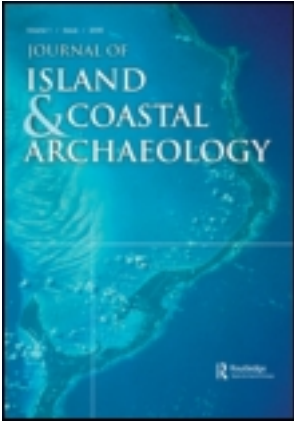


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Fish and Fishing in Holocene Cis-Baikal, Siberia: A Review

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ABSTRACT

Eastern Siberia's Lake Baikal and its tributaries are productive fisheries, and the region's Holocene archaeological sites confirm that this is a long-standing phenomenon. Recent zooarchaeological investigations of sites here allow Holocene fishing practices to be examined in more detail than was previously possible. Along much of the lake's coast, bathymetry is very steep and the water very cold; here fishing appears to have been supplemental to other subsistence practices such as sealing and ungulate hunting. In shallower areas, waters were warmer and supported very productive fisheries for littoral species, perhaps through the use of nets or traps. The region's rivers offered their own resident species but also were used as spawning grounds by some lake fishes. The lake's littoral fisheries, while productive, likely produced fish throughout the year and did not require complex labor organization to be effectively used. Some sections of the region's rivers, particularly those that were spawning grounds for some lake fishes, may have required more complex sociopolitical organization to be exploited efficiently. Such fish runs were short-lived and the best fishing places likely were spatially restricted. This potentially created the need for pools of labor, required organization of harvesting and processing, and generated surpluses that could be stored and manipulated.

Keywords zooarchaeology, economy and subsistence, fishing, social organization, Russia, Siberia

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INTRODUCTION

Lake Baikal and its nearby rivers offer an abundance of aquatic food resources unmatched in the rest of the interior southern boreal region of Siberia (Figure 1). The archaeological record of Holocene hunter-gatherers and pastoralists here in part reflects this abundance. Much fishing equipment is found in some sites, seal (*Phoca sibirica*) bones are numerous in settlements along portions of the Baikal coast, and studies of diet through isotope analyses of human remains indicate long-standing use of aquatic foods. Here we review and discuss patterns in aquatic fauna use by Holocene occupants of Cis-Baikal focusing specifically on fishes. To start, we outline characteristics of Lake Baikal and its fauna that we consider significant for understanding Holocene subsistence practices. A review of Cis-Baikal's zooarchaeological record of fishing is then offered, including several new sets of data. Finally, we speculate on patterns in Middle Holocene fishing in Cis-Baikal and their relationships to other phenomena, including issues of labor organization and climate and environmental change. To begin, basic information about recent research here is provided, along with a very brief review of Cis-Baikal's Holocene culture history.

The Baikal Archaeological Project (BAP), a large multidisciplinary research endeavor centered at the University of Alberta, has been investigating the Holocene archaeological record of the Cis-Baikal region for over 10 years, and much of the data presented here derive from this project. Cis-Baikal, following Michael (1958), encompasses the area north and west of Lake Baikal, including the Angara River and its tributaries downriver from the lake to Ust'-Ilimsk, the upper Lena River to Kirensk, and the west coast of the lake itself (including the lake's largest island, Ol'khon; Figure 2). Archaeology in this region traditionally (and as part of the BAP) has been heavily focused on its abundant Holocene hunter-gatherer cemeteries, while its habitation sites and the materials within them have garnered far less recent scientific attention. Zooarchaeological research in particular has been very under-developed. Few

assemblages have been systematically analyzed using modern methods, and field recovery techniques typically have not involved the use of sieves. Existing collections are often biased toward the remains of large-bodied fauna, and interpretations of ancient subsistence practices previously were quite speculative and based on little hard data. Further, faunal remains rarely have been quantified systematically here, and most available data consists of simple lists of taxa present. The work of the BAP has sought to address these issues in recent years by employing modern recovery techniques at several sites, building a faunal skeletal comparative collection for zooarchaeological research, and publishing detailed accounts of faunal remains analyzed (Losey et al. 2011; Losey et al. 2008; Nomokonova et al. 2009a, 2009b, 2010, 2011).

Reviews of the region's Holocene archaeological record can be found in Weber et al. (2010) and Weber and Bettinger (2010) and are only briefly outlined here to provide context for the rest of the paper. Habitation sites dating to the Early Holocene have been identified along the shore of Baikal and in Cis-Baikal's river valleys, but specifics about subsistence strategies during this period are limited and human remains rare. Recurrently used burial places (cemeteries) first appear in this region during the period from 8000 to 7000 cal BP (the Early Neolithic). From ~7000 cal BP to 6000 cal BP (the Middle Neolithic), burials essentially cease to be made, but the region continued to be occupied. At ~6000 cal BP, burials once again reappear in the region (Late Neolithic, 6000-5000 cal BP) and continue to be made throughout the Bronze Age (~5000-2500 cal BP). Virtually all Cis-Baikal Middle Holocene cemeteries are located on the Angara downstream from the lake, the Little Sea coastline, or the upper Lena River—almost none have been documented in the vast stretches between these three waterways. The hiatus in burials corresponds in time with pronounced climate change in the region, which included significant warming and drying, decreased seasonal fluctuations in temperature and precipitation, and a suite of local environmental changes (few of which are well understood;

