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Corrigendum to "Middle Holocene hunter–gatherers of Cis-Baikal, Eastern Siberia: Chronology and dietary trends" [Archaeological Research in Asia 25 (2021) 100234]

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The authors regret to inform that they have found a few incorrect numbers in Table 1 of the paper. The authors would like to apologise for any inconvenience caused.

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Table 1

Geographic and cultural distribution of radiocarbon dates analyzed in the paper: A. Numbers of radiocarbon-dated cemeteries. In cases where more than one mortuary tradition was represented at a given location, each was counted as a separate cemetery. For example, the Ust'-Ida I cemetery on the Angara had graves of the Kitoi (EN), Isakovo (LN), and Glazkovo (EBA) mortuary traditions graves and, therefore, counted as three separate cemeteries.

A. Numbers of dated cemeteries

	Mortuary tradition					
Micro-region	Khin	Kitoi	Isakovo	Serovo	Glazkovo	Row Totals
Angara	3	9	2	1	7	22
Baikal SW		1			1	2
Little Sea	8			6	10	24
Upper Lena South	4		1	3	9	17
Column Totals	15	10	3	10	27	65

B. Numbers of corrected radiocarbon dates

Micro-region	Khin	Kitoi	Isakovo	Serovo	Glazkovo	Row totals
Angara	3	105	37	3	27	175
Baikal SW		120			9	129
Little Sea	16			26	132	174
Upper Lena South	6		1	36	39	82
Column Totals	25	225	38	65	207	560

C. Percentages of corrected radiocarbon dates by mortuary tradition

Micro-region	Khin	Kitoi	Isakovo	Serovo	Glazkovo
Angara	12.0	46.7	97.4	4.6	13.0
Baikal SW	0.0	53.3	0.0	0.0	4.3
Little Sea	64.0	0.0	0.0	40.0	63.8
Upper Lena South	24.0	0.0	2.6	55.4	18.8
Column totals (%)	100.0	100	100	100	100

D. Percentages of corrected radiocarbon dates by micro-region

Micro-region	Khin	Kitoi	Isakovo	Serovo	Glazkovo	Row totals (%)
Angara	1.7	60.0	21.1	1.7	15.4	100
Baikal SW	0.0	93.0	0.0	0.0	7.0	100
Little Sea	9.2	0.0	0.0	14.9	75.9	100
Upper Lena South	7.3	0.0	1.2	43.9	47.6	100

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Full length article

Middle Holocene hunter–gatherers of Cis-Baikal, Eastern Siberia: Chronology and dietary trends

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ABSTRACT

Analyses of radiocarbon dates (all corrected for the freshwater reservoir effect) and associated stable isotope values obtained from the skeletal remains of ~650 individuals provide many new insights about Middle Holocene hunter–gatherers (HGs) of the Cis-Baikal region, Eastern Siberia. The new radiocarbon evidence clarifies the culture history of the region by defining better the boundaries between the chronological (archaeological periods) and cultural (mortuary traditions) units, as well as our understanding of the transitions between them. Furthermore, differences between the four archaeological micro-regions with regard to the timing and duration of these culture historical units have come into focus for the first time. In terms of dietary patterns, the Early Neolithic foragers of the Angara and Southwest Baikal trended towards a greater reliance on aquatic foods. A similar trend was found in the Late Neolithic (LN) Isakovo group on the Angara, while the LN Serovo group in the Little Sea trended towards an increased dietary reliance on terrestrial game. In the Early Bronze Age HGs, a mosaic of dietary patterns was found: some groups experienced dietary shifts (frequently emphasizing different foods), while other groups displayed stability. Such differences were found even between close neighbours. All these results suggest significant variation in patterns of culture change within and between archaeological periods, mortuary traditions, and micro-regions. Some cultural patterns developed at a quick pace, others much more slowly; some appear to have collapsed rapidly, while others probably went through a more gradual transition to a different pattern. Additionally, this large set of radiocarbon dates allows novel insights into patterns of cemetery use: some seem to have been used continuously, others only sporadically, and some show long periods of disuse. Moreover, some cemeteries of the same mortuary tradition were apparently in use substantially earlier than others were even established. In sum, Cis-Baikal Middle Holocene HG strategies underwent a range of changes not only at the boundaries between relevant culture historical units but also within such units. New insights suggest considerable spatio-temporal variation in the nature, pace, and timing of these developments.

1. Introduction

Two papers of this special issue are dedicated to chronology of Middle Holocene hunter-gatherers (HG) of Cis-Baikal, Eastern Siberia.[1] This study focuses on the matters of culture historical periodization and dietary changes while the second paper (Bronk Ramsey et al., 2020) examines temporal aspects in the development of the various mortuary traditions in the region as well as the chronological structure and patterns of cemetery use.

It will be demonstrated in this paper that examination of past hunter-gatherer adaptive strategies can generate new and important insights when stable isotope analysis (carbon and nitrogen) of human skeletal

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[1] Cis-Baikal is the area of about 200,000–250,000 km^2 (roughly the size, for example, of the United Kingdom) located immediately west of Lake Baikal between its northwest coast and Ust'-Ilimsk on the Angara (Fig. 1).

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remains is combined with radiocarbon dating of each individual. The approach is particularly powerful when dealing with large numbers of individuals, allowing the examination of both synchronic and diachronic patterns, the latter including also dietary trends, over a temporal scale relevant to human lifetimes. This applies to Middle Holocene HGs in the Cis-Baikal region. From the time of the first applications of the stable isotope method to archaeology [e.g., Chisholm et al., 1982; Schoeninger et al., 1983; Vogel and van der Merwe, 1977; Tauber, 1981], units of analysis have been normally defined based on geographic (e.g., region, archaeological sites, coast, inland etc.), broad chronological (e.g., Mesolithic, Neolithic etc.), and economic (e.g., HG, farmers etc.) criteria. While there are exceptions, radiocarbon dating often has been limited to a small sample of individuals analyzed isotopically with the chronological placement of the others assumed to be broadly similar based on context or other archaeological data.

Over the last few decades this approach has helped to document past diets and subsistence patterns as well as to elucidate other aspects of human behaviour in a broad range of geographic, chronological, and cultural settings. Given the isotopic variation present in the marine ecosystem, studies in coastal settings have been especially effective in documenting variability in the use of marine food resources [e.g., Chisholm et al., 1983; Eerkens and Bartelink, 2013; Fischer et al., 2007a; Guiry et al., 2015; Kusaka et al., 2010; Newsome et al., 2004; Schulting and Richards, 2001, 2002; Tsutaya et al., 2014; Yesner et al., 2003; Walker and DeNiro, 1986]. Given the less predictable isotopic values of freshwater systems, studies in such settings have been more challenging, nonetheless demonstrating considerable variability in the dietary use of aquatic foods [e.g., Bonsall et al., 2000; Eriksson et al., 2003; Lillie et al., 2011; Lovell et al., 1986; Meadows et al., 2020; Schoeninger, 1999]. Novel approaches involving the application of stable sulphur isotope analysis and single amino acids have also been brought to bear on the question of using freshwater foods [Naito et al., 2013; Nehlich et al., 2010].

The variability identified in the abovementioned studies has generally been linked to factors such as location, migrations, mobility (i.e., the presence of 'outsiders'), identity or ethnicity, age and sex. Temporal change, other than considered in large time-blocks, has received less attention. This is because, in the absence of systematic radiocarbon dating, the units of analysis, however defined, are essentially chronologically flat, while in fact they may encompass individuals that are separated from one another by centuries. In other words, such units of analysis lack temporal resolution (i.e., historical depth). Inevitably, this forces an assumption, at least implicit, that no dietary change occurred within such units (periods). This presents serious limitations regarding the examination of finer-scale patterns in HG diets, including trends, and how they might relate to other factors (e.g., environmental or technological changes).

Cis-Baikal presents great potential to explore isotopic, and hence dietary, variability among HGs in boreal settings. Its innate advantages are: (1) The unique isotopic ecology of Lake Baikal, with different species of fish and an endemic seal exhibiting the range of isotopic variability reminiscent of marine rather than northern lacustrine settings [Katzenberg and Weber, 1999a; Katzenberg et al., 2009, 2012; Weber et al., 2011]; and (2) The availability for analysis of a very substantial number of HG skeletal remains with generally excellent bone preservation (from cemeteries ranging in size from a few burials to hundreds) and spanning the entire Middle Holocene. The large sample size allows the robust (i.e., statistically significant) identification of even relatively subtle differences within and between groups, as well as over time. This last aspect is facilitated by the Baikal Archaeology Project's methodology that includes the combined stable isotopic (carbon and nitrogen) analysis and radiocarbon dating of all individuals. It is this aspect of the general approach that allows examination of diachronic trends in far greater detail than is usually possible, particularly for prehistoric HGs.

Until very recently, it was not possible to take full advantage of the opportunities inherent to the Cis-Baikal materials. The stable isotope results clearly indicated that essentially all Middle Holocene HGs of the region relied to variable degrees on aquatic foods [Weber et al., 2011], thus implying that the radiocarbon age of human skeletal remains was potentially impacted in an equally variable manner by the freshwater reservoir effect (FRE). This issue is not unique to Cis-Baikal, and affects the vast majority of HG studies in coastal, riverine, and lacustrine settings, complicating the development of accurate chronologies [e.g., Cook et al., 2001; Fischer et al., 2007b; Meadows et al., 2016; Molto et al., 1997; Schulting and Richards, 2001; Yoneda et al., 2002; Wood et al., 2013]. The discovery of the FRE in the Baikal ecosystem [Nomokonova et al., 2013] and the development of the method to correct it [Bronk Ramsey et al., 2014; Schulting et al., 2014, 2015, 2020] has facilitated a new stage of research. This is important for at least three reasons.

First, the new ability to correct radiocarbon dates obtained on human skeletal remains, the main source of data for chronological studies on Middle Holocene HGs in the area, requires that all previously defined chronological boundaries [Weber et al., 2010] are reassessed and accordingly revised, and not only on the regional scale but for each of the archaeological microregions separately. This is essential also because the FRE-corrected cultural chronology can now be matched better with other chronological sequences not subjected to FRE biases,

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	Mortuary tradition					
Micro-region	Khin	Kitoi	Isakovo	Serovo	Glazkovo	Row Totals
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C. Percentages of corrected radiocarbon dates by mortuary tradition.						
Micro-region	Khin	Kitoi	Isakovo	Serovo	Glazkovo	
Angara	12.0	46.7	97.4	4.6	13.0	
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Little Sea	64.0	0.0	0.0	40.0	63.8	
Upper Lena South	24.0	0.0	2.6	55.4	18.8	
Column totals (%)	833	100	100	100	100	
D. Percentages of corrected radiocarbon dates by micro-region.						
Micro-region	Khin	Kitoi	Isakovo	Serovo	Glazkovo	Row totals (%)
Angara	1.7	60.0	21.1	1.7	15.4	100
Baikal SW	0.0	93.0	0.0	0.0	7.0	100
Little Sea	9.2	0.0	0.0	14.9	75.9	100
Upper Lena South	7.3	0.0	1.2	43.9	47.6	100

A. Numbers of radiocarbon-dated cemeteries. In cases where more than one mortuary tradition was represented at a given location, each was counted as a separate cemetery. For example, the Ust'-Ida I cemetery on the Angara had graves of the Kitoi (EN), Isakovo (LN), and Glazkovo (EBA) mortuary traditions graves and, therefore, counted as 3 separate cemeteries.
B. Numbers of corrected radiocarbon dates.
C. Percentages of corrected radiocarbon dates by mortuary tradition.
D. Percentages of corrected radiocarbon dates by micro-region.

such as climatic and environmental histories. Second, the availability of a large body of corrected dates offers the unique potential to investigate other bodies of archaeological and bioarchaeological data generated over the last few decades through examination of Cis-Baikal Middle Holocene human skeletal remains from the perspective of HRC. This is expected to provide important new insights about many aspects of HG behaviour in the area. And third, all this combined provides an opportunity for an entirely fresh synthesis of the entire corpus of archaeological, bioarchaeological, and paleoenvironmental information currently available, both old and new, as well as explanation of the identified spatiotemporal patterns of cultural variation and change. This is attempted in a different paper of this volume [Weber, 2020].

The previous step of this work focused on the initial reassessment of the regional culture historical boundaries and identification of dietary trends among Cis-Baikal Middle Holocene HGs, the former employing a set of 256 corrected radiocarbon dates, the latter informed by analysis of such dates in conjunction with human carbon and nitrogen stable isotope results available for each of the dated human individuals [Weber et al., 2016a, 2016b]. Neither of these tasks was realistic prior to the development of the new method of correcting radiocarbon dates on human skeletal remains for the FRE. While a few other papers in this volume also contribute to these broad objectives, the express goals of this study are: (1) To define better period boundaries of the regional Middle Holocene culture history; (2) To begin, whenever possible, building microregional chronologies; and (3) To expand search for dietary trends at regional, microregional, and group levels.

2. Materials

This analysis is based on 560 sets of radiocarbon dates and stable isotope measurements currently available for the Middle Holocene HGs of Cis-Baikal (Table 1), more than a twofold increase since the first study [Weber et al., 2016b]. As before, young children (0–5 years old, $n = 55$) are excluded from this examination for two reasons: first, their stable isotope measurements are expected to be affected by breastfeeding [Waters-Rist et al., 2011]; and second, the same nursing effect makes the matter of correcting their radiocarbon dates complicated [Schulting et al., 2014]. An additional seven sets of results have been removed from analysis for such reasons as the unknown skeletal age of the dated individual, uncertainty over duplication of an already existing date for a given individual, or an obviously aberrant ^{14}C date that could not be presently rectified by an analysis of a different sample.

Included in the analysis is the Early Neolithic (EN) female from Shamanka II (SHA_2004.042.02,[2] Supplement 1) who was previously excluded because her adult bone stable isotope measurements, and particularly the δ^{15}N value, indicated a diet much different from the rest of the Shamanka II cemetery population. Therefore, the equation used to correct ^{14}C dates from Shamanka II was considered not applicable to this case. In the meantime, molars from this female have been subjected to sequential dentine microsampling for stable isotope analysis producing childhood and adolescent results well within the range of variation characteristic of the remainder of the Shamanka II population. Consequently, the ^{14}C date for this individual has been corrected now using the stable isotope data from molar microsampling, allowing its addition to the current dataset.

