group (n = 21) from Khuzhir-Nuge XIV shows a growing reliance on seal hunting and three GFS samples (Khuzhir-Nuge XIV, n = 22; Khadarta IV, n = 9; and Ulan-Khada, n = 10) show the increasing consumption of large and medium game and, perhaps, also plant foods. Considered together, it appears that locals increased their reliance on game hunting while non-locals relied more on seal hunting. The common denominator of all these trends is the stable, probably moderate, consumption of fish, consistent with the archaeological record from Ityrkhei Cove in Kurkut Bay (Little Sea), where the number of fish bones in the EBA layers is much lower than in the Neolithic layers (Losey et al., 2008). This mosaic of patterns gains additional significance when the distances between groups are considered. At Khuzhir-Nuge XIV, the GF and GFS samples come from two neighboring sectors; Khadarta IV and Kurma XI (its dominant GFS component showing no trend, n = 17) are located only about 12 and 15 km northwest from Khuzhir-Nuge XIV along the coast, respectively; and Ulan-Khada is only about 17 km away around Mukhor Bay.

The EBA biochemical data also evince an interesting pattern of asymmetrical migration: more people moving to the Little Sea from other microregions than the reverse (Weber and Bettinger, 2010; Weber and Goriunova, 2013; Weber et al., 2016; Weber et al., 2011). Ancient DNA data imply that the LN–EBA population was genetically distinct from EN groups across Cis-Baikal, though new results from the Little Sea hint at some continuity between these groups (Moussa et al., 2018; Moussa et al., 2020; Moussa, 2015). On a regional scale, the LN and EBA cultural patterns overlap chronologically, indicating a rather complicated transition. Continued research and assessment of the expanded set of radiocarbon dates may reveal microregional differences

**Table 10**
Formation of the LN cultural pattern—Transition 4.

| Variable | Description |
|---|---|
| Environment | Cooling and drying climate; forest retreat; increasing patchiness |
| Population | Stable in size; crowding within open landscape and along ecotones |
| Group size | Small number of small to medium groups |
| Group mobility | Relatively high |
| New technology | No important innovations other than larger ceramic vessels |
| Hunting | Individual with bow; large, medium, and small game |
| Fishing | Non-intensive and some of the less intensive forms |
| Social relations | Moderate social differentiation and moderate inter- and intra-group competition for access to resources |
| Mortuary activities | Structured formal burials; small and medium cemeteries |

in the timing of this shift, but these are not expected to affect the main points of this argument.

#### 5.4.1. Formation of the Late Neolithic pattern (6050–4970 cal. BP)

Subsequent to the long period of stability, the forests began to retreat after ~6500 cal. BP and the conditions for open landscape game improved, for some time likely without any major impact on HG subsistence strategy, group size, or distribution. Eventually, however, the steppe and forest-steppe expanded enough to support more HG groups relying mainly on hunting large and medium game. The LN pattern (Table 10) was formed by the surviving MN groups living in the remnants of open landscape and the "forest people" coming out of the woods seeking a better life. Not all these people were necessarily direct descendants of the dispersed Kitoi population: over such a long time the genetic and cultural makeup of the original EN groups likely changed significantly (Weber et al., 2016; Mooder et al., 2005; Mooder et al., 2006; Moussa et al., 2018; Weber et al., 2020; Moussa et al., 2020; Moussa, 2015).

The LN evolutionary landscape differed from LM and EN times in several important ways. First, all LN groups were bow hunters from the outset and, thus, always had the flexibility to organize themselves into groups of any size, as required. As environment continued to change, more people moved from the forest onto the open landscape, perhaps leading to population crowding and increased competition for access to the best hunting grounds and, to a lesser extent, fisheries. Hence, the re-emergence of formal cemeteries, as territorial markers legitimizing access to critical resources, no later than *~6050 cal. BP*—**Transition 4**. Since the environmental conditions for game hunting were good and getting better, circumstances favouring intensive forms of fishing never developed again as its less-intensive techniques were entirely adequate to compensate for occasional, mostly seasonal, shortages of game food.

Second, the forest retreat was slower than its expansion during the Atlantic period. Based on the principle of IFD, the movement of HG groups onto the open landscape would have mirrored this pace and slowed down, or even stopped entirely, when the open landscape ceased to offer any significant advantages over life in the taiga. And third, in the forests, life with the bow was still viable, game hunting was still the dominant food procurement strategy, non-intensive fishing by small groups worked just fine, and small patches of steppe and forest-steppe continued to open up. Consequently, the crowding and competition which had become a reality of life on the open landscape may have discouraged these people from moving out of the woods.