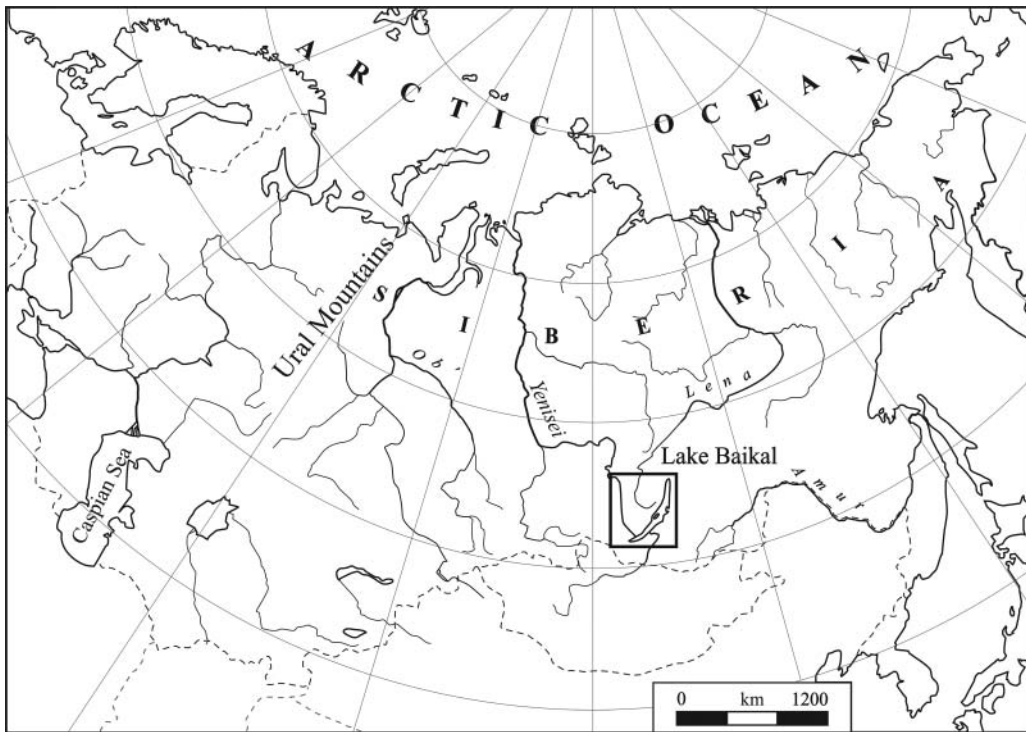


Figure 1. Map of northern Eurasia. The box marks the location of the map in Figure 2.

White and Bush 2010). Ancient DNA studies of human remains indicate that populations in the region before and after the hiatus (the Early Neolithic versus the Late Neolithic and Early Bronze Age) are genetically discontinuous, likely indicating population replacement. Early and Middle Holocene dwellings of any sort are undocumented here, suggesting high residential mobility throughout these periods. The period from about 3000 to 2500 cal BP marks the arrival of pastoralists in Cis-Baikal (the Iron Age, followed by the Mongolian Time), who relied on a mixture of herding (primarily sheep, goats, cattle, and horses), hunting, and fishing. Pastoralism persisted in the area throughout the Late Holocene. Some millet and barley cultivation also occurred during the latter portion of the pastoral period (Dashibalov 1995).

Stable isotope studies of human diets are restricted by the availability of human remains, which in Cis-Baikal are largely limited

to the Neolithic and later periods. Stable carbon and nitrogen isotope studies of several hundred sets of Neolithic and Bronze Age human remains show that diets in this region were variable, but nearly all individuals, regardless of the sub-region they were buried in, relied to some extent on aquatic resources (fishes and the lake's freshwater seals; see Katzenberg et al. 2009, 2010; Katzenberg and Weber 1999; Weber et al. 2002). The stable isotope data seems to indicate that fish use was most extensive among the populations living on the Angara and on the Little Sea coast of the lake, and least extensive among the populations living on the upper Lena River. Unfortunately, no stable isotope data currently is available for Late Holocene human remains here. While the stable isotope data values of individuals and populations can be analyzed and compared in numerous ways that make them extremely useful, in many cases they are ambiguous about which

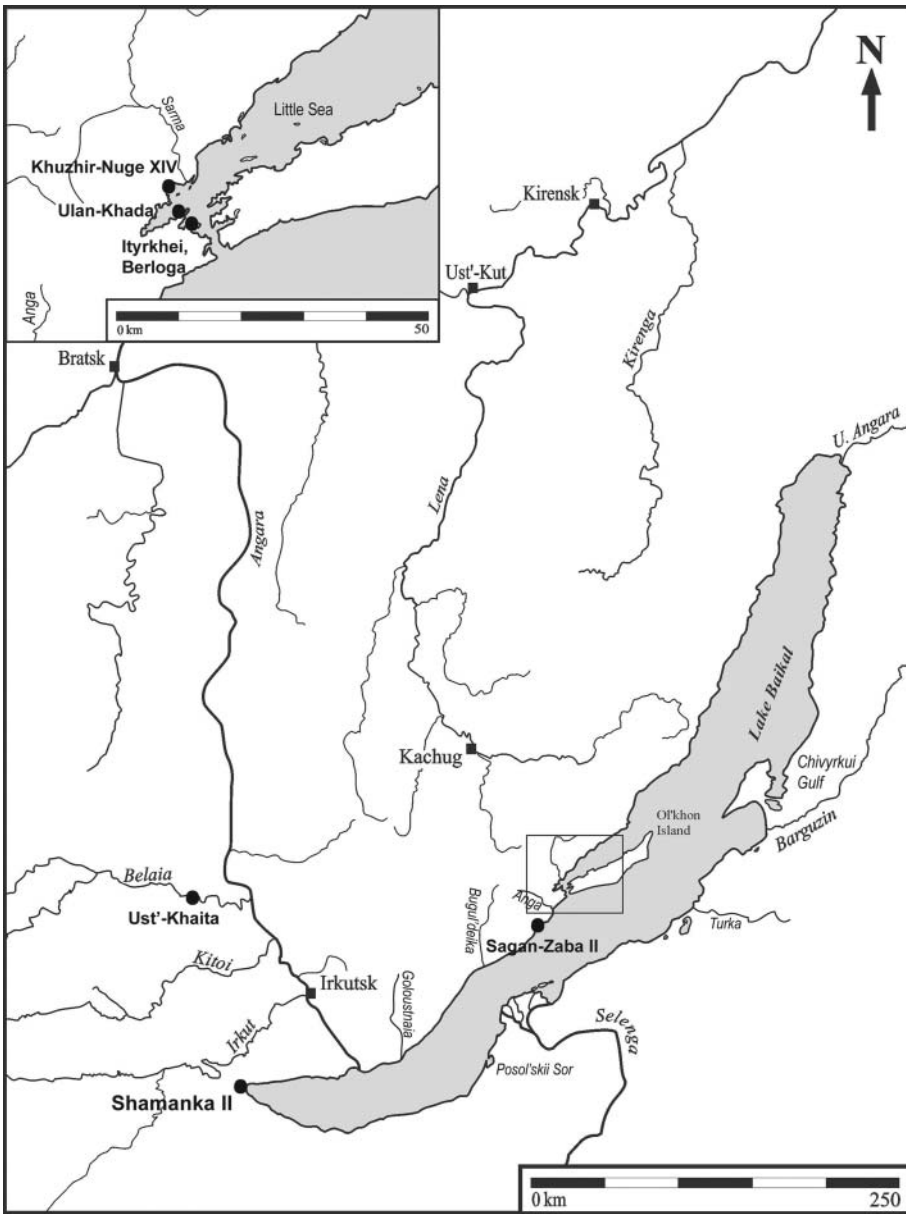


Figure 2. Map of Lake Baikal, Russia, with major geographic features and archaeological sites noted. Inset shows the Little Sea region on the lake's west coast.