With the exception of Southwest Baikal, which was already very well represented, the number of available ^{14}C dates and associated stable isotope signatures for the other three microregions and relevant mortuary traditions within them at least doubled (Table 1). In the Angara valley the count increased from 76 to 176 analyzed individuals, in the Little Sea microregion from 64 to 174, and on the Upper Lena from 27 to 82. For specific mortuary traditions, the most important changes regard the *Isakovo* and *Serovo* group, with the number of analyzed individuals increasing from 22 to 103. Within each microregion, the most consequential are the much larger numbers of biochemical results now available for the *Serovo* mortuary tradition in the Little Sea (from 8 to 26) and on the Upper Lena (from 0 to 36).

Despite this substantial expansion, the new dataset is still not as representative in cultural and spatial terms as one would wish it to be (Table 2). For example, on the Angara, of the total of ~578 archaeologically well documented burials of known mortuary tradition, only 176 (30%) have biochemical results, a mere 3 represent the *Serovo* mortuary tradition, and for the *Isakovo* group only 1 date comes from a cemetery other than Ust'-Ida I. In the Little Sea microregion, the overall percentage is about 50% and all relevant mortuary traditions are essentially equally represented. The same regards the Upper Lena, where the number is even higher (57%), but mostly on the account of the almost complete dating of Verkholensk [White et al., 2020a]—by far the largest cemetery known to date in this microregion [Okladnikov, 1978], which also dominates the *Serovo* group of burials there. Also, the Upper Lena has seen much less fieldwork than the other microregions. Some of these biases are addressed further in the Discussion section.

Absent from the analyzed dataset is burial No. 3 (1972) from Shamanskii Mys on the Ol'khon Island in the Little Sea microregion. The burial is of interest because it shows a few similarities with the *Kitoi* mortuary tradition from the Angara valley and Southwest Baikal as well

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. For the following reasons the numbers presented in Table 2 differ somewhat from those published previously (Weber and Bettinger, 2010: Table 3):

Mortuary tradition Period	Category	Microregion				Total
		Angara	Baikal SW	Upper Lena S	Little Sea	
Khin LM–EN	Cemeteries	6		6	10	22
	Graves	8		12	38	58
	Individuals	8		14	44	66
Kitoi EN	Cemeteries	13	1			14
	Graves	147	99			246
	Individuals	215	159			374
MN	Lack of documented formal cemeteries					
Isakovo LN	Cemeteries	23		1		24
	Graves	94		1		95
	Individuals	124		1		125
Serovo LN	Cemeteries	4		5	10	19
	Graves	19		30	42	91
	Individuals	20		51	70	141
Glazkovo EBA	Cemeteries	47	1	12	16	76
	Graves	193	12	65	200	470
	Individuals	211	14	77	230	532
Totals	Cemeteries	93	2	24	36	155
	Graves	461	111	108	280	960
	Individuals	578	173	143	344	1238

(1) Graves with incomplete archaeological information and thus uncertain assignment to specific mortuary tradition (e.g., generically classified before as Neolithic) are excluded;
(2) Graves are grouped by mortuary tradition rather than by archaeological period as before;
(3) Several graves have been assigned to a different mortuary tradition based either on the reassessment of the archaeological information or on the radiocarbon date;
(4) The Upper Lena North micro-region is excluded; and.
(5) Late Bronze Age graves, included previously in the Bronze Age category, are excluded.

[2] Master ID numbers contain the following information: mnemonic name of the cemetery (e.g., K14 for Khuzhir-Nuge XIV); excavation year (e.g., 1997); grave number (e.g., 007), and burial number in cases with multiple interments in the same grave.

as a few rather unique characteristics. Three ^{14}C dates exist for this grave: 5720 ± 50 BP measured on a wood sample at a laboratory in Leningrad, Russia [Konopatskii, 1982: 71], 6550 ± 35 BP measured also on wood at a laboratory in Novosibirsk, Russia [Konopatskii, 1982: 71], and 6310 ± 80 BP obtained on human bone at the Isotrace Laboratory in Canada [Weber et al., 2006]. The dates on wood don't need correction and the Canadian date can be corrected for the FRE using the stable isotope results ($\delta^{13}C = -18.3‰$, $\delta^{15}N = 13.7‰$) available for the same bone sample [Weber et al., 2011] giving the age of 6038 ± 95 BP. The three dates do not combine in any combination and rejecting the suspiciously young date on wood does not help much as the two other dates do not combine either. Thus, the biochemical results available for the SHM_1972.003 burial are not included in the present study, hoping that it will be possible to resample its skeletal remains for repeat tests. Still, the much larger dataset of ^{14}C dates and stable isotope results allows significant expansion of the analytical scope of this examination as outlined later.

3. Typological classification

A few summaries of the variation in Middle Holocene mortuary practices in Cis-Baikal have been published recently in English [e.g., Bazaliiskii, 2010; Bazaliiskiy and Savelyev, 2003; Goriunova, 2010; Goriunova et al., 2020a; Goriunova et al., 2020b; Weber, 1995; Weber and Bettinger, 2010; Weber et al., 2016b]. Rather than repeating these again, the matter is presented in a succinct but systematic format making sure that the same points are covered for each mortuary tradition. For a more comprehensive assessment and understanding of this material, however, examination of the numerous original sources in Russian and the growing number of detailed accounts in English is necessary [e.g., Weber et al., 2008, 2012].

3.1. The earliest Holocene mortuary practices

A.P. Okladnikov [1950] identified two graves showing some very "archaic" characteristics and overall quite different from his four main groups (*Isakovo, Serovo, Kitoi*, and *Glazkovo*, as in his sequence). Subsequent research documented many more such graves, mainly in the Little Sea and Upper Lena microregions where some of them show a few parallels with the *Kitoi* mortuary pattern. In the Okladnikov model, these graves were termed the *Khin* mortuary tradition and dated to the Mesolithic. The *Khin* term, however, is rarely employed anymore because of the substantial amount of variation displayed by this group of graves [Bazaliiskii, 2010; Goriunova et al., 2020a; Weber, 2020]. Their current number is already in the 50–60 range. In this paper, to keep the matter simple, the *Khin* label is used in reference to all graves of this kind from the entire region (Supplement 1). Generally, the appearance of *Khin* graves marks beginning of the Late Mesolithic (LM).

- Distribution: Angara, Little Sea, and Upper Lena.
- Cemetery size: Very small, usually with single or a few graves, rarely several.
- Grave stone structures: Present or absent.
- Body position: Mostly flexed, rarely extended.
- Burial orientation: Variable (N, NW, or E).
- Number of burials: Mostly single interments, sometimes multiple.
- Use of red ochre: From isolated spots to full coverage.
- Grave goods: Small in number but relatively diverse showing similarities with the Mesolithic (e.g., prismatic blades) and the EN *Kitoi* material culture (e.g., fishing tackle including mainly simple and composite fishhooks, harpoons, and leisters). Ornaments and portable art are rare and include red deer canine and boar tusk pendants, and beads.
- Other characteristics: Considerable variation in mortuary characteristics between and within microregions.

3.2. The Kitoi mortuary tradition

Although the *Kitoi* mortuary tradition occupied the wrong chronological position in the culture historical sequence developed by Okladnikov [1950], thus clouding archaeological research on Cis-Baikal Middle Holocene HGs for a long time [e.g., Weber, 2020: Table 1], its current chronological placement within the EN is no longer debated.

- Distribution: Angara and Southwest Baikal (Kultuk Bay).
- Cemetery size: Medium to very large, occasionally single graves.
- Grave stone structures: Predominantly absent.
- Body position: Predominantly extended and occasional flexed, bundled (secondary?), or prone interments.
- Burial orientation: Mostly N, sometimes S (in graves with head-to-toe burials).
- Number of burials: Mostly single; graves with more than one interment are common and in many such cases the burials are arranged head-to-toe and in layers.
- Use of red ochre: Copious amounts, almost omnipresent.
- Grave goods: Variable in kind (60–65 categories) and number (from no grave goods to hundreds). Most common are lithic shanks of composite fishhooks and bifacial arrowheads. Other well-represented categories include stone, bone, and antler tools (unilateral harpoons and a range of points and shafts or handles of composite tools), objects made of green nephrite (knives and adzes). Bone bow stiffeners are known from several graves. Ceramic vessels, mitre-shaped pots with net impressions, are very rare. Common ornaments include rings, beads, and pendants made of red deer canines, boar tusks, or bone. Mother-of-pearl pendants and zoomorphic art (moose heads, fish, and seal) are rare.
- Other characteristics: Differences between microregions and cemeteries include the mortuary use of fire, bear rituals, and post-mortem disturbances. Burials sometimes have missing skulls.

3.3. The Isakovo mortuary tradition

In the Okladnikov [1950] model, the *Isakovo* group marked the beginning of the Neolithic, but it is clear today that it dates to the Late Neolithic (LN). Furthermore, it is chronologically parallel to the *Serovo* group rather than preceding it, as believed by Okladnikov.

- Distribution: Angara. For this study, one of the graves excavated by Okladnikov in 1951 at Verkholensk (No. 13) on the Upper Lena [Okladnikov, 1978] has been identified, based on the orientation of the burial, as potentially representing *Isakovo* (Supplement 1).
- Cemetery size: Small to medium.
- Grave stone structures: Present.
- Body position: Extended supine.
- Burial orientation: Parallel to the Angara River with the heads pointing upstream (generally S).
- Number of burials: Mostly single inhumations but multiple interments (frequently with children) are not uncommon and then arranged side by side on the same level.
- Use of red ochre: Essentially absent.
- Grave goods: 20–25 categories. Mitre-shaped ceramic vessels, recorded in ~70% of graves, are common. Other frequent objects include lithic arrowheads, a range of bone and antler points, bone or antler shafts of double-sided composite tools (daggers and spears), and harpoons. Large lithic bifaces are rare and so is the fishing gear. Ornaments include red deer canine, bone, and boar tusk pendants, none particularly common. Objects of anthropomorphic and other art are rare. Overall, little variation in kind and number of grave goods.
- Other characteristics: Unusually large number of subadult burials at some cemeteries.

3.4. The Serovo mortuary tradition

In the Okladnikov [1950] model, the *Serovo* group was assigned to the middle portion of the Neolithic directly following or preceding *Isakovo* and *Kitoi*, respectively. In today's chronology, *Serovo* is younger than *Kitoi* by a few thousand years and chronologically parallel to *Isakovo*.

- Distribution: Angara, Little Sea, and Upper Lena.
- Cemetery size: Small to medium.
- Grave stone structures: Present.
- Body position: Extended supine.
- Burial orientation: Perpendicular to river (Angara or Lena) with the head pointing away from it. In the Little Sea, generally N, that is also away from the open lake.
- Number of burials: Mostly single inhumations but multiple interments, arranged either side by side on the same level or on top of one another, are not uncommon particularly in the Little Sea.
- Use of red ochre: Relatively frequent but limited to small and isolated patches.
- Grave goods: 30–35 categories. On the Angara and in the Little Sea, egg-shaped ceramic pots are present in all graves. On the Upper Lena, the pots are mitre-shaped and occur in ~50% of graves. Ground stone adzes or axes and composite knives are also typologically similar to the specimens found in *Isakovo* graves on the Angara. Many stone, bone and antler tools are equally common everywhere. Large bifacially formed points (spearheads) are believed to distinguish *Serovo* assemblages from *Isakovo*. On the Angara, arrowheads and composite points, daggers, and knives also differ morphologically from *Isakovo* counterparts. Bow stiffeners made of bone have been documented in at least a dozen of graves, mostly on the Angara but also in the Little Sea [Bazaliiskii, 2010:84; Goriunova et al., 2020b]. Fishing gear (bone and antler harpoons, and a few stone fish-lures) is generally rare although perhaps a little more common on the Upper Lena. Anthropomorphic and zoomorphic art (fish-lures and bird carvings) is rare too. Red deer canine and boar tusk pendants also occur but are not very common. Burials with rich grave goods appear to be more frequent than in *Isakovo*.
- Other characteristics: Differences between and within microregions include mortuary use of fire and employment of birch bark for wrapping or covering interments as well as the frequency of some categories of grave goods as mentioned above.

3.5. The Glazkovo mortuary tradition

Unlike the other mortuary groups, the relative chronological position of the *Glazkovo* group has never been disputed [Okladnikov, 1955]. Since the time it was first defined at the beginning of the 20th century, it has always been associated with the Early Bronze Age (EBA) due to, obviously, the first appearance of copper and bronze objects.

- Distribution: Angara, Southwest Baikal, Little Sea, and Upper Lena.
- Cemetery size: Small to large.
- Grave stone structures: Present.
- Body position: Extended supine, rarely with flexed legs or in "sitting" position (i.e., tightly flexed).
- Burial orientation: On the Angara and Upper Lena parallel to the river with the heads pointing downstream (generally N); in the Little Sea generally parallel to the coastline with heads pointing SW; in Southwest Baikal the graves are oriented N-S or NW–SE with the heads pointing N or NW.
- Number of burials: Mostly single inhumations but multiple interments, arranged side by side on the same level or, rarely, on top of one another, occur too.
- Use of red ochre: Rare and occurs mostly in isolated spots, but in the Little Sea a few burials are entirely, or almost entirely, covered in ochre.
- Grave goods: Many categories found in *Isakovo* and *Serovo* graves are repeated but differ from them in morphological detail (adzes and axes, composite tools, harpoons, bone points, arrowheads, bifaces, etc.). New, or at least much more common than in *Isakovo* and *Serovo* graves, are objects made of white nephrite (disks and rings) but artefacts made of green nephrite also occur. Knives, needles, and fishhooks are the most common utilitarian copper and bronze objects while ornaments include mainly rings and one specimen of a unique medallion depicting the shaman drum. Ceramic pots are rare and fishing gear (composite fishhook shanks and barbs, and harpoons) is even less frequent. Boar tusk and red deer canine pendants as well as small beads occur in all microregions (although not at all cemeteries), the latter much more frequently than the former.
- Other characteristics: Differences between microregions and cemeteries include mortuary use of fire and post-mortem disturbances.

3.6. Summary of typological dating

As noted previously [Weber et al., 2016b], regardless of the range of variation displayed by this entire mortuary evidence, most graves, are relatively easy to classify as long as they display at least some combination of the standard diagnostic characteristics. Difficulties emerge when they do not and, in such instances, only radiocarbon dating can help. This problem applies mostly to the graves identified as *Khin* as well as disturbed or intact graves with few or no accoutrements and particularly so in the Little Sea microregion where the *Serovo* and the earlier mortuary groups display a few similarities, such as the N orientation and the presence of stone structures (Goriunova et al., 2020a, 2020b). Overall, typology works relatively well but only as a general temporal classification tool to identify coherent analytical units for further chronological analysis employing radiocarbon dating.