With the demands for cooperative fishing never as pressing as during the EN, LN groups remained relatively small and never organized themselves into anything resembling the large Kitoi alliances. Due to an overall lower reliance on fishing, and using mainly its less-intensive forms, the LN pattern displayed a much narrower range of microregional differences than that characterizing the EN. With competition for access to resources, capable marriage partners, and demand for specialized craftsmen and leaders all less intense than during the EN, LN groups also displayed a much lower level of inter- and intra-group social and economic differentiation.

Recent examination of the chronology and variation of Serovo cemeteries in the Little Sea—better documented than those on the Angara and Upper Lena—offers additional relevant insights (Bronk Ramsey et al., 2020; Goriunova et al., 2020). Although the history of the Serovo pattern in this area was quite long, none of the cemeteries grew to a considerable size and most were used at different times. Moreover, all individuals with the GFS diet belong to the same, rather long, dietary trend, regardless of the location of the cemetery in which they were interred. This continuity implies that most of these groups functioned sequentially rather than concurrently; that their home ranges, perhaps, moved from place to place around the Little Sea; and that LN overall population size and density were still rather low. These inferences suggest a foraging strategy similar to the MN pattern and not much different from the EN approach in this microregion. In sum, it seems that the Serovo strategy in the Little Sea, still optimized for the environmental conditions that prevailed during the MN, lacked the capacity to take advantage of the gradually improving conditions for game hunting. This scenario is likely applicable also to LN groups on the Angara and Lena rivers.

#### 5.4.2. Formation of the Early Bronze Age pattern (4970–3470 cal. BP)

Accounting for the introduction of the EBA pattern—Transition 5 (Table 11)—requires a different approach because, relative to the LN, the technology and subsistence remained essentially the same and the minor climatic and environmental changes were insufficient to explain the shift. General similarities in diet between LN and EBA groups in areas where both have been examined support this notion (Winterhalder and Smith, 1981; Weber et al., 2020; Waters-Rist et al., 2020). Regardless of these continuities, the EBA pattern was still notably different from that of the LN in several important ways.

First, despite a number of similarities, a few key differences (e.g., orientation) make the EBA mortuary protocol almost unmistakably recognizable from that of the LN. This is also true in the Little Sea, where the new orientation makes EBA graves clearly stand out from earlier ones while the orientation of the EN and LN graves was the same.

Second, the numbers of formal cemeteries and graves were considerably higher in the EBA than in the LN—a phenomenon well documented in the Angara valley, on the Upper Lena, and in the Little Sea (Weber and Bettinger, 2010). If the number and distribution of burials can be used as a measure, even a crude one, of population size and distribution, EBA groups must have found a way of packing at least twice as many people into essentially the same environment as LN ones. The Little Sea, in particular, would have been home to as many people as the Angara or Upper Lena microregions—perhaps for the first time in the entire Middle Holocene. If not, there must have been reasons for so many more formal burials and in more numerous cemeteries.

Third, even though all these groups subsisted on the same narrow

**Table 11**
Formation of the EBA cultural pattern—Transition 5.

| Variable | Description |
|---|---|
| Environment | Cooling and drying climate; forest retreat; increasing patchiness |
| Population | Growth in overall size; crowding within open landscape and along ecotones |
| Group size | Larger number of small to medium groups |
| Group mobility | Lower |
| New technology | Copper and bronze objects |
| Hunting | Individual with bow; large, medium, and small game (seal on Lake Baikal) |
| Fishing | Non-intensive and less intensive forms |
| Social relations | Moderate social differentiation; moderate inter- and intra-group competition for access to resources |
| Mortuary activities | Structured formal burials; small to large cemeteries |

range of foods, the EBA HGs displayed a dietary diversity unknown during the LN and more akin to that of the large Kitoi population, as evidenced by data from the Upper Lena and Little Sea microregions (Weber et al., 2020).

Fourth, despite the potentially substantial population growth and increased dietary diversity, there is little evidence for a concomitant increase in socio-political differentiation. To be sure, the wealthy EBA burials are somewhat richer than those of the LN, but they are far from the wealthy Kitoi interments, both in number and diversity of grave goods.

Thus, relative to the LN foragers, EBA groups were able not only to pack more people into the same space and to generate new dimensions of dietary variation, but also to retain relative socio-political equality despite the ecological differences between microregions. While the large numbers of EN Kitoi people on the Angara and in Southwest Baikal produced considerable socio-political inequality, the equally large, or even larger, EBA population—especially in the Little Sea—did not have the same effect. Apparently, the EBA pattern was driven by factors other than climate, environment, and technology.