particular animals were consumed. This is the case at least in this area because many of the potentially exploited aquatic species have quite similar isotope values (see Katzen-

berg et al. 2010:184–185), and because various diets can produce similar isotope signatures in humans. Further, they tell us little about how, when, and where animals were

procured, all of which are important for inferring various aspects of past lifeways. We do not mean this as a critique of stable isotope studies, but rather point out these shortcomings to emphasize the need to integrate these research findings with those produced through zooarchaeological studies. To understand both datasets, a basic understanding of the region's aquatic fauna is needed.

FAUNA OF LAKE BAIKAL AND ITS RIVERS

Most descriptions of Lake Baikal begin by discussing its great age and considerable depth. These features are important because the two have allowed for the development of a unique aquatic environment within which humans have long participated. Lake Baikal reaches a maximum depth of 1642 m (INTAS project 99-1699 Team 2002), and unlike most other deep lakes, is oxygenated throughout its water column (Martin et al. 1998). The lake's exact age is debated, but it is clearly millions of years old. A unique deep-water fauna has evolved here, and many of these species are major prey items for animals utilized by the region's Holocene hunter-gatherers (for a detailed description of Cis-Baikal major fishes and their habitats, see Weber 2002:57-58; Weber et al. 2002:241-245). For example, the lake's seals (*Phoca sibirica*), which are a freshwater adapted species most closely related to the arctic's ringed seal, feed largely on endemic sculpins, golomianka (*Comephorus dybowskii*, *C. baicalensis*, and *Cottocomephorus grewingki*) and various amphipods, all relatively small fauna adapted to the lake's deep waters (Kozhova and Izmest'eva 1998). The sculpins and golomianka make up over 95% of the total fish biomass in Baikal's pelagic waters (Sideleva 2003). The bulk of the modern commercial fishery, however, is focused on omul' (*Coregonus autumnalis migratorius*), a herring-like whitefish averaging about 30 cm in length and closely related to the arctic cisco. Omul' are primarily commercially taken in relatively deep waters in the open lake using large fine-gauge trawl nets.

Lake Baikal has some stretches of water that are comparatively warmer and shallower, and these regions and their fauna also were important for human subsistence. The lake's gulfs, sors, lagoons, and river mouths support a variety of fishes. For example, commonly encountered fish in these comparatively shallow waters include perch (*Perca fluviatilis*), roach (*Rutilus rutilus lacustris*), dace (*Leuciscus leuciscus baicalensis*), ide (*L. idus*), pike (*Esox lucius*), whitefish (*Coregonus lavarentus baicalensis*), and burbot (*Lota lota*). Locations such as the southern reaches of the Little Sea of Lake Baikal (Figure 2), where many Holocene human cemeteries and habitation sites are found, are particularly rich in these littoral species. Sturgeon (*Acipenser baeri stenorhynchus*), taimen (*Hucho taimen*), and lenok (*Brachymystax lenok*) are also present but far less abundant in the lake; today they are extremely rare throughout Baikal due to overfishing and habitat degradation (Matveyev et al. 1998). At present, taimen and lenok are relatively common in nearly all of the region's rivers; this pattern likely has persisted throughout the Holocene. While several hundred rivers drain into Lake Baikal, very few of any size meet the lake along its western shore. Most of our archaeological research has occurred along this western shoreline, on the Angara River (the lake's only outlet), and on the upper Lena River just outside of the lake's watershed to the northeast. The major rivers draining into the lake such as the Upper Angara, Barguzin, Turka, and Selenga drain areas to the north, east and south of the lake. Most lands just west of the lake drain into tributaries of the Angara or Upper Lena. All of these rivers and streams have been modified in some way by human activities during the recent past. All have been intensively fished and some, particularly the Angara River below the lake, have been dammed for the production of hydroelectricity.

The rivers connected to the lake have their own resident fishes such as taimen, lenok, pike, roach, arctic grayling (*Thymallus arcticus*), tugun (*Coregonus tugun*), and sterlet (*Acipenser ruthenus ruthenus*), but importantly also were utilized by some lake fishes as spawning areas. Populations of

omul' spawn in mid-summer in the Upper Angara and Selenga rivers while other runs of these fish use rivers and streams entering the Posolsky Sor and Chvyrkui Gulf along the lake's east coast (Kozhova and Izmes't'eva 1998). Very few omul' spawn in streams along the lake's west coast; the most notable (and perhaps the only) population to do so utilizes the Sarma River (see inset, Figure 2), a small stream near the south end of the Little Sea. Baikal black and white graylings (*T.a. baicalensis* and *T.a. baicalensis brevipinnis*), both highly prized fatty fish, also use the rivers and streams entering the lake. In early spring black grayling exploit small streams for spawning, including the Sarma, Anga, Bugul'deika, and Goloustnaia rivers along the lake's western shore, but also use the Angara between Irkutsk and the lake. White grayling prefer larger rivers, particularly those entering the lake's eastern shore.

FISHING AND THE ARCHAEOLOGICAL RECORD

Archaeologists have for decades speculated on the role of fish and fishing in the ancient economies of Lake Baikal (Khlobystin 1969; Okladnikov 1948; Petri 1926). Despite this, studies of fish remains from sites on the lake and its tributaries are extremely rare; prior to 2006, only three assemblages with small NISP counts had been described (Ulan-Khada, NISP = 78; Nizhniia Berezovka, NISP = 78; Nizhne-Ivolginskoe Gorodistche, NISP = 203; Tsepkin 1966, 1976). Most faunal studies in the Lake Baikal region only have tended to list the presence or absence of fish, with little further quantification provided (but see Tsepkin 1966, 1976, 1980; Mamontov et al. 2006). Methods for identifying archaeological specimens are virtually never stated. As such, most speculation about the roles of fish and fishing at Lake Baikal has been based on patterns in site distribution and the abundance of and diachronic changes in fishing technologies.