Based on the typological criteria summarized above, all dated human burials have been assigned to a specific mortuary tradition (MORTRAD, Supplement 1). Only in 8 instances was the published typological classification overwritten based in part on the re-evaluation of the archaeological context and in part on the radiocarbon date:

- K14_1997.007 [Weber et al., 2008], SMS_1987.022, and SMS_1987.024 from *Serovo* to *Khin* [Goriunova, 1997];
- KUL_1977.001 from *Serovo* to *Glazkovo* [Konopatskii, 1982];
- UK4_1959.012 from *Kitoi* to *Serovo* [Komarova and Sher, 1992];
- UK4_1959.014.02 and UK5_1959.001 from *Glazkovo* to *Serovo* [Komarova and Sher, 1992]; and
- VKL_1951.013 from *Serovo* to *Isakovo* [Okladnikov, 1978].

Continued perusal of relevant literature, may justify a few more changes of this kind.

Lastly, we resisted the temptation to identify additional typological groups in the mortuary record, a trend visible in a few recently published pieces [e.g., Bazaliiskii, 2010; Goriunova, 1996, 2002; Goriunova et al., 2020a]. Since none of such new units are particularly well documented or generally accepted yet, their employment in this study would inevitably be quite controversial and not particularly beneficial.

Table 3
Regression equations for correcting radiocarbon dates on human skeletal remains for the Freshwater Reservoir Effect employed in the study [after Weber et al., 2016a].

Microregion	FRE correction equation
Angara & SW Baikal	$Y = -1388.85 + 125.45 \times \delta^{15}N$
Little Sea	$Y = -3329.54 - 125.60 \times \delta^{13}C + 95.11 \times \delta^{15}N$
Upper Lena	$Y = -4289.89 – 211.19 \times \delta^{13}C + 45.38 \times \delta^{15}N$

In sum, the five main mortuary groups—*Khin*, *Kitoi*, *Isakovo*, *Serovo*, and *Glazkovo*—complemented by spatial criteria (microregions and cemeteries) are entirely sufficient for this study to proceed and to provide new useful insights.

4. Methods

The approach developed for the previous two studies [Weber et al., 2016a, 2016b] has been modified only with regard to a few points. Therefore, to save space, presentation of methodological matters is reduced to the necessary minimum. The steps that have remained unchanged are not discussed here further and include the following: (1) All laboratory protocols for dating and stable isotope analyses done at the Oxford Radiocarbon Accelerator Unit, University of Oxford, UK (Supplement 1); (2) Methods 1, 2, and 3 of combining ^{14}C dates in cases where more than one date was produced for the same individual; and (3) Averaging of the chemical data, including the δ^{13}C and δ^{15}N values, from multiple radiocarbon and stable isotope runs. Regarding combining ^{14}C dates, of the 63 individuals with multiple determinations, 60 passed the χ^2 test (Ward and Wilson 1978), while 3 cases failed by only a small margin and were retained in the analysis (Supplement 1).

4.1. Methodological modifications

As mentioned, all conventional ^{14}C dates were first corrected for the FRE using one of the equations from Table 3 and then subjected to Bayesian analysis.

The experience gained from the recent work and the availability of a much larger set of radiocarbon dates justify a few changes to the approach employed previously. The first modification regards the use of

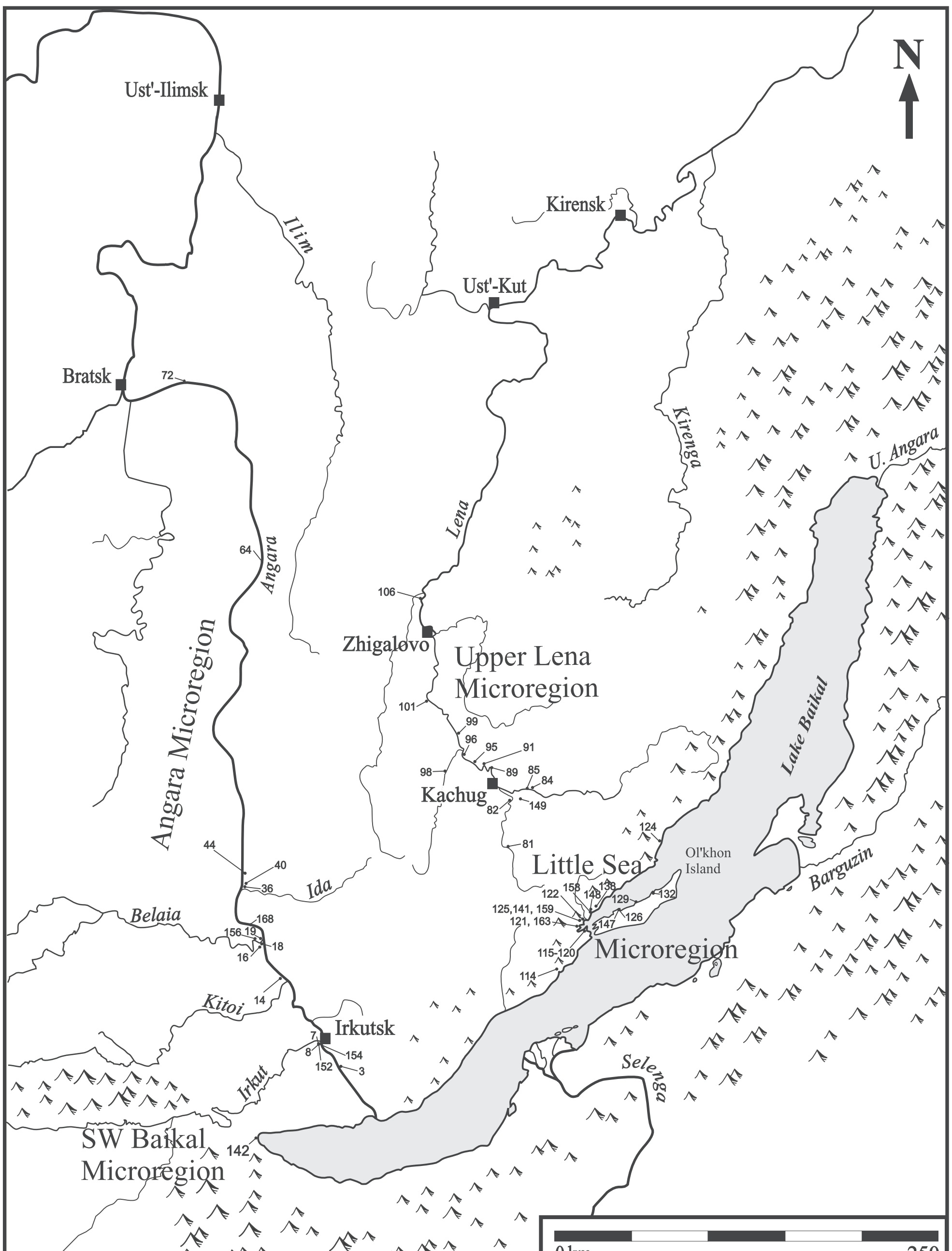


Fig. 1. Cis-Baikal and location of Middle Holocene cemeteries analyzed in the paper. [Black and white].

the correction equations developed for the four microregions of the broader Cis-Baikal. In a vast majority of the cases, radiocarbon dates have been corrected using the equation specific for the microregion where a given cemetery is located. For example, dates from the Ulan-Khada cemetery located in the Little Sea microregion, have been transformed with FRE correction equation developed for this area. In a number of instances, however, the stable isotope data indicate a diet typical of a microregion other than the one where the individual was interred after their death. In such cases, it was deemed justified to apply correction for the microregion implicated by the stable isotope results. More specifically, if stable isotope data for an individual buried at one of the Little Sea cemeteries (e.g., Ulan-Khada) suggested a diet match with the Angara microregion, the latter (i.e., non-local) FRE correction was applied replacing in analysis the date corrected initially with the local equation. Such non-local corrections have been applied in 12 cases, all noted in Supplement 1.

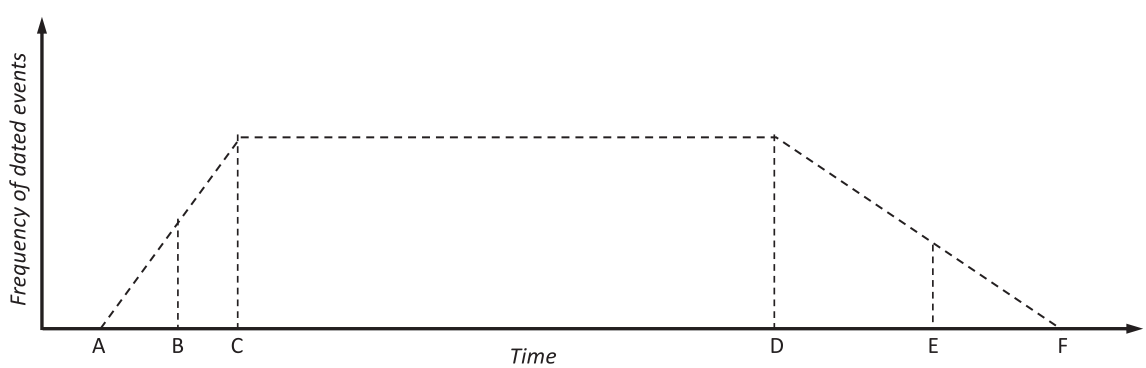
Next, the archaeological materials from the Upper Lena microregion sort themselves spatially into two areas: The South—between and around the towns of Kachug and Zhigalovo; and the North—around the town of Ust'-Kut, some 300 km downstream the Lena River (Fig. 1). Because of this geographic separation, the materials from the Upper Lena North area are not included in the analysis, while all radiocarbon dates currently available for human burials from Upper Lena South, have been corrected using the equation developed for the latter [Schulting et al., 2015]. For brevity, the area is referred to as the Upper Lena microregion.

The Bayesian analysis of the ^{14}C dates has been somewhat modified too in the sense that grouping of radiocarbon dates into analytical units is based explicitly on the mortuary tradition (MORTRAD), assigned to each human burial (Supplement 1). The regional scale of analysis thus employs the following four mortuary groups: *Khin, Kitoi, Isakovo/Serovo*, and *Glazkovo*. These spatially broad groups are further divided into smaller units based on the archaeological microregion. At this scale, whenever the sample size is sufficient, the analysis is conducted using the following five separate mortuary groups: *Khin, Kitoi, Isakovo, Serovo*, and *Glazkovo*. Such approach permits assessment of potential microregional overlaps in the development of relevant mortuary traditions.

Also, the previous analysis was conducted assuming two ideal distributions of the dated events: *Uniform* and *Trapezium*, ran as separate models with all dates available for entire Cis-Baikal included in either [Weber et al., 2016b]. For the following reasons, the current study employs only models built on the assumption of the *Trapezium* distribution. First, the archaeological processes (i.e., development of various mortuary traditions at regional and microregional scales as well as establishment and abandonment of individual cemeteries) examined here are all population level phenomena. As such, changes in the distribution of specific events (i.e., burials) over real time and their accumulation in the archaeological record, particularly at the start and end of each distribution, are expected to be gradual rather than abrupt. Consequently, the transitions between mortuary traditions are expected to be cumulative, potentially overlapping, rather than transformative and non-overlapping as assumed by the *Uniform* distribution model. Second, the *Trapezium* distribution allows assessment of the tempo of cultural processes (i.e., period transitions) while the assumption of the *Uniform* distribution denies such important insights. Limiting analysis only to the *Trapezium* models also substantially reduces the number of various chronological parameters to assess, an important practical consideration as the *Trapezium* models generate a good number of them already. This, however, does not mean that future analyses will not employ the *Uniform* distribution as it may be actually a better fit for some of the units of analysis, particularly in the small to medium size range.

Supplements 2–18 show the structure of the Bayesian models used in this analysis, with the employed OxCal commands explained below:

- *Sequence* to order events within *Phase* (group of events);
- *Boundary* to model an average start and end of each *Phase*;
- *Start* and *End* to find the start and end of each *Boundary* with a gradual transition period; more specifically, *Start* of the lower *Boundary* and *End* of the upper *Boundary* refer to the first and last occurrence of an event within the group of dated events, whereas *End* of the lower *Boundary* and *Start* of upper *Boundary* refer to the points in time between which the frequency of the dated events is assumed to be relatively stable (i.e., neither rising nor declining);
- *Transition* to account for the duration of a non-instantaneous (i.e., gradual) transition period; more specifically, calculated as a difference between the *Start* and *End* of each *Boundary*, lower and upper; and



Legend
A: Start of lower Boundary (*Transition*)
B: Average start of lower Boundary (*Transition*)
C: End of lower Boundary (*Transition*)
D: Start of upper Boundary (*Transition*)
E: Average start of upper Boundary (*Transition*)
F: End of upper Boundary (*Transition*)
A–C and D–F: Duration of lower and upper Boundaries (*Transitions*)
A–F: Temporal range of the dated events (*Span*)

Fig. 2. Explanation of the chronological terms generated by the Bayesian analysis of radiocarbon dates.

- *Span* to define temporal range of the dated events, calculated as a difference between the earliest and latest dated burial within the analyzed dataset.

Fig. 2 illustrates the meaning of some of these terms.

Another modification of the Bayesian analysis regards how the models were executed. Previously, the entire Middle Holocene set of available 256 ^{14}C dates was entered into two separate models, one for the *Uniform* and one for the *Trapezium* distribution, each with the full sequence of dated events divided into four groups. This meant that the various chronological boundaries generated by the models were or were not constrained by the presence or absence of the datasets immediately preceding or proceeding the dataset in question. For example, since in Cis-Baikal there are no human burials dating to the Middle Neolithic (MN), the lower boundary of the proceeding LN was unconstrained in the model by the presence of older dates, while its upper boundary was constrained by the dates representing the following EBA burials. To avoid this kind of inconsistency, in the current analysis, each dataset representing a specific unit of analysis, such as regional or microregional mortuary tradition, has been run as an independent model. Consequently, all generated chronological parameters are independent of any other dataset, thus generating what we believe is a more realistic assessment of each transition, including its timing and tempo. The downside of the approach is that not all parameters generated now are directly comparable to those obtained previously.

Detailed results of each OxCal model are presented in Supplements 19–35, which, in addition to the chronological parameters, show also the technical diagnostic information regarding each model. This diagnostic information is further summarized and discussed in Supplement 36.

As before, the search for trends in Cis-Baikal Middle Holocene HG diets is based on the Pearson product-moment correlation (PCC) tests between mean calibrated radiocarbon dates and δ^{13}C and δ^{15}N measurements obtained from the same samples of human skeletal remains. This approach allows detection of linear trends between the two pairs of variables. Search for nonlinear trends would expand the scope of the current study beyond the available limits and, therefore, is not included. While, admittedly, examination of linear trends only has some limitations, it is still a vast improvement over approaches that do not allow assessment of chronological trends in diet at all.