The most parsimonious explanation for the relatively smooth transition into the EBA pattern seems to be the introduction of a different socio-economic organization, which may have involved any of the following: (1) New mechanisms of land tenure that reduced the menace, costs, and risks inherent to competition and hostilities between neighbours; (2) New patterns of group formation, marriage, and descent that improved labour efficiency and access to home ranges over generations; (3) Expanded exchange networks that gave better access to resources not available locally; and (4) More equitable distribution of and access to wealth, prestige, and power between genders and age groups that lowered internal competition [e.g., Kelly, 2013].

These innovations lifted the barriers to population growth present during the LN and would have also encouraged people still living in the forest to come out and join the growing number of HGs building new and prosperous community. The EBA groups were likely firmly based within smaller home ranges and travelling less within and between microregions. The EBA strategy was not an adaptation to the demands of intensive fishing, like the Kitoi, but rather a strategy optimized for the stable environmental conditions which favored game hunting.

The socio-economic significance of small to medium cemeteries, such as Khadarta IV, now seems clearer. They likely represent multiple generations of leaders of specific socio-economic units, each operating within their home ranges and controlling the use of local food resources. In the process, some of these small units may have increased their reliance on one type of food or another. The socio-economic role of Khuzhir-Nuge XIV, the largest known EBA cemetery in the entire Cis-Baikal, however, is less clear. It has been hypothesized to be a "community" cemetery in contrast to "specialized" ones: the former—disposal places for members of many local units and including all age groups, women and men, and people of various social positions and roles; the latter (e.g., Khadarta IV or Kurma XI)—resting places for select individuals, mainly adult males (McKenzie et al., 2008). Perhaps, but such classification is only the first step in addressing a few important questions. For example, Why, as revealed by recent chronological analysis (Bronk Ramsey et al., 2020), did the need for a community cemetery arise only during the second half of the EBA in the Little Sea? Or, Why did the smaller specialized cemeteries rarely have rows while Khuzhir-Nuge XIV had many? And, Why is Khuzhir-Nuge XIV the only cemetery in the area with such a complicated spatio-temporal structure and a large group of individuals with the GF diet?

It is useful now to reconsider the place of origin of the EBA Little Sea individuals with GF diet. It has been suggested that these people came from the Upper Lena (Weber and Goriunova, 2013) but this may not be the case, as noted by Schulting et al. (Schulting et al., 2015), because the Upper Lena EBA and Little Sea EBA GF diets differ slightly in terms of carbon isotopic values and, more importantly, in terms of their radiocarbon offsets. In light of the argument presented here, perhaps it was instead the people from the woods around the Little Sea who are represented by the GF diet group.

The last matter to consider is the role of copper and bronze objects in the formation of the EBA socio-economic pattern. It has long been accepted that the appearance of such artifacts was essentially synonymous with the beginnings of the Glazkovo mortuary tradition, thus implying some sort of link between them. This new technology, with no connection to any aspect of LN crafts, was probably introduced from the outside, and most metals were probably made elsewhere too, for evidence of local manufacturing is absent. Where the copper and bronze objects came from is not particularly vital to this examination. However, whether or not the formation of the EBA socio-economic pattern, including its mortuary protocol, was in fact coterminous with the appearance of the first metals is relevant to understanding the LN–EBA transition because there is no inherent reason why it should be.

Recent assessment of the chronology of EBA cemeteries, burials, and associated metal artifacts, however, is inconclusive on this point. This is because the available radiocarbon evidence suggests that Glazkovo graves appeared first in the Angara valley but the number of dated burials with metals is currently extremely small there (n = 2) and the sample of dated burials is small too (n = 19) (Bronk Ramsey et al., 2020) even though about 200 interments are known (Table 2). Regardless of the timing, once metal objects were introduced they likely became valued and desired items, playing an important role in acquiring prestige and status, and that persons commanding their distribution probably garnered much influence within Cis-Baikal and beyond. As such, competition over access to metals and control over local and external exchange networks, involving also other goods not available locally, may have led to social tension. The evidence emerging now from Khuzhir-Nuge XIV suggests that, indeed, status and prestige were frequently contested during the second half of cemetery use, which dates to the latter portion of the Glazkovo interval (Bronk Ramsey et al., 2020). Detailed assessment of this matter requires more work.