Many scholars have argued that fishing was not a major focus of subsistence practices until the Holocene (Everstov 1988;

Khlobystin 1965, 1969; Medvedev 1969, 1971; Okladnikov 1950, 1955). No Pleistocene sites with fish remains have been identified on Lake Baikal, but several such sites have been found nearby on the lake's tributaries (Abramova 1962; Tashak 1996). Harpoons and barbed bone points have been argued to be the earliest fishing implements, and these appear here during the late Pleistocene (Medvedev 1969, 1971; Okladnikov 1955). Single-piece bone and antler fishhooks are evident in the early Holocene (Medvedev 1969, 1971; Novikov and Goriunova 2005; Okladnikov 1955; Svinin 1971, 1976). Composite fishhooks with stone shanks and barbs appear to become relatively abundant about 8,000 years ago, particularly in mortuary sites (Medvedev 1971; Novikov and Goriunova 2005; Okladnikov 1950, 1955; Svinin 1976). During the Early Neolithic period, stone fish hook shanks were quite variable, ranging in length from ~2 to 20 cm, probably indicating efforts to target fish of a wide size range. Possible stone fish lures also first appear during this period (Georgievskaiia 1989; Okladnikov 1948, 1950; Studzitskaia 1976).

Direct evidence for fishing nets or traps is lacking on Lake Baikal, but many investigators have argued for their presence in the mid- to late Holocene. Supposed net sinkers (notched stones), bone needles (interpreted as netting needles), and cordage impressions on pottery have all been used to argue for the use of fishing nets (Georgievskaiia 1989; Novikov and Goriunova 2005; Okladnikov 1950, 1955). Based on the size of fish harvested at the Ityrkhei habitation site (described below), Losey et al. (2008) also argued for the use of nets or traps on Lake Baikal during the Early and Middle Holocene. Several researchers have suggested that the employment of nets on the lake required the use of boats (Georgievskaiia 1989; Medvedev 1971; Okladnikov 1955), but no ancient boats have been found. Some place the appearance of boats during the Developed (or Late) Neolithic period (~6000 cal BP) (Novikov and Goriunova 2005) or the Bronze Age (~4500 cal BP) (Khlobystin 1963).

Stable isotope studies have been made on human remains from multiple Holocene

hunter-gatherer cemeteries in the Lake Baikal area (Katzenberg et al. 2009, 2010; Katzenberg and Weber 1999; Weber et al. 2002). As stated earlier, these studies indicate all analyzed groups in Cis-Baikal were eating fish, but fish use was variable depending upon time period, location, and individual. In the most detailed analyses of human nitrogen and carbon isotope values in Cis-Baikal, Katzenberg et al. (2009) assessed aquatic food use among individuals buried in the Khuzhir-Nuge XIV cemetery near the southern end of the Little Sea; nearly all of the tested sets of human remains from this cemetery are from the Bronze Age (here ~4700 to 5000 cal BP; Weber et al. 2005). The isotope analyses indicated that all individuals were consuming aquatic foods, including both seals and fishes. Katzenberg et al. (2009:671) suggest that the fishes likely contributing most to the diet here were lenok, dace, and some perch. In addition, diets varied within the cemetery, with one group of spatially associated individuals perhaps depending more on terrestrial herbivores than others, or another group possibly depending more on seals and high trophic level fish such as sturgeon and pike.

Zooarchaeology

Our analyses of fish remains from the region's archaeological sites was based upon the use of a comprehensive fish skeletal comparative collection made by Nomokonova and Losey in Irkutsk, Russia, and the quantification procedures utilized followed widely accepted standards (e.g., Reitz and Wing 1999). Losey et al. (2008) and Nomokonova et al. (2009a, 2009b) first examined previously collected and newly excavated faunal remains from the Ityrkhei habitation site. Located at the southern end of the Little Sea around 8 km from the Khuzhir-Nuge XIV cemetery, Ityrkhei appears to have been used through most of the Holocene but was most intensively occupied from ~8000 to 4300 cal BP. Despite originally being excavated without the use of sieves, the early excavations here of ~290 m³ still resulted in the recovery of 8,400 (NISP) faunal remains, 97% of

which were fish bones. Excavations in 2005 of ~7 m³ of deposits and using 2 mm sieves produced 11,300 faunal remains, over 99% of which were fish. The faunal recovery rate using the 2 mm sieves was just over 1,600 specimens per cubic meter. If such density of faunal remains was characteristic of the entire site area, this suggests that if the same recovery techniques were used during the early excavations at Ityrkhei, over 450,000 fish remains could have been collected. Clearly, when Ityrkhei was being most intensively occupied, subsistence activities focused on fishing. Notably, while recovery rates of fish remains were clearly impacted by the use of sieves, the overall rank order of fish species did not change with their use. This suggests that the unsieved collections from the region likely retain useful information about the ordinal ranking of fishes used at particular sites, but not about fish bone deposition rates.

The taxonomic composition of Ityrkhei varies little through time and reflects a proximity to the lake's warm, shallow waters; perch, roach, and dace, all common littoral species, account for 93% of the identified specimens. Coregonidae (whitefishes, including omul') account for only 5% of the total, followed by pike at 2%. Sturgeon and lenok, two species inferred through stable isotope analyses to have been important in some individual's diets at the nearby Khuzhir-Nuge XIV cemetery, were absent. The taxonomic abundances observed in the Ityrkhei data match well with historic fish catches in this region, providing little evidence for substantial changes in fish distributions here during the Holocene. Seasonality of site occupation is unclear; all identified fishes are currently present near Ityrkhei year-round. The southern Little Sea region today is a popular ice fishing location for perch, pike, roach, dace, and in some areas whitefish, but is also commonly fished during periods of open water via small watercraft and nets. The open-water fishery is particularly productive in spring when perch, roach, dace, and pike congregate in the shallows for spawning and feeding.