Our previous work has demonstrated that the ^{14}C dates corrected for the FRE and all additional dates generated through subsequent processing (e.g., mean or median calibrated dates, and mean or median modelled dates), give essentially the same PCC results, all much different from the results using conventional ^{14}C dates prior to correction [Weber et al., 2016a, 2016b]. Since modelled dates depend each time on the structure of the analyzed dataset and, thus change from analysis to analysis, this study reports only results from PCC tests between the two stable isotope measurements and mean calibrated dates (i.e., not modelled; Supplement 1). This ensures direct comparability with future work.

4.2. Units of analysis

The nature of the archaeological materials examined here, allows identification of a number of practical units of analysis—*primary* and *secondary*, both equally important for the understanding of Cis-Baikal Middle Holocene HG history. The *primary* units of analysis are defined based on the combination of archaeological and geographic criteria, the former referring to the mortuary traditions reviewed earlier in the paper, the latter referring to the four archaeological microregions and the Cis-Baikal region as a whole. This alone generates over a dozen primary units of analysis, of which a few are not represented in the dataset at all and a few are too small for further analysis (Table 1). These *primary* units of analysis are used mainly for the assessment of culture history at the regional and microregional scales of analysis.

The *secondary* units of analysis are defined by a combination of additional archaeological or bioarchaeological criteria. The former may include separate cemeteries, spatial units within them, phases of use, or mortuary characteristics, while the latter may employ biological sex, diet groups, or place of birth of the examined individuals. They are particularly applicable to a few large cemeteries such Lokomotiv and Ust'-Ida I in the Angara valley, Shamanka II on Southwest Baikal, Khuzhir-Nuge XIV and Kurma XI in the Little Sea, and Verkholensk on the Upper Lena, most of which have been at the center of our long-term project for many years now (Fig. 1). Such *secondary* units of analysis are employed in the examination of dietary trends only. Questions pertaining to the history of use of individual cemeteries and microregional differences in the development of the main mortuary traditions are addressed in a separate study, an examination that complements this research in several important ways [Bronk Ramsey et al., 2020].

Obviously, to search for additional dietary trends, it is also possible to define units based on various combinations of the *primary* and *secondary* criteria. The challenge here is to identify units that are also meaningful and relatively homogenous in social, economic, and subsistence terms. More specifically, the risk is that such larger units may include smaller ones each pursuing somewhat different dietary patterns thus masking any trends that may have existed (c.f., section 6). Overall, the number of viable units of analysis is rather large but many are too small to yield meaningful results. Consequently, to save space, while a very large number of units, defined in many different ways, have been examined, only results that are considered to be both culturally and statistically meaningful are reported and discussed further.

4.3. Data assessment

A few comments are in order regarding the oldest radiocarbon date from the Verkholensk cemetery. After the FRE correction, the date for VKL_1951.013 is roughly 500 years older than the next 2–3 LN dates from the entire Upper Lena microregion or Verkholensk alone. Although the date falls quite in line with the rest of the dates for the entire Cis-Baikal, where it marks the start of the *Isakovo/Serovo* combined group (Supplement 1). The important point is that grave and burial orientation, one of the leading characteristics used by Okladnikov in his classification, are different in this case from the rest of the *Serovo* component at Verkholensk. Grave 13 is parallel to the Lena, that is as *Isakovo* or *Glazkovo* graves on the Angara, and the burial's head points upstream, as in *Isakovo* on the Angara [Okladnikov, 1978]. In the absence of any diagnostic grave goods, it is unclear why Okladnikov grouped this grave together with the *Serovo* graves, all aligned perpendicular to the river with burial heads pointing away from it, as on the Angara. Perhaps the grave represents a rare and early case of the *Isakovo* mortuary tradition on the Upper Lena or some other mortuary group not well documented yet. While there are no grounds for excluding this date from the regional dataset, it is excluded from the analysis of the *Serovo* group on the Upper Lena. Re-dating of this burial using a different sample is recommended.

Likewise, Okladnikov [1978] did not fully recognize the different mortuary character of Grave 19 (with an infant), also at Verkholensk, classified now as *Khin* based on its very early conventional date. This discrepancy, however, is inconsequential for our study because the date is removed from analysis anyway as it represents an infant and, thus, has not been corrected.

Since the PCC analysis is quite sensitive to outliers, ideally all datasets suitable for examination of dietary trends should be screened for such rogue results. The previous work [Weber et al., 2016a, 2016b] employed the outlier labeling technique [Hoaglin et al., 1986; Hoaglin and Iglewicz, 1987]. This time, however, the matter has been complicated by the large number of units of analysis potentially to be subjected to PCC testing and thus, also, to screening for outliers. The fact that each mean calibrated date comes with its own error term, complicates the process further. An additional complication is related to the fact that even when a dataset of isotopic results shows no outliers, such outliers

Table 4
Results of Bayesian chronological analysis of radiocarbon dates for Middle Holocene mortuary traditions in Cis-Baikal, Siberia.

	Cis-Baikal			Angara			SW Baikal			Little Sea			Upper Lena		
Chronological terms	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ
Indices:	Khin, *n* = 25 Amodel 98.2 Aoverall 98.2			Khin, *n* = 3 Insufficient data			Khin, *n* = 0 Insufficient data			Khin, n = 16 Amodel 95.4 Aoverall 95.3			Khin, n = 6 Insufficient data		
Lower Phase Boundary															
Average Start	8466–8062	8565–7954	8263 ± 169							8266–7959	8440–7859	8137 ± 154			
Start	8709–8443	8956–8386	8630 ± 155							8538–8264	8810–8207	8459 ± 163			
End	8461–7426	8512–7325	7896 ± 358							8226–7429	8363–7334	7815 ± 288			
Transition	0–1254	0–1403	734 ± 437							0–1041	0–1207	645 ± 353			
Upper Phase Boundary															
Average End	7268–7090	7349–6958	7165 ± 97							7361–7192	7432–7047	7256 ± 97			
Start	7500–7157	7693–7008	7344 ± 175							7489–7232	7698–7098	7380 ± 146			
End	7143–6906	7225–6705	6987 ± 139							7297–7064	7368–6826	7133 ± 148			
Transition	0–462	0–826	357 ± 250							0–306	0–696	247 ± 221			
Span of Phase	1203–1368	1136–1457	1290 ± 81							892–1075	818–1167	986 ± 90			
Indices:	Kitoi, n = 225 Amodel 78.1 Aoverall 82.4			Kitoi, *n* = 105 Amodel 98.4 Aoverall 96.4			Kitoi, *n* = 103 + 17 = 120 Phase 1: Amodel 76.1 Aoverall 80.0 Phase 2: Amodel 99.7 Aoverall 92.4			Kitoi, n = 0 Insufficient data			Kitoi, n = 0 Insufficient data		
Lower Phase Boundary															
Average Start	7538–7508	7557–7497	7525 ± 15	7532–7482	7565–7461	7509 ± 25	7526–7486	7552–7466	7507 ± 21						
Start	7578–7517	7621–7507	7558 ± 31	7583–7506	7630–7484	7552 ± 38	7580–7501	7636–7490	7555 ± 40						
End	7521–7471	7541–7435	7492 ± 26	7520–7435	7558–7359	7467 ± 49	7516–7435	7540–7350	7460 ± 48						
Transition	0–85	0–164	66 ± 49	0–108	0–234	85 ± 72	0–121	0–260	95 ± 78						
Upper Phase Boundary															
Average End	7078–7016	7099–6979	7042 ± 32	7061–6918	7121–6880	6997 ± 65	6767–6683	6785–6621	6711 ± 45						
Start	7489–7388	7515–7320	7424 ± 56	7388–6918	7446–6900	7180 ± 160	6780–6703	6803–6635	6731 ± 42						
End	6696–6626	6726–6589	6659 ± 35	6876–6748	6939–6697	6815 ± 62	6766–6660	6785–6568	6691 ± 61						
Transition	713–835	638–887	766 ± 66	0–637	0–673	364 ± 205	0–47	0–164	40 ± 53						
Span of Phase	796–886	759–937	845 ± 45	606–716	558–773	663 ± 55		Cf. Table 5							
Indices:	Isakovo/Serovo, n = 103 Amodel 103.5 Aoverall 97.0			Isakovo, n = 37 Amodel 83.1 Aoverall 66.1			Isakovo/Serovo, n = 0 Insufficient data			Serovo, *n* = 26 Amodel 104.6 Aoverall 104.5			Serovo, n = 36 Amodel 106.9 Aoverall 105.4		
Lower Phase Boundary															
Average Start	5755–5669	5805–5625	5713 ± 44	5519–5411	5564–5348	5469 ± 48				5253–5095	5351–5038	5187 ± 80	5585–5505	5629–5470	5548 ± 40
Start	6097–5990	6172–5953	6053 ± 57	5559–5414	5621–5352	5495 ± 61				5353–5155	5492–5098	5282 ± 105	5640–5535	5715–5495	5600 ± 57
End	5449–5309	5524–5217	5374 ± 74	5494–5397	5526–5329	5443 ± 49				5253–4999	5328–4799	5093 ± 133	5564–5446	5609–5376	5496 ± 59
Transition	573–765	482–890	678 ± 100	0–68	0–174	52 ± 55				0–243	0–564	189 ± 179	0–132	0–273	103 ± 84
Upper Phase Boundary															
Average End	4963–4845	5000–4755	4889 ± 62	5387–5301	5433–5279	5350 ± 41				4752–4613	4805–4521	4672 ± 72	5135–5010	5192–4914	5059 ± 69
Start	5365–5147	5435–4938	5219 ± 128	5410–5312	5453–5292	5370 ± 44				4835–4625	5031–4543	4757 ± 118	5487–5286	5555–5099	5351 ± 118
End	4632–4498	4695–4415	4559 ± 69	5378–5279	5431–5243	5330 ± 49				4706–4523	4760–4389	4586 ± 99	4830–4695	4942–4595	4764 ± 80
Transition	553–841	293–975	660 ± 165	0–51	0–135	40 ± 42				0–210	0–533	171 ± 165	479–748	0–881	583 ± 158
Span of Phase	1277–1419	1212–1501	1351 ± 73	59–203	0–269	137 ± 70				431–648	345–756	548 ± 106	663–781	538–858	713 ± 74
Indices:	Glazkovo, *n* = 208 Amodel 84.7 Aoverall 99.7			Glazkovo, *n* = 27 Amodel 94.4 Aoverall 92.4			Glazkovo, n = 9 Amodel 87.5 Aoverall 73.6			Glazkovo, *n* = 133 Amodel 93.5 Aoverall 93.6			Glazkovo, n = 39 Amodel 97.7 Aoverall 97.3		
Lower Phase Boundary															
Average Start	4492–4391	4555–4355	4450 ± 50	4902–4731	5004–4638	4820 ± 90	4065–3908	4191–3852	4005 ± 90	4461–4351	4520–4308	4411 ± 54	4718–4516	4816–4345	4599 ± 111

(*continued on next page*)

Table 4 (*continued*)

Chronological terms	Cis-Baikal			Angara			SW Baikal			Little Sea			Upper Lena		
	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ
Start	5003–4921	5053–4893	4969 ± 41	5036–4811	5216–4725	4949 ± 126	4139–3930	4312–3854	4055 ± 128	4985–4903	5045–4880	4955 ± 43	4881–4642	5058–4579	4798 ± 129
End	4004–3819	4130–3750	3931 ± 96	4881–4601	4967–4313	4691 ± 165	4017–3855	4161–3766	3954 ± 92	3960–3755	4065–3679	3867 ± 100	4700–4267	4791–3830	4399 ± 254
Transition	948–1160	810–1251	1039 ± 109	0–320	0–749	258 ± 233	0–126	0–394	101 ± 131	984–1207	871–1304	1088 ± 110	0–553	0–1085	399 ± 336
Upper Phase Boundary															
Average End	3659–3599	3685–3567	3627 ± 29	4035–3780	4163–3659	3906 ± 128	…–3670	…–3548	3760 ± 120	3675–3616	3701–3586	3644 ± 28	3541–3401	3656–3315	3479 ± 80
Start	3855–3725	3917–3646	3784 ± 67	4439–3805	4700–3710	4185 ± 263	3964–3715	3966–3588	3808 ± 110	3772–3645	3852–3608	3722 ± 64	3674–3408	4017–3341	3604 ± 177
End	3514–3434	3546–3390	3470 ± 39	3786–3540	3872–3339	3627 ± 137	…–3601	…–3424	3702 ± 151	3627–3522	3665–3462	3565 ± 52	3475–3295	3528–3135	3353 ± 105
Transition	228–408	123–503	314 ± 93	0–889	0–1126	558 ± 334	0–119	0–375	95 ± 125	0–205	0–348	156 ± 102	0–308	0–774	251 ± 243
Span of Phase	1347–1437	1314–1495	1400 ± 46	954–1155	857–1262	1055 ± 101	0–367	0–457	213 ± 145	1243–1344	1204–1406	1301 ± 51	1113–1283	1057–1373	1208 ± 82

All dates are modelled highest posterior distribution (HPD) BP.

may become visible only when examined together with radiocarbon dates and these may occur at any spot along the chronological continuum defined by the dates. Such outliers, very likely, represent individuals with non-local diets and should be excluded from the PCC analysis. Therefore, the matter was simplified by combining the formal outlier detection protocol with visual examination of scatterplots between relevant variables (i.e., mean calibrated dates vs. δ^{13}C and mean calibrated dates vs. δ^{15}N measurements) for each unit of analysis considered useful for PCC tests. The outlier labeling protocol was implemented in cases where scatterplots suggested that PCC results could be biased by the presence of a rogue result(s) at the tails of each distribution of stable isotope or radiocarbon measurements. In cases where visual examination of scatterplots between the relevant variables suggested presence of stable isotope outliers along the chronological continuum, PCC tests were run with and without them.

As before, only one individual, SHA_2004.042.02 from the Shamanka II cemetery, was identified as an outlier for its low δ^{15}N value of 10.4‰ (Supplement 1). Even though its ^{14}C date has been now corrected using stable isotope results from sequential sampling of the molar dentine (see Section 2), which allowed its inclusion in the Bayesian aspect of this analysis, the individual was removed from the assessment of dietary trends. While no other individuals had to be removed from the larger units of analysis ($n \geq 20$), visual examination of scatterplots proved to be very practical means of identifying many of the smaller units ($n < 20$) as not suitable for PCC analysis. Furthermore, all individuals, whose diets (i.e., stable isotope values) were considered non-local relative to the area of burial, were also removed from the examination of dietary trends. This, of course, regards the already mentioned female from Shamanka II (SHA_2004.042.02), as well as the 12 individuals with non-local diets mentioned earlier.