The material presented here implies that, overall, the EBA system was relatively stable. Consequently, its end—Transition 6—might have had little to do with environmental change, resource depletion, or socio-economic stress (Table 12). More likely, it was influenced by the arrival of horse-mounted pastoralists from outside the region with a preference for the open landscape to be used as pasture for domesticates (horse and cattle) as well as for supplementary game hunting. They may have also arrived with improved weapons such as more powerful bows (recurve?), arrows and spears with metal points, and with bronze axes, daggers, and perhaps even swords. Unable to compete with such military "muscle", the EBA groups would have resorted to one of the only two available survival tactics: join the unassailable newcomers or disperse into the woods, likely employing both to some degree.

**Table 12**
Termination of the EBA cultural pattern—Transition 6.

| Variable | Description |
|---|---|
| Environment | Stable, essentially modern climatic and environmental conditions |
| Population | Arrival of horse-mounted pastoralists with superior bronze weapons and recurve bow(?)<br>Dispersal of the EBA population into the forest<br>Assimilation of the remaining EBA groups into the immigrant population |
| Group size | Small groups in the forest |
| Group mobility | High in the forest |
| New technology | Limited use for the new weapons and horse in the forest |
| Hunting | Individual with bow in the forest; large, medium, and small game |
| Fishing | Non-intensive in the forest |
| Social relations | Limited social differentiation |
| Mortuary activities | No or rare formal burials in the forest |

## 6. Summary

The Middle Holocene HG groups of Cis-Baikal obviously had no control over the long-term climatic and environmental changes affecting the region. Of these, the most important in terms of impacting the entire HG adaptive strategy, were changes in the distribution of boreal forest and the corresponding changes in the distribution of open landscape and its game resources. Although these HGs might have had equally little say over which technological innovations were introduced into the region and when, they were in full command of whether or not to adopt them and how to adjust them to the local environmental and cultural settings or, alternatively, how to modify the existing socio-economic systems to make them work.

The bow-and-arrow was clearly the driving force behind the entire Kitoi pattern. Local HG groups had been "primed" for this technology for some time, as evidenced by LM developments, which imply that already back then people were trying to cope with expanding forests, population crowding, and diminishing returns from hunting, but were unable to solve these problems with available means. If the bow had arrived earlier, the Kitoi pattern likely would have formed earlier and may have also lasted longer. If it had arrived somewhat later, the Kitoi pattern would very likely have been short-lived and, perhaps, would not have had enough time to develop to the same degree. If the bow had appeared much later, when the forests had reached their maximum expansion or were already in retreat, the Kitoi probably would never have developed at all.

While the bow-and-arrow "formed" the Kitoi pattern, its spatial distribution across Cis-Baikal was controlled by the environment: the combined effects of the availability of open landscape with its large and medium game, as well as access to fisheries that were suitable for intensification—the latter a practical use of the labour surpluses generated by bow hunting and a necessary response to the growing risks of hunting failure and diminishing returns. This is why the Kitoi pattern was confined to the upper section of the Angara and Southwest Baikal, the rest of the Angara and the Upper Lena probably already overgrown by forest, and the fishery of the latter never good enough. In the Little Sea, game was probably too thin and the fisheries did not meet all the conditions of intensification.

The bow also "wrote" the final chapter in the history of the Kitoi pattern, serving as a crucial factor in its dismantling. The bow allowed Kitoi groups to disband and disperse, the only viable solution under the changing environmental conditions, leading directly to the formation of the MN cultural pattern. The new pattern endured across Cis-Baikal for a long time and would likely have continued for much longer, if it were not for the change in climate which gradually reversed the forest trend from expansion to stabilization and, eventually, retreat.

While gradual climate and environmental changes were more important than bow technology for the formation of the LN cultural pattern, it was the availability of the bow that enticed the forest people to return to the patches of steppe and forest-steppe opening up across Cis-Baikal. Increased returns from game hunting generated labour surpluses, this time channeled mainly—at least initially—to population growth. The bow of the LN people was a different version of the composite bow with which the Kitoi people dispersed a few thousand years earlier. The shorter Kitoi bow would have been more effective in the forest and along ecotones where game needed to be approached closely, while the longer, and perhaps more powerful, Serovo bow would have been more practical in the open landscape where it was difficult—and risky—to try and approach game closely. Under these conditions, the LN pattern was less restricted spatially than the EN Kitoi. Consequently, a "new Kitoi" did not form and the LN system differed substantially from the highly socially and economically differentiated EN pattern. While subtle, the role of the bow in facilitating this new arrangement is evident and logical.

The factor that limited further growth of the LN pattern was its socio-economic organization, which remained based on the MN model, adapted to life in the forest: small, dispersed groups with high residential mobility operating within large home ranges. Although the system likely did not create too many problems because of the expanding open landscape, the related to it improving conditions for red and roe deer, and the efficiency of bow hunting, it nevertheless limited growth. The point is, that just as LM groups were "ready" for the arrival of the bow, LN groups were "ready" for socio-economic reform.