Following the initial analysis of Ityrkhei, we sought to assess which fishing tech-

nologies were employed by the ancient inhabitants of this site. Very little fishing equipment was recovered from Ityrkhei itself; possible fishing-related implements include a Mesolithic bone harpoon and a single ground stone fishhook shank and 'netting' needle from the Neolithic. An unspecified number of notched stones, interpreted as net weights, were also found in the Neolithic deposits. Using a sample of modern perch of various sizes collected from the Little Sea, we developed a series of regression formulas that allowed us to assess the size of perch harvested at Ityrkhei (Losey et al. 2008). Our calculations indicated that almost no perch under about 20 cm in total length were taken. As Baikal perch reach maturity when around 15 to 20 cm in length, this suggests a focus on adult individuals. We suggested that these fish size estimates indicate selectivity resulting from the use of technologies such as large-gauge nets or traps; acquiring fish solely through hook and line fishing would almost certainly result in the inclusion of many smaller individuals as perch of any size readily take baited hooks. Fishermen using large-gauge monofilament gill nets in the Little Sea today commonly harvest catches dominated by perch, roach, and dace, along with smaller numbers of pike, a taxonomic pattern closely matching our data from Ityrkhei. Furthermore, roach and dace have very small mouths relative to their body size and are difficult to take with hook and line when using anything but extremely small hooks (Sabanev 1996).

In 2009, two other Little Sea faunal assemblages were analyzed, both of which contained fish but were excavated without the use of sieves. The first of these is Berloga, located about 200 m east of Ityrkhei on Berloga Cove. This site was occupied at various points in the Holocene, but its primary periods of occupation seem to be the early and middle Holocene (Mesolithic and Neolithic) as well as the Bronze/Iron Age transition; only three radiocarbon dates are available for this site, and assignment of layers to temporal periods is based largely on artifact typology (Goriunova 1984; Goriunova et al. 1996). Our analyses focused on materials recovered during the 1977 excava-

tions of Berloga (Nomokonova et al. 2009b). Only 507 total faunal specimens (NISP) were present in this collection, and 337 of these were fish, with only 69 specimens being identified to at least the family level (Table 1). All but 12 of the fish remains were recovered from the Mesolithic and the Neolithic layers. As at Ityrkhei, perch are by far the most abundant taxon followed by pike, sturgeon, and Cyprinidae.

The second recently analyzed assemblage was from Ulan-Khada (Figures 2 and 3). This site is located about 2.1 km from Ityrkhei on a peninsula overlooking Mukhor gulf; the Khuzhir-Nuge XIV cemetery is about 4.5 km directly northwest of Ulan-Khada across the gulf. We analyzed faunal remains recovered from the site during excavations in 1974, 1982, and 1990 (Nomokonova et al. 2011); the total number of identified specimens was 2746 of which 1567 were fish (Table 1). Ulan-Khada appears to have been used intermittently throughout much of the Middle Holocene; 11 radiocarbon dates from this site range in age from roughly 3250 to 5500 uncalibrated years before present, but typological assessment suggests a period of occupation spanning from 3100 to 6600 years before present (Goriunova 1984; Goriunova et al. 1996). Unlike at the previously discussed Little Sea sites, Salmonidae here are the most abundant taxon by NISP. All of these specimens are vertebræ centra, which are notoriously difficult to identify past the family level. Many of these may be from whitefish; head elements of this group of fishes were identified in the assemblage, and Mukhor Bay is a well-documented whitefish-spawning region (Kozhov and Misharin 1958; Nomokonova et al. 2009a:85). Whitefish enter Mukhor bay in fall prior to ice formation for spawning. Like the Cyprinidae, whitefish have very small mouths and are difficult to take with a hook and line; today nets are a commonly used and effective means of taking whitefish in this region. The relative abundance of Salmonidae specimens may indicate that an open water net fishery was in operation during the fall at Ulan-Khada. As at the other southern Little Sea sites we analyzed, perch are also present in substantial numbers, being nearly as abundant as

Table 1. Fish remains identified at Berloga, Ulan-Khada, and Sagan-Zaba II (S-Z II) by number of identified specimens (NISP).

Taxa	Common name	Iron/Bronze Age transition				Bronze Age				Neolithic				Mesolithic					
		Berloga Khada	Ulan-Khada	S-Z II	Berloga Khada	Ulan-Khada	S-Z II	Berloga Khada	S-Z II	Berloga Khada	Ulan-Khada	S-Z II	Berloga Khada	Ulan-Khada	S-Z II	Berloga Khada	Ulan-Khada	S-Z II	Total
<i>Acipenser baeri</i>	Siberian sturgeon			8		3		28						12		7		4	62
<i>Esox lucius</i>	Pike	1	1	1		4				2				14		6			29
<i>Perca fluviatilis</i>	Eurasian perch	2	1	2		248		5		44				48		3			353
<i>Lota lota</i>	Burbot													2					2
<i>Leuciscus baicalensis</i>	Baikal dace			3				1											4
<i>Rutilus rutilus</i>	Roach			1		1													2
Cyprinidae	Cyprinidae family					2		1		1				1		3			14
<i>Thymallus arcticus</i>	Arctic grayling			3				1											3
<i>Coregonus</i> sp.	Whitefish			6		43		8						3					60
Salmonidae	Salmonidae family			459		333		363						29					1330
Pisces— unidentified		1		199		926		141		212				67		56			107
Total NISP		3	3	682	0	1560	0	548	0	259	0	176	75	4	4	110	3499		



Figure 3. The southern Little Sea of Lake Baikal near Ulan-Khada (color figure available online).

Salmonidae; trace amounts of sturgeon, pike, and Cyprinidae were also identified. Again, this suggests that historically observed fish distribution patterns in the Little Sea are quite long-standing.