5. Discussion: Chronology of Cis-Baikal Middle Holocene mortuary traditions

Results from the Bayesian analysis of the regional and microregional sets of radiocarbon dates are presented in Table 4.

The first general point to be made is that, due to the number of various uncertainties inherent to both the typological classification and ^{14}C dating and the subsequent analysis, the presented results are only the best possible statistical approximations rather than fixed chronological boundaries. Therefore, we prefer to search for general patterns in the numbers generated by the Bayesian analysis rather than to pay unwarranted attention to details and small differences.

Second, the previous analysis [Weber et al., 2016b], due to its preliminary character, reported only average phase boundaries (*Average Start* and *Average End)*, both at the 68% and 95% confidence intervals and the means, with associated errors, of these boundaries (Fig. 2). In addition to the means, this study reports also the start, end, and duration of each boundary (*Start*, *End*, and *Transition*) because this information is necessary to assess the tempo of each transition in cases where sufficient information is available. To simplify presentation, all lower boundaries reported below are mean *Start* dates without the error term ("±") rounded to the nearest ten and all upper boundaries are mean *End* dates, rounded in the same way.

Third, it is important to keep in mind that the regional scale clearly masks microregional differences in the timing and duration of each cultural transition. Logically, any microregional offsets in the timing of a given transition would also make its duration much longer on a regional scale. While the transition parameters modelled separately for each microregion are expected to be a more realistic reflection of the real culture history, the relatively small sample size of some of these units, as for the LN in each microregion and EBA on the Angara and Upper Lena, may have biased the microregional results. Therefore, caution in the analysis and interpretation of these parameters is necessary.

Lastly, all dates referred to in this and subsequent sections are modelled calibrated dates BP (i.e., highest posterior distribution, HPD)

Table 5
Results of Bayesian chronological analysis of radiocarbon dates for the *Kitoi* mortuary tradition in Cis-Baikal, Siberia.

Chronological terms	Kitoi Lokomotiv (*n* = 80)			Kitoi Angara excl. Lokomotiv (n = 25)			Kitoi Shamanka Phase 1 (n = 103)			Kitoi Shamanka Phase 2 (n = 17)		
	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ
Indices:		Amodel 91.6 Aoverall 89.2			Amodel 92.9 Aoverall 90.6			Amodel 76.1 Aoverall 80.0			Amodel 99.7 Aoverall 92.4	
Lower Phase Boundary												
Average Start	7525–7475	7560–7450	7501 ± 26	7408–7247	7510–7189	7343 ± 81	7526–7486	7552–7466	7507 ± 21	6837–6756	6905–6741	6811 ± 45
Start	7571–7495	7622–7475	7542 ± 39	7605–7401	7710–7335	7518 ± 97	7580–7501	7636–7490	7555 ± 40	6862–6758	6953–6742	6831 ± 59
End	7517–7433	7555–7341	7461 ± 52	7350–6980	7470–6884	7167 ± 159	7516–7435	7540–7350	7460 ± 48	6815–6744	6890–6718	6792 ± 42
Transition	0–103	0–243	82 ± 76	0–584	0–689	351 ± 207	0–121	0–260	95 ± 78	0–47	0–160	40 ± 51
Upper Phase Boundary												
Average End	7141–7056	7194–7011	7101 ± 44	6895–6782	6946–6707	6832 ± 59	7251–7188	7290–7168	7224 ± 31	6767–6683	6785–6621	6711 ± 45
Start	7268–7058	7429–7035	7199 ± 110	6972–6802	7119–6731	6906 ± 94	7376–7192	7452–7178	7297 ± 80	6780–6703	6803–6635	6731 ± 42
End	7101–6953	7125–6863	7004 ± 73	6855–6704	6904–6584	6757 ± 83	7201–7120	7225–7073	7152 ± 41	6766–6660	6785–6568	6691 ± 61
Transition	0–308	0–506	194 ± 166	0–183	0–429	149 ± 134	0–264	0–340	145 ± 111	0–47	0–164	40 ± 53
Span of Phase	398–537	358–615	480 ± 67	522–695	434–765	604 ± 84	307–401	278–458	363 ± 47	0–138	0–252	104 ± 78

All dates are modelled highest posterior distribution (HPD) BP.

and, by convention, are presented in italics.

5.1. The Khin mortuary tradition

On the regional scale, the earliest Holocene graves of this group ($n = 25$) appear around *8630 cal. BP*, or a little earlier, and they disappear from the archaeological record around *6970 cal. BP* (Table 4). This implies a very long duration and an extremely low occurrence rate of these mortuary events even if the burials without a radiocarbon date yet are taken into consideration. The sample size is too small regionally, and microregionally obviously too, for the chronological parameters to be analyzed in much detail. Interestingly, the oldest three events come from three different microregions: Upper Lena, Angara, and Little Sea (Supplement 1). This suggests pan-regional presence of conditions—cultural or environmental—favoring such developments. Roughly half-way through the regional history of the *Khin* mortuary tradition, the *Kitoi* pattern forms in the Angara valley and on Southwest Baikal, replacing in the former the *Khin* pattern. On the Upper Lena and Little Sea, the *Khin* group continues without many changes in the mortuary protocol way into the second half of the *Kitoi* duration. The replacement of the *Khin* group by the *Kitoi* in the Angara valley perhaps explains the low number of the former graves there, whereas the frequency of the *Khin* graves in the Little Sea is relatively much higher. The intermediate number of *Khin* graves on the Upper Lena is likely the result of much less fieldwork conducted there, and it should not surprise to see it increase in the future.

5.2. The Kitoi mortuary tradition

Due to the large number of ^{14}C dates ($n = 225$) confined to two microregions, the chronological parameters of the *Kitoi* group come into sharp focus (Tables 4 and 5).

In the Angara valley and on Southwest Baikal, the *Kitoi* appears around *7560 cal. BP*, with both of its largest cemeteries known to date, Lokomotiv and Shamanka II, being established about the same time and equally quickly. However, *Kitoi's* disappearance seems to be rather variable with the large cemeteries probably abandoned earlier than the smaller ones. More specifically, it seems that Shamanka II Phase 1 ended first, quickly followed by Lokomotiv, and finally the rest of the *Kitoi* cemeteries on the Angara and Southwest Baikal (Shamanka II Phase 2) all cease to be used too. No *Kitoi* cemeteries appear to be in use past *~6690 cal. BP* or even earlier.

Shamanka II with its two phases of use is a particularly interesting record of the *Kitoi* history. Neither Angara as a whole nor Lokomotiv show such discontinuity. While the formation of the *Kitoi* mortuary pattern and the establishment of the Lokomotiv and Shamanka II cemeteries appear to be relatively fast processes, the return of mortuary activities to Shamanka II, after some substantial time, shows even faster tempo. Likewise, the decline in the frequency of these activities during Phase 2 seems to be much faster than during Phase 1. The overall impression is that Phase 2 at Shamanka II took very little time, perhaps only a few generations, several at the most, thus on the short end of the chronological parameters generated by the Bayesian analysis.

In sum, both the lower and upper *Kitoi* transitions clearly appear to be not only faster than those associated with the *Khin* mortuary tradition but also much faster relative to the transitions for the *Isakovo*, *Serovo*, and *Glazkovo* patterns. The cultural significance of the fast tempo of the *Kitoi* formation and dissolution in general, and the meaning of the very short Phase 2 at Shamanka II in particular, are discussed elsewhere (Weber, 2020).

5.3. The Isakovo and Serovo mortuary traditions

The first and last graves representing the combined *Isakovo/Serovo* mortuary traditions date in Cis-Baikal probably to *~6050* and *~ 4410 cal. BP*, respectively (Table 4). The regional parameters of the lower and upper *Boundaries* of this combined group are a lot more extended in time relative to what is seen in the microregions separately and both appear to be somewhat offset relative to one another.

As mentioned earlier, at least some of these offsets are likely the product of the rather small sample sizes, as well as a few additional sampling biases. More specifically, on the Angara, most dates represent *Isakovo* ($n = 37$) with only 3 confirmed *Serovo* dates and, furthermore, most *Isakovo* dates ($n = 36$) come from only one cemetery—Ust'-Ida I, although the temporal distribution of ^{14}C measurements is quite continuous there. On the Upper Lena, Verkholensk dominates the *Serovo* group with 31 of all *Serovo* dates (n = 36) coming from this one cemetery. In the Little Sea, the sample is not dominated by any one cemetery (26 dates from 6 cemeteries), but 2 dates from Ulan-Khada are much older than the rest. In contrast to the lower boundary, the distribution of dates near the upper *Isakovo/Serovo* boundary appears to be quite continuous everywhere.

Constrained by these caveats, the following additional observations can be inferred about the history of the *Isakovo* and *Serovo* mortuary traditions in Cis-Baikal, most of which, however, require confirmation through continued radiocarbon dating. First, having excluded the old date for VKL_1951.013, the *Isakovo* sequence for the Angara valley essentially parallels the *Serovo* sequence on the Upper Lena. However, the end of *Serovo* on the Upper Lena currently seems to be somewhat younger than the end of *Isakovo* on the Angara. Second, in the monographic publication of Verkholensk, Okladnikov [1978] labelled this component of the cemetery as *Archaic,* thus suggesting an age somewhat older relative to *Serovo* on the Angara. This notion is not yet supported by the current ^{14}C data, mostly on the account of very few *Serovo* dates from the Angara. Third, regardless of whether the two old dates from Ulan-Khada are included or excluded, the *Serovo* sequence in the Little Sea appears to be somewhat younger overall than in the other two microregions. And third, as suggested by the results for the Angara valley, where the *Isakovo* group is represented essentially by one cemetery only (Ust'-Ida I), the establishment and abandonment of at least some of the large *Isakovo* and *Serovo* cemeteries could have been processes as quick as those characterizing the large *Kitoi* cemeteries a few millennia earlier (Table 4). Bronk Ramsey et al. (2020) discuss this matter further.

5.4. The Glazkovo mortuary tradition

Although the number of *Glazkovo* radiocarbon dates is almost as large as the number of *Kitoi* dates, the *Glazkovo* chronological parameters are not as sharply defined. This is because the *Glazkovo* sample comes from all four microregions, not just two, and as such, any microregional offsets in boundaries will diffuse their regional focus. Furthermore, the sample is heavily biased towards the Little Sea, which provides 132 of 207 *Glazkovo* dates (Tables 1 and 3). Consequently, the parameters defining the lower boundary are essentially those of the Little Sea *Glazkovo* group. With that in mind, the oldest *Glazkovo* graves appear in Cis-Baikal around *4970 cal. BP* and the youngest around *3470 cal. BP*.

At the scale of the microregions, there are probably only a few differences that are statistically significant. The Upper Lena group, while likely starting around the same time as everywhere else, may have continued for a little longer, at least longer than in the Little Sea. The small sample from Southwest Baikal ($n = 9$), which comes from one cemetery (Shamanka II) is not chronologically as tight as one might perhaps expect and, besides, is clearly shifted towards the second half of the entire *Glazkovo* history. Moreover, in two (i.e., Little Sea and Upper Lena) out of three microregions where both *Glazkovo* and *Isakovo* or *Serovo* graves are known, chances are good that these mortuary traditions were in use side by side for some time. This overlap is particularly long in the Little Sea area. That *Isakovo/Serovo* and *Glazkovo* on the Angara are separated by a temporal gap, is very likely the result of the small samples there.

In sum, outside of Southwest Baikal, the *Glazkovo* mortuary tradition appears to start around the same time everywhere with strong evidence for temporal overlap with the *Isakovo* and/or *Serovo* mortuary patterns. The end of *Glazkovo*, however, may have been chronologically somewhat variable between the microregions.

5.5. Summary: Regional culture history

The chronological boundaries for each Cis-Baikal Middle Holocene mortuary tradition generated through Bayesian modelling, provide now parameters for defining chronological boundaries of archaeological periods. More specifically, the lower boundary of a given archaeological period is defined by the chronological parameters of the lower boundary associated with the mortuary tradition characterizing the period. For example, the lower LM boundary is defined by the chronological parameters marking the lower boundary of the *Khin* mortuary group. The upper boundary of a given archaeological period, however, is defined by the chronological parameters of the lower boundary associated with the following mortuary tradition. For example, the upper boundary of LM is characterized by the chronological terms marking the lower boundary of the *Kitoi* mortuary tradition. The MN boundaries, a period lacking mortuary radiocarbon data, are defined indirectly by the upper and lower boundaries associated with the preceding (i.e., *Kitoi*) and following (i.e., *Isakovo/Serovo*) mortuary groups. Lastly, the EBA period

Table 6
Summary of culture history of Middle Holocene hunter–gatherers in Cis-Baikal based on Bayesian chronological analysis.

Period	Chronologial terms	Cis-Baikal (Weber et al., 2016b)			Cis-Baikal (current)			Summary (current)	
		68.2%	95.4%	μ ± σ	68.2%	95.4%	μ ± σ	Period	HPD Cal. BP
Late Mesolithic	Start **	8713–8386	9040–8277	8612 ± 206	8714–8440	8967–8384	8630 ± 155	Late Mesolithic	8630–7560
	Average Start	8418–8069	8609–7967	8277 ± 176	8476–8119	8593–7975	8263 ± 169		
Early Neolithic	Start **	7545–7496	7583–7483	7527 ± 26	7578–7517	7621–7507	7558 ± 31	Early Neolithic	7560–6660
	Average Start	7516–7488	7532–7475	7503 ± 14	7538–7508	7557–7497	7525 ± 15		
	Average End	7065–6999	7090–6958	7027 ± 33	7078–7016	7099–6979	7042 ± 32		
	End **	6689–6604	6727–6556	6643 ± 43	6696–6626	6726–6589	6659 ± 35		
Middle Neolithic *	Start **	7476–7378	7500–7304	7411 ± 53	6696–6626	6726–6589	6659 ± 35	Middle Neolithic *	6660–6060
	Average Start	7065–6999	7090–6958	7027 ± 33	7078–7016	7099–6979	7042 ± 32		
Late Neolithic	Start **	5766–5513	6054–5446	5698 ± 169	6097–5990	6172–5953	6053 ± 57	Late Neolithic	6050–4970
	Average Start	5626–5471	5759–5413	5571 ± 88	5755–5669	5805–5625	5713 ± 44		
Early Bronze Age	Start **	5066–4941	5148–4901	5017 ± 64	5003–4921	5053–4893	4969 ± 41	Early Bronze Age	4970–3470
	Average Start	4674–4524	4747–4438	4597 ± 76	4492–4391	4555–4355	4450 ± 50		
	Average End	3760–3694	3795–3657	3726 ± 34	3659–3599	3685–3567	3627 ± 29		
	End **	3727–3626	3764–3548	3665 ± 55	3514–3434	3546–3390	3470 ± 39		

All dates are BP modelled highest posterior distribution (HPD).
* Defined indirectly by the upper and lower boundaries calculated for the Kitoi and Isakovo–Serovo datasets, respectively.
** Chronological terms calculated but not reported in Weber et al., 2016b.