What directly prompted reform at this particular time and why its main archaeological manifestation involves changes in mortuary protocol is unclear. Neither seems related to the introduction of metal objects which was probably a later development. Two points, however, are clear. First, it was important for EBA people to show continuity with LN groups through the frequent placing of their graves in close spatial proximity to LN graves. Second, new organization allowed for the packing of many more groups, and a lot more people overall, into the same space. It also created conditions for the expansion into new places where less intensive forms of fishing could be practiced regardless of fishery quality. Of all Middle Holocene cultural patterns with a substantial mortuary component (i.e., excluding the LM and MN), EBA groups are the first that were not only present in roughly equal numbers in all microregions but the model looked essentially the same everywhere. This means that EBA groups were able to lift the environmental and cultural barriers that restricted the spatial distribution and growth of previous patterns. In sum, the EBA system was so successful because of environmental stability, socio-economic reorganization, and much lesser reliance on fishing.

Overall, the expansion and retreat of boreal forest was important because it directly affected the distribution and abundance of large and medium terrestrial game, the core of HG subsistence in Middle Holocene Cis-Baikal. The bow was important because its increased return rates provided a solution to the problems created by the expanding forest. Moreover, adoption of the bow as the dominant hunting technique was the most likely, and perhaps the only, means of reorganizing food procurement in Cis-Baikal enough to set the intensification of fishing in motion [Bettinger, 2015: 44]. These two processes were the main factors in the formation of the Kitoi pattern. While the bow subsequently created a series of new problems for these people, at the same time it offered a solution: dispersal into the expanding forest, which would not have been equally successful with the atlatl or spear. The bow made life on the taiga viable until the retreating forests opened enough landscape for people to start leaving the woods. And again, it was the bow that made this a relatively smooth transition. Obviously, the bow was crucial not only because of its technological superiority in game hunting but also because of its flexibility: working equally well for HG groups of any size and in any environment.

Fishing and fisheries were important because they worked as a differentiating force: the more intensive the fishing, the more limited its spatial distribution and the greater the microregional differences between cultural patterns. Thus, intensive fishing and game hunting pulled the adaptive strategies in two opposing directions: fishing towards differences and hunting towards similarities between groups and microregions.

Lastly, social relations were important because they provided something that none of the other factors could: finetuning the social fabric that helped optimize operation of the general strategy. It is clear that the social organization changed several times over the Middle Holocene and future research will have to examine these matters in more detail.

It is possible that the EN Kitoi people, facing mounting economic difficulties, attempted to reform their social structure but any such efforts were unsuccessful under the overwhelming pressure of encroaching forests and diminishing returns from hunting. It is also possible that no new social solutions were explored because there was not enough time and the pressures were too strong. Phase 2 at Shamanka II, for example, suggests a return to the same pattern that forced the abandonment of the area not long before. The LN–EBA transition,

however, was of a very different character as it worked on many levels—social, economic, and demographic—making the EBA strategy equally successful across the entire region regardless of local environmental differences. It would be interesting to see how the EBA pattern continued to evolve, had its trajectory not been truncated by the arrival of horse-mounted pastoralists.

## 7. Conclusions

This examination provides a general account of the evolution of Middle Holocene HGs in Cis-Baikal, emphasising internal factors and developments on a regional scale. Many local differences and details have been highlighted too, though their explanation is beyond the scope of this assessment and, in many instances, the empirical data are still insufficient to address these matters. For example, from the analysis of the currently available set of 560 radiocarbon dates (Weber et al., 2020), it is already evident that the regional scale masks differences between microregions in the timing and duration of cultural developments. Logically, any microregional offsets in the timing of a given phenomenon would make its duration longer on a regional scale. Whether or not these differences are an artifact of several still relatively small samples is not yet clear (Weber et al., 2020; Bronk Ramsey et al., 2020).

Certainly, there are other equally pressing inquiries. First is the history of boreal forest distribution within each archaeological microregion as not enough is currently known about this matter. Next is the spatio-temporal variation in the genetic make-up of these groups for, again, little has been done so far and the data currently available offer ambiguous insights. The potential for this rapidly growing approach to provide a range of novel information is very strong. Regional, microregional, and cemetery scales of analysis are of obvious interest, but equally important are even smaller units such as cemetery sectors and clusters, rows of graves, graves with multiple interments, and dietary groups. Lastly, many new details of social relations, beyond the generalities currently available, can be revealed through a systematic assessment of the large body of mortuary data.

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## Declaration of Competing Interest

None.

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