Faunal samples from the open coast of Lake Baikal are much more limited in scope. Our only existing sample comes from the Baikal Archaeological Project's recent excavation of Sagan-Zaba II, located about 50 km south of the Little Sea on the lake's west coast (Figures 2 and 4). Occupied throughout the early and middle Holocene by hunter-gatherers, and in the late Holocene by pastoralists (who also hunted and fished), Sagan-Zaba appears to have been utilized mostly as a sealing camp. Despite the consistent use of 3 mm sieves for the recovery of archaeological materials here, fish remains account for less than 1% of the total NISP at the site (Nomokonova et al. 2010). Just over 1,500 fish remains were recovered,

almost entirely through the use of sieves, and around 1,000 of these could be identified to at least the family level. The majority was found in deposits dating to the last 2,000–4,000 years, but smaller quantities also were found in the earlier Neolithic and Mesolithic layers. In the later deposits, Salmonidae strongly dominate the identified specimens. A few specimens could be identified as grayling and *Coregonus* sp., but the remainder could not be more specifically identified. In the Neolithic deposits fish remains are not very abundant and are numerically dominated by perch followed by Salmonidae, and smaller quantities of pike, sturgeon, whitefish, burbot, and Cyprinidae also are present. The Mesolithic layers contain only trace amounts of grayling. The apparent relatively minor importance of fish here is in keeping with our knowledge of fishing conditions in this immediate area today. Analyses of seal remains from Sagan-Zaba



Figure 4. View of Sagan-Zaba from the cliffs north of the cove (color figure available online).

suggest that during most of the Holocene, the primary season of site occupation was early spring, likely when the lake was still ice-covered (Nomokonova 2011). The waters adjacent to Sagan-Zaba are deep and cold, and the region is not a popular fishery at any time of year. Small quantities of grayling are taken from the shore via hook and line, and small quantities of omul' are captured with nets here in summer; winter ice fishing

is limited, in part due to its distance from passable roads, but also due to the comparatively low density of fish in the area. It is possible that the ancient fish remains recovered from Sagan-Zaba represent low-intensity ice fishing that supplemented and helped to even out variability in food availability that resulted from less consistently productive subsistence practices such as sealing and ungulate hunting. Similar modes of fishing may

have been practiced at many spring sealing locations along the coast.

The final recent zooarchaeological study in the region was conducted on fish remains recovered from the Ust'-Khaita habitation site on the Khaita River (Mamontov et al. 2006), a tributary of the Belaia River which meets the Angara about 140 km downstream from the lake. Five radiocarbon dates on unspecified materials from several layers where fish remains were found range from 6625 to 8350 uncalibrated years before present. Only portions of the site were sieved (primarily hearths) and it is unclear what collection procedures were employed to obtain the specimens reported. Neither absolute numbers of specimens nor minimum numbers of individuals are indicated in the report, but identifications (always to species) were apparently made on both bones and scales. Results are reported in terms of percent represented by each taxon per layer, and an overall 'average' of taxonomic abundance is also presented. Grayling, burbot, pike, whitefish, sturgeon, taimen, lenok, roach, and ide are all identified as being present. The investigators also summarize earlier work by the ichthyologist Tsepkin on other Angara River area archaeological fish bone assemblages (Ust'-Belaia, located where the Belaia River meets the Angara, and Verkholenskaia Gora in Irkutsk). These assemblages too were obtained without the use of sieves, consist of only a handful of specimens from each site, and all faunal remains were identified to the species or even subspecies level. All are quantified in the same manner as the material from Ust'-Khaita. The sites are reported to contain many of the same species seen at Ust'-Khaita but also include perch. While these results should be viewed with some skepticism due to the recovery, quantification, and identification techniques employed, they do suggest that Holocene fisheries on the Angara and its tributaries included an array of species—no one taxon dominates. Clearly much more zooarchaeological research is needed on the Angara River and its tributaries, a truly massive area of Cis-Baikal, before more definitive statements about Holocene subsistence practices here can be made.

DISCUSSION

Understanding the roles of fish and fishing in Holocene Cis-Baikal cultural developments requires combining the available archaeological data, which is admittedly limited, with an understanding of fish behavior, habitat preferences, nutritional characteristics, and availability relative to other subsistence resources. Additional factors to consider include human demography and settlement patterns, available technologies, and issues related to differential access and control of food and harvesting, processing, and storage equipment; environmental change during the Holocene is also likely extremely important for understanding temporal trends in fish use. While it is impossible to address all of these issues in detail here, we highlight several key points that have been largely unaddressed in both the Russian- and English-language literature on the region.

Many researchers have suggested that omul' was the most important fish to ancient foragers of Lake Baikal (Everstov 1988; Novikov and Goriunova 2005; Svinin 1976). However, the zooarchaeological data available to date provides no evidence for their use. Omul' likely were not important subsistence resources in Cis-Baikal because of their habitat preferences and distribution. These fish are primarily associated with the cold and deep regions of the lake (pelagic areas), except when they enter rivers for spawning. As stated earlier, nearly no omul' spawning streams are found on the lake's western shore, nor do they appear to have spawned in the Angara River. Notably, during some seasons these fish do feed in waters near shore, including the eastern shoreline of the Little Sea (along Ol'khon Island's west coast; Kozhov and Misharin 1958). However, omul' are herring-like in shape, having fusiform bodies and relatively small mouths; they require fine-gauge nets or traps to be efficiently harvested. In other words, to capture omul', in most cases foragers living in Cis-Baikal would have had to search deep open waters using high-time and -material investment technologies such as fine-gauge nets and boats (fishing through the ice in winter would not require boats, however). It is

not argued here that Holocene foragers in Cis-Baikal lacked these technologies or the capacity to use them. Rather, the time and material expense of exploiting omul' made other fishes here far more likely to have been regularly targeted. Their importance was likely much greater where and when they were more readily accessible and predictably located, such as during spawning in rivers along the lake's northern and eastern shores (outside of Cis-Baikal).

Along the west coast of the lake itself, littoral fishes and species such as whitefish probably played far greater roles in human subsistence practices than did omul'. Much of this coast, however, is characterized by steep bathymetry and cold waters, both being unfavorable conditions for these fishes. In general, there are few broad expanses of shallow warm water, and the deep and cold areas appear to support fish in low densities, particularly in the upper portion of the water column. A notable exception to this pattern is the southern end of the Little Sea, the most productive littoral fishery on the lake's west coast. Unlike most of the west coast of Baikal, the Little Sea area has a true coastal plain, and in its southernmost reaches, numerous shallow bays and some lagoons. These support large and comparatively dense populations of perch, roach, dace, and pike, and in some areas and seasons, whitefish (e.g., Mukhor Bay, see above). Today this region supports a nearly year-round (freeze-up and break-up periods are much less intensively fished) recreational and small-scale commercial fishery for these species. In addition, while no area of Lake Baikal is free from treacherous winds that make boating dangerous, the Little Sea's undulating coastline makes it more suitable to small boat travel than any other area along the west coast. For ancient foragers, littoral fish in the Little Sea would have been more predictably located and easier to access than the offshore, deep-water preferring omul'. In addition, species such as pike, perch, and burbot are easily taken with baited hooks, while others such as whitefish, roach, and dace can most effectively be taken with gill nets—expensive small-gauge nets (which require more woven line per length of net) like those required for

omul' were not required. The present zooarchaeological record from the Little Sea supports these interpretations. Fishing appears to have begun on the Little Sea over 10,000 years ago and littoral species and whitefish appear to have been the primary prey at all analyzed sites throughout the Holocene. The species focused upon varied slightly depending upon site location and local ecological conditions, and some mass harvesting with large-gauge nets or traps was likely occurring; hooks and spears also were utilized.