Table 7
Summary of the PCC tests between mean calibrated radiocarbon dates BP and stable isotope measurements. Only units of analysis showing at least one statistically significant correlation are included.

No.	Spatial unit of analysis	MorTrad	Period	Diet		PCC	$\delta^{13}C$	$\delta^{15}N$	Trend description	Excluded outliers & other notes
Early Neolithic trends										
1	Lokomotiv, Cluster 2, 4, 5	Kitoi	EN	n/a	Date	r	−0.276	−0.648**	Increasing consumption of local upper Angara fishes.	Fig. 3A
						Sig. (2-tailed)	0.045	0.000		
						N	53	53		
						R^2 Linear		0.420		
2	Shamanka II, Phase 1, SE Cluster, row burials	Kitoi	EN	n/a	Date	r	−0.328	−0.827**	Increasing consumption of local Kultuk Bay fishes and, perhaps, some Baikal seal.	Fig. 3B
						Sig. (2-tailed)	0.019	0.000		
						N	51	51		
						R^2 Linear		0.684		
3	Shamanka II, Phase 1 SE Cluster scattered burials	Kitoi	EN	n/a	Date	r	0.773**	−0.108	Increasing consumption of fishes from a non-local, probably riverine, fishery.	Fig. S2
						Sig. (2-tailed)	0.000	0.679		
						N	17	17		
						R^2 Linear	0.598			
4	Shamanka II, Phase 2	Kitoi	EN	n/a	Date	r	−0.198	−0.886**	Increasing consumption of local Kultuk Bay fishes and, perhaps, some Baikal seal.	Fig. 3C
						Sig. (2-tailed)	0.447	0.000		
						N	17	17		
						R^2 Linear		0.785		
Late Neolithic trends										
5	Ust'-Ida I	Isakovo	LN	n/a	Date	r	−0.586**	−0.749**	Increasing consumption of local, middle Angara, fishes.	Fig. 4
						Sig. (2-tailed)	0.000	0.000		
						N	36	36		
						R^2 Linear	0.343	0.561		
6	Little Sea	Serovo	LN	GFS	Date	r	0.800**	−0.536*	Increasing consumption of large and medium game and some Baikal seal.	UK5_1959.001, EL3_1988.001: Outliers for $\delta^{15}N$ Fig. S3
						Sig. (2-tailed)	0.000	0.010		
						N	22	22		
						R^2 Linear	0.640	0.287		
Early Bronze Age trends										
7	Khadarta IV	Glazkovo	EBA	GFS	Date	r	0.943**	−0.411	Increasing consumption of large and medium game and, perhaps, also plant foods.	Fig. 5A
						Sig. (2-tailed)	0.000	0.271		
						N	9	9		
						R^2 Linear	0.889			
8	Khuzhir-Nuge XIV, Center–East	Glazkovo	EBA	GFS	Date	r	0.538**	−0.069	Increasing consumption of large and medium game and, perhaps, also plant foods.	Fig. S4A
						Sig. (2-tailed)	0.010	0.760		
						N	22	22		
						R^2 Linear	0.289			
9	Ulan-Khada (II, IV & V)	Glazkovo	EBA	GFS	Date	r	0.671*	0.247	Increasing consumption of large and medium game and, perhaps, also plant foods.	Fig. S4B
						Sig. (2-tailed)	0.034	0.492		
						N	10	10		
						R^2 Linear	0.450			
10	Khuzhir-Nuge XIV	Glazkovo	EBA	GF	Date	r	0.259	−0.707**	Increasing consumption of Baikal seal.	K14_1999.059.01: Outlier for $\delta^{13}C$ & ^{14}C Fig. S4C
						Sig. (2-tailed)	0.256	0.000		
						N	21	21		
						R^2 Linear		0.500		

(continued on next page)

Table 7 (*continued*)

Early Neolithic trends No.	Spatial unit of analysis	MorTrad	Period	Diet		PCC	$\delta^{13}C$	$\delta^{15}N$	Trend description	Excluded outliers & other notes
11	Obkhoi	Glazkovo	EBA	n/a	Date	r	0.566*	−0.242	Increasing consumption of large and medium game and, perhaps, also plant foods.	Fig. S4D
						Sig. (2-tailed)	0.044	0.425		
						N	13	13		
						R^2 Linear	0.320			
12	Upper Lena, Verkholensk area: Verkholensk, Borki, Makrushino, Ulus-Khal'skii, Manzurka, Makarovo, Ust'-Iamnaia	Glazkovo	EBA	n/a	Date	r	0.195	0.718**	Increasing consumption of local fish.	MAK_1992.018: non-local GFS diet Fig. 5B
						Sig. (2-tailed)	0.410	0.000		
						N	20	20		
						R^2 Linear		0.516		
13	Shamanka II	Glazkovo	EBA	n/a	Date	r	−0.581	−0.750*	Increasing consumption of local Kultuk Bay fishes.	Fig. S4E
						Sig. (2-tailed)	0.101	0.020		
						N	9	9		
						R^2 Linear		0.563		

Date = Mean calibrated date BP.
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

is defined in full by chronological parameters for the *Glazkovo* mortuary tradition.

Table 6 shows results from the current analysis and, for comparison, from the first assessment (Weber et al., 2016b). As noted earlier, only the *Average Start* was published in the previous study, so the other parameters (*Start* and *End*) are included here for comparison. Although there seems to be enough data already to suggest that the timing of the chronological boundaries of some of these mortuary traditions differed between microregions, it is premature to present such local culture history models due to the sampling biases frequently mentioned earlier.

In general, and as expected, the main difference between the two studies regards the chronology of the MN. The difference is a direct product of the much-expanded set of *Isakovo* and *Serovo* ^{14}C dates, which indirectly define the upper MN boundary. Otherwise, most *Average* boundaries are essentially the same as before. However, an argument can be made that period boundaries should be defined not by such *Averages,* but rather by the earliest (i.e., *Start*), or latest (i.e., *End*) events. In such case, the boundaries may be quite different from the *Average* boundaries depending on the duration of each *Transition*. The EN and the LN illustrate this point rather well. The lower boundary of the EN shows a quick *Transition* while the LN starts with quite a long *Transition* and, thus the difference between *Average Start* and *Start* parameters is negligible in the first case but substantial in the latter (Table 6). This is best illustrated by the duration of the MN, its length roughly half of what the *Average* terms indicate.

While it is understandable that one would like to have archaeological periods defined with much sharper boundaries, or with much less statistical uncertainty, the radiocarbon approach advanced in this study is still much better than the typological dating, which offers no hope for insights of the kind provided by the radiocarbon method. Moreover, this work also shows clearly that continued radiocarbon dating has the potential to bring many of the still diffused boundaries into much sharper focus such as the one already available for the EN period with its *Kitoi* mortuary tradition.

6. Discussion: dietary trends

Assessment of the dietary trends summarized in Table 7 requires a few introductory comments.

First, our ability to identify such trends among Cis-Baikal Middle Holocene foragers rests, most importantly, on our ability to identify units of analysis that are as homogeneous as possible with regards to the place of birth, membership in a social group, and diet type of the examined individuals. This step may employ any of the *primary* and *secondary* unit-defining criteria mentioned earlier. This is important because, for example, inclusion in the analysis of a mix of individuals with local and non-local diets, obviously, has the potential to confuse any pattern characteristic of either the local or non-local group. Khuzhir-Nuge XIV and Khadarta IV—two neighbouring cemeteries in the Little Sea microregion, an area with well-documented movement of people from other places around Cis-Baikal and the presence of two different diets (Game–Fish–Seal, GFS, and Game–Fish, GF), illustrate this point very well. Khuzhir-Nuge XIV is a large cemetery (72 examined EBA individuals) with complex spatial organization and much variation in mortuary ritual, diet (both GFS and GF diet types are present), and place of birth (local and non-local). All this suggests that the cemetery was used by people belonging to many socio-economic groups [Weber et al., 2008; Weber and Goriunova, 2013]. Consequently, identification of homogenous units of analysis is a challenge for this cemetery population. In contrast, Khadarta IV, located a mere ~12 km away from Khuzhir-Nuge XIV, is a small cemetery with only 9 EBA individuals (all adults), simple spatial structure and limited mortuary variation. Moreover, all individuals display the same GFS diet. Perhaps, this is the reason why this site shows a pattern of dietary change that is one of the most-clear of all units tested.

Second, a simple hypothetical example shows additional complications of this kind. Imagine two multigenerational kin groups, representatives of which were interred side by side at the same large cemetery. One of these groups experienced a dietary trend while the other did not but otherwise their diets did not differ much in terms of stable isotope variation and any other *primary* or *secondary* archaeological criteria were insufficient to see them archaeologically. In such a case, not only would the presence of these two kin groups remain unrecognized through our analysis, but the dietary trend experienced by one of them would not be recognized either. More specifically, if members of the Khadarta IV group were interred at Khuzhir-Nuge XIV, rather than at a separate cemetery, even such a clear trend would likely remain invisible, unless they were interred in a separate cluster or row of graves. Consequently, there are probably quite a few more dietary trends in the currently available dataset of biochemical results for 560 Cis-Baikal foragers relative to what we have been able to identify through this examination.

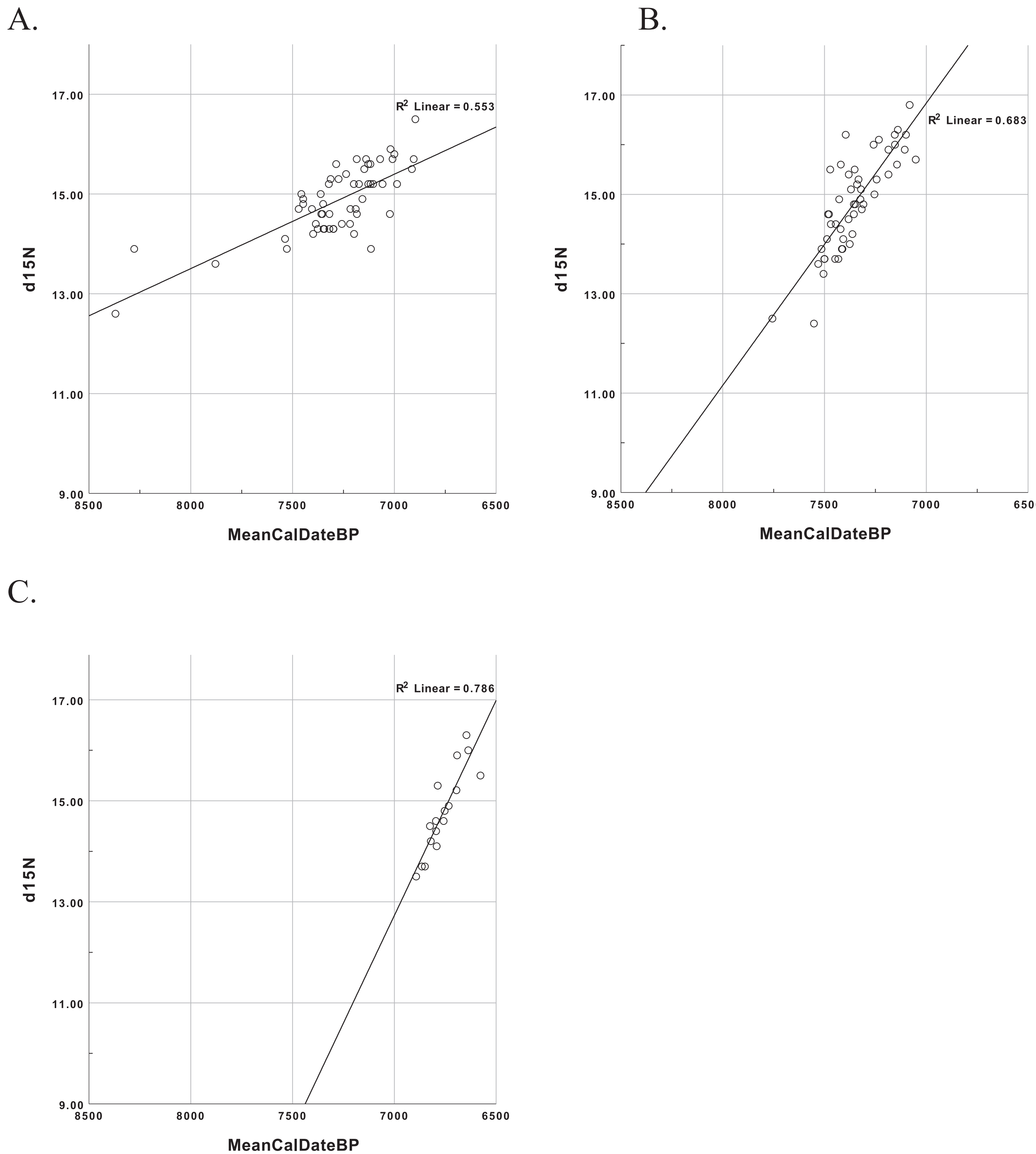


Fig. 3. A. Mean cal BP dates by $\delta^{15}N$ for the *Khin* and *Kitoi* (Lokomotiv Cluster 2, 4, and 5) burials, Angara. B. Mean cal BP dates by $\delta^{15}N$ for the *Kitoi* burials from Shamanka II, Phase 1, SE Cluster, row burials, Southwest Baikal. C. Mean cal BP dates by $\delta^{15}N$ for the *Kitoi* burials from Shamanka II, Phase 2, Southwest Baikal.

Third, our search for dietary trends among these groups employs a test of association (PCC) between the two isotopic measurements ($\delta^{13}C$ and $\delta^{15}N$), on the one side, and the mean calibrated date BP, on the other, available for each of the examined human individual. It is necessary to keep in mind that the PCC measures only the strength of association between two numerical variables. In other words, it measures how far on average a pair of data (in our case, $\delta^{13}C$ and mean calibrated date, or $\delta^{15}N$ and mean calibrated date) within any given dataset is from the best-fit line. As such, the coefficient of correlation carries no information about the contribution of any food kind to the diet of any group of individuals. For example, if the *r* for one of the two measured pairs of variables is close to +1, as between $\delta^{13}C$ and mean calibrated dates for Khadarta IV (Table 7), it only means that all data points are very close to the best-fit line. In this case, as the dates get younger, the $\delta^{13}C$ values become lower, and that the contribution of the food group(s) that best explains such change steadily grows or declines with time, not that it is high or low.

Fourth, and related to the above, the structure of any particular diet, must be inferred from the assessment of human stable isotope values in the context of stable isotope measurements available for all possible food groups and in conjunction with other available archaeological information, such as the faunal data [c.f., Katzenberg and Weber, 1999b; Katzenberg et al., 2009, 2012; Losey and Nomokonova, 2017; Losey et al., 2008, 2012; Nomokonova et al., 2015; Weber et al., 2002, 2011, 2016a, 2016b]. Although evaluation of diet structure of the examined units is not a goal of this analysis, our current understanding of the identified changes in diet over time is given in the "*Trend description*" column of Table 7. The nature of these trends is inferred from the available knowledge about the dietary variation among these HG groups as well as from the knowledge about the stable isotope ecology of Cis-Baikal terrestrial and aquatic ecosystems. Both of these insights are considered sufficient, at least in general terms, for this assessment to proceed.

Lastly, previous work on dietary trends among Cis-Baikal Middle Holocene HGs was limited to *Kitoi* groups from the Angara valley and Southwest Baikal, because at the time most other samples were considered either not large enough or the laboratory work was still in progress [Weber et al., 2016a, 2016b]. As such, all patterns described here for the LN and EBA groups have not been published yet.

6.1. Late Mesolithic dietary trends

The group of 25 burials classified as the *Khin* mortuary tradition spans both the LM and EN periods representing three microregions: the Angara valley ($n = 3$), the Little Sea ($n = 16$), and the Upper Lena ($n = 6$). The Little Sea dataset displays no directional change in stable isotope values over time and the other two are too small to show any meaningful patterns on their own. However, as noted before [Weber et al., 2016b], the three LM individuals from the Angara valley appear to extend back in time the beginning of the dietary trend documented for the EN *Kitoi* group from this microregion (Fig. 3A).

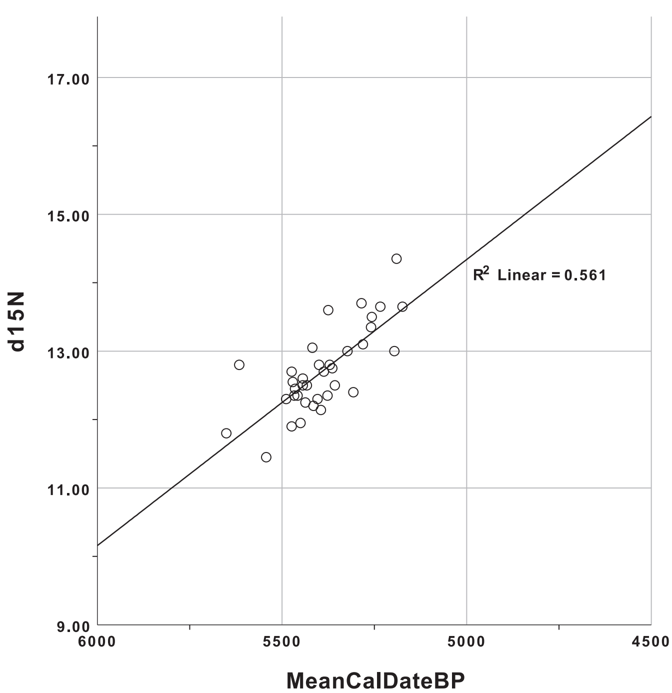


Fig. 4. Mean cal BP dates by $\delta^{15}N$ for the *Isakovo* burials from Ust'-Ida I, Angara.

6.2. Early Neolithic Kitoi dietary trends

The dietary variation and trends among the *Kitoi* groups in the Angara valley and on Southwest Baikal have already received much attention in our two previous studies [Weber et al., 2016a, 2016b]. While all patterns established for the Shamanka II cemetery population on Southwest Baikal remain in force, the expansion of the Angara sample has improved our understanding of the dietary variation there. It appears now that on the Angara the dietary trend was driven by and limited to individuals interred only in three spatial clusters of the Lokomotiv cemetery: Cluster 2 ($n = 41$), Cluster 4 ($n = 7$), and Cluster 5 ($n = 5$), where most graves are arranged in rows and many have multiple burials in them (Table 7). This pattern resembles much the situation documented for Shamanka II, where the main trend in Phase 1 is also driven by row burials from the SE Cluster of graves [Weber et al., 2016a; and below]. None of the smaller *Kitoi* samples from the Angara (Galashikha and Ust'-Belaia) display dietary trends when analyzed on their own or together.

The dietary trend that has come to a sharper focus with the expansion of the Lokomotiv sample is best explained in terms of increased consumption of local fishes from the section of the Angara between Lake Baikal and the Irkut River and perhaps a few kilometers further downstream from the mouth of the latter. According to Kozhov [1950]; Weber et al., 2002, this fishery is dominated by three species only: black grayling, lenok, and taimen', accounting for 80, 15, and 5% of its volume, respectively [Weber et al., 2002]. Importantly, of these three, the black grayling population migrates between the lake and the very upper section of the Angara. Since in freshwater fishes, the $\delta^{13}C$ values are directly related to the primary productivity of the aquatic habitat [France, 1995; Kiyashko et al., 1991, 1998; Katzenberg and Weber, 1999a; Ogawa et al., 2000; Yoshii, 1999; Yoshii et al., 1999], the black grayling is thus expected to carry a $\delta^{13}C$ signature that is a product of stable isotope ecologies characterizing these two ecosystems. The modern specimens obtained from Bol'shie Koty near the source of the Angara are our best available proxy of this migrating population of black grayling and their $\delta^{13}C$ values range between −14.0 and − 11.0‰ [Weber et al., 2011]. The other two fishes are resident to the Angara only and their $\delta^{13}C$ signatures should be much lower than those of the black grayling and close to the −27.0 to −24.0‰ range, which is typical for the freshwater lotic ecosystems.

Since the dietary variation at Shamanka II, the only *Kitoi* cemetery in the Southwest Baikal microregion, has been thoroughly discussed recently [Weber et al., 2016a], only the most relevant findings need to be mentioned (Table 7). Like at Lokomotiv, the main dietary trend at Shamanka II (Fig. 3B) is accounted by the burials ($n = 51$) interred in rows of graves in the SE Cluster of the cemetery, its largest spatial unit where many graves have multiple interments. This group of burials dates to Phase 1. However, unlike Lokomotiv, Shamanka II shows two phases of use and Phase 2, although much shorter than Phase 1 and with fewer burials analyzed here ($n = 17$), repeats exactly the same dietary trend characteristic of the SE Cluster row burials from the earlier phase (Fig. 3C). Moreover, and also unlike Lokomotiv, the scattered burials from the SE Cluster of Phase 1 (n = 17) show a dietary trend too (Fig. S2). This trend, however, is isotopically different from the other two trends present at Shamanka II as the mean calibrated dates correlate with $\delta^{13}C$ values, not $\delta^{15}N$ measurements, and this suggests also a different source of the consumed fish (Table 7).

The dietary trends found for Phase 1 SE Cluster row burials and Phase 2 individuals are both best accounted for by the increasing over time contribution of the local Kultuk Bay fishes to the diet of these people and, perhaps, some minor consumption of the Baikal seal. However, it is unclear what accounts for the trend observed in the scattered burials from Phase 1 of the SE Cluster. It has been suggested previously that these people perhaps fished on the lower Selenga River, some 230 km to the east [Weber et al., 2016a] but the new human stable isotope data from the Fofanovo cemetery with LM to EBA burials do not

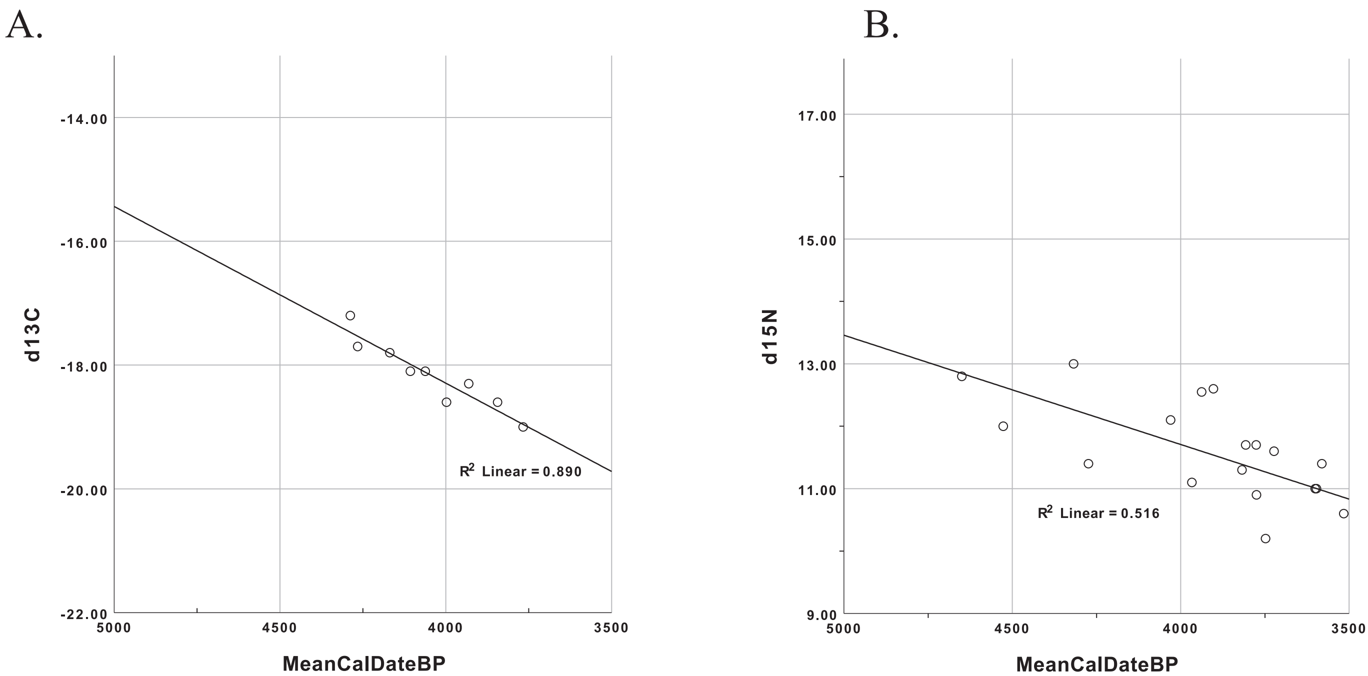


Fig. 5. A. Mean cal BP dates by $\delta^{13}C$ for the *Glazkovo* burials from Khadarta IV, Little Sea. B. Mean cal BP dates by $\delta^{15}N$ for the *Glazkovo* burials from the Verkholensk area (Verkholensk, Borki, Makrushino, Ulus-Khal'skii, Manzurka, Makarovo, and Ust'-Iamnaia), Upper Lena.

appear to support this idea [White et al., 2020b]. Likewise, these people probably did not harvest fish from the upper section of the Angara, as the Lokomotiv group did, because the two trends are different (Table 7). One other option is that the fishery harvested by the individuals from the scattered burials from Shamanka II Phase 1 of the SE Cluster was on the lower Irkut River where a new *Kitoi* cemetery (Moty-Novaia Shamanka), albeit entirely destroyed by a modern housing project, was recently discovered [Bazaliiskii et al., 2016]. Radiocarbon and stable isotope tests on this material are in progress and may help address this matter.

6.3. Late Neolithic Isakovo and Serovo dietary trends

Two LN dietary trends have been identified: one regards the *Isakovo* sample from the Angara valley, the other the *Serovo* group from the Little Sea (Table 7, Fig. 4). The *Isakovo* sample is quite large ($n = 36$) and quite homogenous at least in that it comes from a single cemetery (Ust'-Ida I). Both relevant correlations are strong and negative. Such pattern is best explained by increased consumption with time of the local middle Angara fishes. It must be remembered that in this section of the Angara (i.e., ~200 km north of its source at Baikal), fishes that live also in Lake Baikal (i.e., black grayling), as is the case in the Angara's upper section, are absent [Kozhov, 1950; Weber et al., 2002]. As mentioned, the fishes of the Angara middle section are expected to carry $\delta^{13}C$ values typical of freshwater river habitats (i.e., in the −27.0 to −24.0‰ range) and $\delta^{15}N$ values characteristic of their trophic position. Importantly, such fish $\delta^{13}C$ values are also close to those describing terrestrial game (red deer and roe deer) and plants potentially consumed by these groups [Weber et al., 2002, 2011]. This is probably why the *Isakovo* sample displays correlation with both stable isotopes rather than $\delta^{15}N$ only as at Lokomotiv, whose people, according to our understanding, also increased with time contribution of the local fishes to their diet. The difference between the two places is that the fishery of the first section of the Angara is dominated by the black grayling of the Baikal origin, while the latter fishery is a mixture of only local riverine fishes, the former with much higher $\delta^{13}C$ values than the latter. This is probably why the Lokomotiv group shows strong correlation only between mean calibrated dates and $\delta^{15}N$.

The *Serovo* sample from the Little Sea is also of sufficient size ($n = 22$) to detect a dietary trend (Table 7, Fig. S3). While all individuals represent the GFS diet, they come from six cemeteries, so the chances that they represent social units following somewhat different subsistence and dietary options are perhaps higher than was the case with the *Isakovo* sample on the Angara. Consequently, the dietary signal perhaps is not as "clean" is it would have been had it come from a more homogenous unit. Still, both stable isotope measurements for the Little Sea *Serovo* GFS group show strong correlation with mean calibrated dates, which is alike the *Isakovo* pattern on the Angara. On the Little Sea, however, the correlation with $\delta^{13}C$ is stronger than the association with $\delta^{15}N$ and the former is positive while the latter is negative, that is quite different from what the *Isakovo* group shows. In our view, the *Serovo* Little Sea pattern is best described as increased consumption over time of large and medium game and some Baikal seal. Game alone would not account for the increase in $\delta^{15}N$ to the measured levels (13.2–17.0‰) while harvesting of the shallow water fishes with relatively high $\delta^{13}C$ values [Weber et al., 2011] would likely cancel this particular trend. Addition of even relatively small amount of seal, characterized by very low and high $\delta^{13}C$ and $\delta^{15}N$ signatures, respectively (−22.1‰ ± 0.8, 13.7‰ ± 1.1, $n = 11$; Weber et al., 2011), is quite consistent with the pattern observed for this unit of analysis.