We postulate that from the perspective of labor organization and control, the Little Sea fishery during the Holocene nonetheless presented relatively limited opportunities for controlling and accumulating large stores of fish. The areas where littoral fishes could be easily obtained were relatively widespread and not highly seasonally restricted—many small bays in the region could be fished simultaneously almost year-round by small groups of foragers. Compared to marine coastal areas of the North Pacific (home to well-documented transegalitarian foraging groups previously compared to foragers in Middle Holocene Cis-Baikal; e.g., Link 1999), we envision the Little Sea area as more akin to a large, productive estuary where an array of fishing could occur; the degree of spatial and temporal clumping of fish seen in rivers utilized by spawning anadromous species along the Pacific coast (which in part created opportunities for the development of large, organized labor pools and processing and storage facilities; see Schalk 1977; Suttles 1968) appears to us an unlikely scenario for the Little Sea. Perhaps rather than obtaining and maintaining use-rights or ownership of specific fishing stations, the issue here for prehistoric foragers was to maintain some level of broader access to this region of productive fishing. Furthermore, most littoral fishes, while regularly consumed in areas such as the Little Sea, may not have been highly ranked among Cis-Baikal's foraging groups, which like many other hunter-gatherers may have ranked prey by factors such as fat content and body size (Hawkes et al. 1982; Kelly 1995; Simms 1987; Speth 1983; Speth and Spielmann 1983; Winterhalder 1981). Most of the littoral fishes

are rather lean; 100 grams of pike and perch flesh, for example, contain less than 1 gram of fat and constitute less than 381 kJ of energy each (USDA 2008). While comparative data for species present in Cis-Baikal are limited, even other fishes here (let alone the region's ungulates and seal) appear to have higher fat and energy contents: whitefishes (*Coregonus* spp.) have 4 g of fat and 506 kJ of energy per 100 g of flesh, grayling (*Thymallus arcticus*) 1.9 g of fat and 406 kJ of energy, and sturgeon (*Acipenser* sp.) 2.04 g of fat and 439 kJ of energy (USDA 2008). Further modeling of prey choice, dietary practices, and mobility and subsistence strategies should take such factors into account.

Large and expensive watercraft likely were not required for accessing the Little Sea's littoral fishes; some fishing could occur on foot during winter through the ice, and during open water periods, from shore or via small and relatively simple watercraft. Processing these fish for storage also may not have been that costly in terms of labor, time, and materials. Given their year-round availability, perhaps littoral fish were mostly obtained in small batches on a day-to-day basis rather than in short-lived periods of intensive harvest; small pools of labor with little organization may have been sufficient to ensure timely processing. Other subsistence activities (hunting, trapping, and gathering) likely could have been carried out simultaneously by other group members when this type of fishing was undertaken. In terms of processing fish for storage, during warm weather periods it seems the most likely preservation process would be wind-drying; the Little Sea is the most arid subregion of the lake's west coast and is extremely windy, both conditions being conducive to wind-drying fish. In our experience, the leanness of the littoral fishes also makes them conducive to wind-drying; it is common to see perch, roach, and dace being wind dried in the Little Sea, but the more fat-rich omul' and grayling rot too quickly for this and are almost always preserved through the use of salt or refrigeration. In some cases, local people dig pits in the ground near the lakeshore for storing fishes for later use. No large technological investments (such as specialized

smoke houses) were likely required for the littoral species, and if fish were only trickling in, large labor pools for processing also likely were not needed. Winter catches destined for storage were undoubtedly frozen and cached, perhaps also with minimal labor or material investment.

Outside of the Little Sea along the lake's more open coastline, subsistence practices probably focused primarily on seal, particularly during the late winter and early spring, and the hunting of ungulates (Nomokonova 2011). Low-intensity fishing likely occurred in these areas, perhaps as a low-return but reliable way of supplementing mammal hunting and trapping. Fish most likely taken in these locations were those preferring the lake's cold waters such as grayling and whitefish; the faunal dataset from Sagan-Zaba supports this interpretation as the overall assemblage is dominated by salmonids. An important exception to this low intensity fishing may have occurred during spawning runs of black grayling in the small rivers along the coastline. These fish today are highly regarded for their taste and support popular recreational fisheries on the Anga River just south of the Little Sea, as well as on the Bugul'deika River further down the open coast. A description of fishing during the late 1800s gives an indication of the productivity and intensity of the black grayling fishing in such settings. Levin (1897) reports that the run of fish in the Bugul'deika River lasted only 7–10 days but that a single person with a harpoon could spear from 3 to 5 'puds' (~49 to 82 kg) of grayling per day. Lenok and pike also can be found in these rivers and streams, but are present in smaller numbers and available year-round (Tolmacheva 2009). Such intensive but productive and accessible fisheries likely were attractive to the region's foragers, and it seems that the laying up stores or feasting from catches from these streams would have been possible. Stable isotope signatures of populations utilizing these small streams may also be distinct when compared to those from elsewhere in Cis-Baikal.

The Upper Lena River is the least well-known region of our study area in terms of subsistence practices. Stable isotope

analyses of Middle Holocene human remains from this area show some of the lowest nitrogen levels in our study area (Katzenberg et al. 2010) suggesting to us that fishing was less important here than on the Little Sea or Angara River. The fishes pursued on the Upper Lena likely were species such as arctic grayling, taimen, lenok, as well as some perch and pike, particularly as one moves further down the river. Fish might have been taken anywhere, but deep sections where fish could overwinter, river confluences, and sections just below waterfalls all were likely to have been highly valued and seasonally productive. Sampling of Holocene habitation sites along the Upper Lena using fine-meshed sieves is needed to evaluate these proposed subsistence patterns.