6.4. Early Bronze Age Glazkovo dietary trends

A good half of the dietary trends identified in the current dataset of biochemical results for Cis-Baikal Middle Holocene HGs relate to EBA groups of the *Glazkovo* mortuary tradition and the only microregion that is not represented among these patterns is the Angara valley. The sample from Khadarta IV, already mentioned earlier, is the best choice to begin this review (Table 7). The biochemical data available for this cemetery ($n = 9$) show a strong positive correlation between $\delta^{13}C$ measurements and mean calibrated dates (Fig. 5A), and such pattern is best explained by increasing with time consumption of large and medium game and, perhaps, also plant foods. The strength of this particular association, the highest among all patterns found so far, and some additional bioarchaeological characteristics describing this sample, make it much more informative than its size alone would suggest at the first glance.

Khadarta IV is a cemetery with 15 graves and 14 burials, 10 of which have been tested for stable isotopes and dated. Nine of these are adults—three of each males, females and indeterminate sex—and one individual is 3–7-years-old and, thus, excluded from this analysis. All these adults display the GFS diet. The mean calibrated dates BP are quite evenly distributed over the span of 521 years with a gap between any 2 chronologically successive burials ranging from 22 to 97 years, 61-year-long on average.

Obviously, these adult women and men could not function on their own. Each of them was a member of a larger HG socio-economic unit consisting of individuals of various age from young children, through adolescents and adults, to seniors. These groups probably operated over generations within the same well-defined home range and followed a consistent subsistence strategy, which gradually resulted in a dietary change so clearly visible in the systematic shift in stable isotope values of those group members that were interred at Khadarta IV. It was likely quite a deliberate decision to bury these particular individuals there and to repeat this process roughly every two or three generations: they were probably leaders of these groups and access to critical resources had to be confirmed by their interment in a family graveyard. That all these nine individuals show such a strong dietary trend also means that, probably, they were born locally as the inclusion of non-locals with even slightly different diets would likely weaken the observed association. It follows then, that these individuals were quite possibly close relatives, members of the same blood line, a notion that can be tested through the genetic approach. A logical question to ask is where were the other members of this multi-generational group buried. A few options come to mind: They were either disposed of in a manner that is archaeologically invisible; or, perhaps, they married out and moved elsewhere; or else, they were buried at large communal cemeteries of the Khuzhir-Nuge XIV kind as suggested by its very complex structure. Thus, Khadarta IV, in addition to other purposes, must have functioned also as a symbolic centre of this particular kin group and its home range over multiple generations.

Two other analytical units in the Little Sea microregion show a trend similar to the one documented for Khadarta IV (Table 7): (1) Individuals with the GFS diet ($n = 22$) from the Centre-East Cluster at Khuzhir-Nuge XIV (Fig. S4A); and (2) All GFS individuals ($n = 10$) from the Ulan-Khada cemetery (Fig. S4B). That neither of these two trends is as strong as the one displayed by the Khadarta group, although still statistically significant, might be related to the lesser socio-economic homogeneity of these two samples. The difficulty of identifying homogenous units of analysis at Khuzhir-Nuge XIV has been already mentioned. Moreover, perhaps some of these individuals represent the Khadarta IV group or some other socio-economic units with similar dietary behaviour. The Ulan-Khada sample combines three spatial clusters (Ulan-Khada II, IV, and V; White et al., 2020a) each, perhaps, representing a different socio-economic unit. It is quite meaningful that despite such difficulties, dietary trends affecting these groups have been nevertheless identified.

Individuals with the GF diet from Khuzhir-Nuge XIV form one additional Little Sea analytical unit that shows a dietary trend. This time the statistically significant association is between δ^{15}N values and mean calibrated dates (Table 7, Fig. S4C). According to our current understanding of the relevant subject matter, it seems that this gradual shift is best accounted for by the increasing with time consumption of Baikal seal. That it is individuals with the GF diet who show such trend should not surprise because it is precisely such diet that has more room for the contribution of the seal to grow than the GFS group, in which this food already is part of the diet and perhaps already achieving its maximum level due to the practicalities of harvesting this seasonally and spatially very restricted food. Recall that people with the GF diet are considered to be born outside of the Little Sea while people with the GFS diet were born either locally or non-locally (Weber and Goriunova, 2013). If the latter, their diet prior to migration to the Little Sea, was likely GF. Thus, it should not surprise either that such newcomers would turn their attention to harvesting a resource absent in their homeland, perhaps under circumstances of restricted access to the game hunting grounds, controlled by the locals.

The Upper Lena microregion, although with a much smaller number of EBA individuals examined ($n = 39$), still shows some interesting insights. Obkhoi ($n = 13$), located on the Kulenga River—a small left tributary of the Lena, and perhaps Verkholensk too ($n = 8$), located directly on the Lena River, are the only two samples that are large enough to show any dietary trends, if present, on their own. However, the diets of these two groups are isotopically different from one another [White et al., 2020a; Weber et al., 2017] and so is the diet of the Ust'-Il'ga sample ($n = 5$). Thus, combining them in search for statistically significant associations between the relevant variables makes no sense and defining units of analysis large enough for statistical analysis becomes difficult. Moreover, the correlations displayed by the Obkhoi and Verkholensk samples are different from one another: at Obkhoi it is the δ^{13}C values and mean calibrated dates that are associated (Table 7, Fig. S4D), while at Verkholensk the correlation is between the $\delta\ ^{15}$N measurements and mean calibrated dates (PCC $r = 0.926$, $p = 0.001$, n = 8). Thus, the trends are quite different. Adding to the Verkholensk EBA group all other examined EBA burials from the area around Verkholensk increases the sample size to 20 and confirms results of the PCC analysis (Table 7, Fig. 5B). The first pattern is best explained by the increasing consumption of large and medium game and, perhaps, also plant foods; the second by the increasing consumption of local fish.

Overall then, the Upper Lena microregion shows its own dietary particularities. The group from Verkholensk and around it is different from the Obkhoi group, only about 20–40 km separating the two, each showing also a different trend. The people from around Verkholensk would have direct access to the Lena fishery which, while never particularly abundant, would still be richer than the fishery of the small Kulenga River, where the Obkhoi group was based. And the diet of the Ust'-Il'ga group, located on the Lena some 100 km further north, is different from both showing much higher δ^{15}N values, but no trend as of yet as the sample is too small.

And the last Cis-Baikal HG group that shows a dietary trend is the EBA component at the Shamanka II cemetery on Southwest Baikal (Table 7, Fig. S4E). The trend is best explained by an increasing consumption of the local Kultuk Bay fishes. It is unlikely that the diet included also the Baikal seal as this would likely result in a weaker correlation between δ^{13}C values and mean calibrated dates as in the EN *Kitoi* samples from this cemetery. In contrast, the EBA sample shows a strong correlation between these two variables, although not statistically significant likely due to the small sample size.

6.5. Summary of dietary trends

The picture emerging from the review of dietary trends experienced by Cis-Baikal Middle Holocene HGs is that of spatial variation growing with time. All EN *Kitoi* trends have to do with the increasing contribution of fish to the diet of these people. Furthermore, the beginning of this general trend seems to go back to the Late Mesolithic times. The sample for the LN is still rather small but it already shows more variation than what we see among the *Kitoi* groups. The *Isakovo* group from the Angara seems to be relying more over time on fishing for their diet while the *Serovo* people from the Little Sea appear to be eating more game with time. Lastly, the variation in dietary trends observed for the EBA exceeds much what has been document for the older periods: the dietary histories differ from one another, almost each emphasizing somewhat different food group (game, fish, seal or even plants).

While many Cis-Baikal Middle Holocene HG groups show a dietary trend of some kind, many do not. There may be a few reasons for this. First, perhaps, indeed, for many groups the diet remained stable over time but this begs a question of why the diet of their neighbours did change with time while their own did not. The second reason has to do with the identification of analytical units for examination as discussed already twice (sections 4.2 and 6). While many units are just too small, combining them into larger units increases the risk that they do not represent homogeneous socio-economic units. Any unit of analysis defined using a combination of the *primary* or *secondary* archaeological criteria may still include individuals belonging to a few different socio-economic units, each with slightly different food procurement practices. In other words, for the dietary trend to be visible in the biochemical data, the analyzed individuals should belong to the same socio-economic unit operating over some time. This, however, cannot always be assured because the units are defined using not such socio-economic criteria, which are generally invisible in the archaeological record, but criteria that are visible, such as spatial distribution of burials, mortuary characteristics, and diet type as well as their various combinations. Thus, some individuals were likely excluded from units which do show trends and included in units which do not. Analyzing together individuals who belonged in their lifetime to different socio-economic units may weaken or hide a dietary trend even if present in their own socio-economic unit.

Third, the membership rules of the examined units of analysis, assumed to represent individuals functioning within the same socio-economic units, may have varied too: some units may have had more outsiders— thus more diverse diets; some fewer—thus less diverse diets. Fourth, the diet of such outsiders may or may not have been different from that of the group they joined. Lastly, the size and the location of home ranges with their food resources, and related travel, all could have been a factor too. Groups that were more mobile and harvested, for example, fisheries with different stable isotope characteristic, are unlikely to show any dietary trend, while those that were less mobile and consistently used the same fishery are more likely to display a trend, if it developed. It follows then, that the subsistence activities of all groups with at least some sort of dietary trend identified through this analysis were probably firmly based in their relatively small home ranges.

A few additional observations can be inferred from the comparison of the timing, i.e., the start and end, between the identified dietary trends within the relevant culture historical periods (Figs. 3–5; Figs. S2–S4). During the EN, the trends for the following three units of analysis essentially parallel one another: Lokomotiv (Clusters 2, 4, and 5), Shamanka II Phase 1 SE Cluster row burials, and Shamanka II Phase 1 SE Cluster scattered burials, with the two Shamanka trends perhaps terminating a little before the end of the Lokomotiv trend. It is also interesting that the two Shamanka trends display the same timing, for there is no obvious reason why they should as each regards a different fishery and the duration of Phase 1 is long enough for such offset to be visible through radiocarbon dating. Obviously, the Shamanka II Phase 2 dietary trend is a much later development relative to the other three documented *Kitoi* trends.

The two LN dietary trends, one identified for the *Isakovo* group from the Ust'-Ida I cemetery and the other characterizing all *Serovo* individuals with the GFS diet in the Little Sea microregion, overlap only partly: the *Isakovo* pattern starting much before the *Serovo* trend and ending also much earlier. For the EBA *Glazkovo* groups, the trends found for Khuzhir-Nuge XIV, Khadarta IV, and Shamanka II generally parallel one another chronologically and, at the regional scale, tend to be shifted towards the second half of the EBA. In contrast, the Ulan-Khada trend appears to start and end much before the other four Baikal trends. On the Upper Lena, the two *Glazkovo* trends are parallel to one another from start to end, span most of the EBA, and thus start much earlier than the three younger *Glazkovo* trends from the Little Sea and another one from Southwest Baikal (Shamanka II).

The identified dietary trends are different not only in terms of diet structure and relative chronology but also in terms of span, ranging from very short- to very long-lived trends. Analysis of the chronology and use patterns of Cis-Baikal Middle Holocene HG cemeteries by Bronk Ramsey et al. (2020) provides more insights on these matters. Lastly, of the 560 examined individuals, 300 (54%) belong to a group displaying a dietary trend but the numbers differ between the main units of analysis: 0% of *Khin*, 61% of *Kitoi*, 95% of *Isakovo*, 34% of *Serovo*, and 50% of *Glazkovo* and even more microregionally (e.g., 85% of *Serovo* and 61% of *Glazkovo* in the Little Sea). These estimates should be taken as provisional.

7. Summary and conclusions

Addressing the problem of direct radiocarbon dating of human skeletal remains by developing equations to correct the effect of old carbon has allowed an entirely fresh approach to the examination of Cis-Baikal Middle Holocene HG adaptive strategies, otherwise not possible. Applying this approach to a series 560 directly dated individuals has produced a number of new and important insights, their detailed assessment going much beyond the goals and space limits of this paper. Instead, the findings from this study and several others included in this special issue are integrated in a separate paper [Weber, 2020]. Consequently, this examination concludes with a descriptive summary of the main results.

First, we have revised and improved our understanding of the Middle Holocene culture history of the region, the boundaries between the chronological (archaeological periods) and cultural (mortuary traditions) units and the tempo of transitions between them. Importantly, differences between the four archaeological microregions in the timing and duration of these culture historical units have come to focus for the first time.

Second, we have expanded our knowledge about dietary trends exhibited by Cis-Baikal HGs. For the EN Angara and Southwest Baikal, we have documented dietary trends towards a greater reliance on aquatic foods. For the LN, we have found that one *Isakovo* group on the Angara increased the dietary reliance on fishing with time, while the trend among the *Serovo* groups in the Little Sea seems to have been towards an increased dietary reliance on game. For the EBA, we have identified a mosaic of dietary patterns: some groups showing dietary trends and most different from one another, while other groups, apparently, displaying stability.

Third, these new findings combined suggest much variation in patterns of culture change within and between archaeological periods and mortuary traditions. Some developed at a quick pace, others at a much slower, some appear to have collapsed rapidly, while others probably went through a more gradual transition to a different pattern. And fourth, the new tool to build high-resolution chronologies for Cis-Baikal Middle Holocene HG cemeteries allows novel insights into patterns of cemetery use. While this matter is explored in more detail in a separate study [Bronk Ramsey et al., 2020], it is already clear that most of the generally accepted assumptions about their continuous and parallel use were incorrect: some cemeteries, indeed, seem to have been used continuously, but others only sporadically, and some show long periods of disuse; moreover, some cemeteries of the same mortuary tradition apparently functioned much before others were even established.

All this clearly demonstrates that Cis-Baikal Middle Holocene HG strategies underwent a range of changes not only at the boundaries between relevant culture historical units, but that many important changes unfolded also within such units. Moreover, the new insights suggest much spatio-temporal variation in the nature, pace, and timing of these developments [c.f., Weber, 2020].

Unquestionably, there is still much work to be done along the lines pursued in this study to improve further our understanding of the evolutionary history of Cis-Baikal Middle Holocene HGs. Rectifying the sampling imbalances between the microregions and tying the new culture history to regional and microregional climate records are perhaps among the most pressing to address first. New insights from ancient genetic studies on the human skeletal remains representing these groups are also awaited with great anticipation.

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Declaration of Competing Interest

The authors have no competing interests.

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