The Angara River in Cis-Baikal, and its major tributaries such as the Kitoi, Irkut, and Belaia, may have supported some of the region's richest Holocene fisheries. Overall, these fisheries probably were taxonomically rich and the species of focus at any given location would have been largely dependent on season of harvest and local ecological conditions. A brief glimpse at Weber's et al.'s (2002) summary table of fishes in the Baikal area shows that nearly all of the region's major species are present in the Angara itself, with the exception of the white grayling and omul'. Particularly important species in these rivers likely were arctic grayling, lenok, taimen, Siberian sturgeon, sterlet, humpback whitefish (*Coregonus pidschan*), and even some of the same littoral fishes as seen in the Little Sea such as pike, perch, roach, and burbot. The presence and abundance of these fishes varies by distance from the lake (see Weber et al. 2002 and references therein), but most species were present in some numbers throughout much of the Angara and its major tributaries. This range of species with widely varying diets, seasonal migration patterns, and body sizes almost certainly required that a diverse set of fishing technologies were used in the past. Clearly, fish were available in these rivers year-round, and in many settlements likely were trickling in and being eaten during all seasons. The annual periods of initial freeze-up and break-up of river ice likely presented the

least favorable conditions for fishing (and for travel).

Seasonal movements of some species likely created opportunities for masses of fish to be taken in relatively limited time spans. For example, the section of the Angara closest to Baikal (from the Irkut River to the Angara's exit from Baikal) was utilized by black grayling for spawning; this region likely was a particularly rich prehistoric fishery. Exploiting these spawning runs may have required more labor (for harvesting and processing) and organization to exploit than many of the region's other riverine or littoral fishes—hundreds of fish could be taken at once and would require immediate processing or consumption. At the same time, the run of black grayling likely would have attracted people from further down the Angara, the lake shore, and the adjacent mountain valleys to this region, resulting in larger than normal population densities in the spring. These runs would have attracted a range of other predators such as lenok, taimen, pike, and seals (the 'prey as bait effect,' following Monks 1987), which too could have been harvested by the region's foragers. Such ecological and social conditions seem some of the most conducive in Cis-Baikal to the development of (but obviously not the sole cause of) social and political complexity—resources were spatially and temporally clumped potentially causing conflicts over access and control, larger than average numbers of people could have been involved, and food production in excess of immediate needs was a good possibility. Harvesting of black grayling through the use of nets or traps may have been particularly productive, and the best places along the river for using these technologies would have been valued and perhaps contested. Such locations would include river mouths, canyons, or waterfalls that forced fish to densely congregate, and even small side channels that would have rendered fish visible and easy to capture with simple technologies. River mouths and other deep and well-oxygenated sections of the rivers also likely were productive areas for taking other fishes; these areas also would provide good over-wintering locations for fish.

Variability in the distribution of fishes on the Angara and its tributaries undoubtedly affected human dietary patterns during the Middle Holocene. In fact, we propose that in many cases this distributional variability had as much effect on human dietary variability as revealed by stable isotope analyses as did Middle Holocene cultural and environmental changes, especially when isotope data is examined on a cemetery-by-cemetery basis (as opposed to viewing the data on an person-by-person basis). For example, those people living roughly between Irkutsk and the lake would have good direct access to black grayling, but would have little to no access to Siberian sturgeon and sterlet, and perhaps very little humpback whitefish (Weber et al. 2002); this section of the Angara is most affected by the ecology of the lake. People living further down the Angara would have no direct access to black grayling but would have sturgeon, sterlet, and whitefish readily at hand; the river here takes on more of a 'typical' Siberian taiga ichthyofauna. In short, it seems quite possible that isotope patterns here will be rather heavily influenced by distance from the lake. Even stable isotope patterns at the predominantly Early Neolithic Shamanka II cemetery at the far south end of Baikal may be influenced by the distribution of riverine fishes. While the cemetery itself is on the lakeshore about 80 km from the Angara's exit from Baikal, it is only a single day's walk (just over 20 km) over rolling hills from the Irkut River that drains the massive Tunka Valley to the west-southwest. Today this river, including its sections nearest Shamanka, is recreationally fished for arctic grayling, taimen, lenok as well as some pike and roach (Tolmacheva 2009).

FUTURE DIRECTIONS

The sketch provided here of Cis-Baikal fisheries is somewhat ahistorical, but this is in part intentional, as chronological trends in subsistence patterns remain somewhat elusive due to the very recent development of modern zooarchaeology in this region. For example, it is imperative to address when the productive fisheries of the Little Sea and Angara River became established, and what

relationships there might be between the formation of these fisheries and the development of the region's various archaeological cultures and mortuary traditions. Were these fisheries productive and stable early in the Holocene, or was the timing of their development more closely correlated with the development of large cemeteries on the Angara and south Baikal (roughly 8,000 years ago)?

Another critical issue that we have yet to incorporate into our interpretations relates to Holocene climate and environment change. For example, how did the documented temperature variability and drying of the broader region in the centuries around 7,000 years ago (An et al. 2000; Bezrukova, Abzeva, et al. 2005; Bezrukova, Krivonogov, et al. 2005; Bezrukova et al. 2010; Bush 2005; Demske et al. 2005; Feng et al. 2006; Fowell et al. 2003; He et al. 2004; Prokopenko et al. 2007; Tarasov et al. 2007, 2009; White and Bush 2010) affect these fisheries, and how might any such affects relate to the large temporal gap in the region's mortuary record (Weber et al. 2002)? Some authors (More et al. 2009) have suggested that modern warming of the region might be beneficial for littoral fishes in Baikal (but perhaps quite damaging to other lake fauna populations), while others (White and Bush 2010) have postulated that increased climatic and environmental variability spanning the early-middle Holocene transition may have triggered disequilibriums in local river fisheries. This latter notion implies that increased aridity may have resulted in a number of inter-related permutations to many local aquatic (and terrestrial) ecosystems, including decreases in both surface runoff and nutrient input into river systems, lower water levels, shifts in habitat and community structure, and variations in seasonal water temperatures, resulting in aquatic subsistence resources that were increasingly erratic, less abundant, and/or too temporally and spatially dispersed during critical periods of the year, perhaps leading to disruptions in the seasonal subsistence base of local hunter-gatherer populations (White and Bush 2010).

These and other scenarios await further modeling on a variety of fronts, a larger body of systematically collected faunal data, closer

scrutiny of human stable isotope signatures, and more resolved climatic and environmental records for the region. We hope that the speculation and new data offered here provide fodder for such ongoing and future research.

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