New Evidence of the Fishing Economy of Stone Age Waterlogged Sites in Central and North-Western Russia: The Example of Zamostje 2

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Abstract

Investigations of Stone Age waterlogged sites in eastern Europe pose a great scientific interest due to the excellent preservation of organic materials. Excavations of settlements like Sārnate, Zvidze (Latvia), Šventoji (Lithuania), Purkajasuo (Finland), and Okhta 1 (Russia) are among the best examples of such research. New investigations in 2010–2013 at the peat-bog site of Zamostje 2 (Sergiev Posad district, Moscow region, Russia) were of special interest thanks to the discovery of a specific fishery zone dated to the Late Mesolithic–Early Neolithic periods. Several constructions made of wood were found in this particular part of the settlement: among them two fish traps made of wooden splinters and bound by common reed tapes, mobile fish screens, and 150 wooden piles. These finds, along with wooden, bone, antler, and pine bark artefacts (fish hooks, harpoons, floats, fishnet knots, paddles, etc.) allow us to state that fishery was a basic economic activity at this site. This statement is further supported by a large number of finds, including fish bones and fish scales, found in relevant cultural layers. Similar fishing constructions have been found recently at other sites in European Russia, too. In this article, we present main elements of the fishing economy at Zamostje 2 and some newly-found materials from other sites in central and north-western Russia. We also propose a typology for wooden fishing structures and outline some patterns of fishing strategies for this territory in the Mesolithic and Neolithic periods.

1 Introduction

In the last two decades, investigations on wetland and peat-bog sites in central and north-western Russia have increased significantly. During these excavations, a large amount of new material dated to the Mesolithic and Neolithic periods has become available and revealed numerous and previously almost unknown evidence of the fishery economy in this territory. The most interesting examples of ancient fishery activities have been revealed during excavations at the sites of Zamostje 2 (Lozovski 1996; 1999; Lozovski et al. 2013a),

Stanovoye 4, Sakhtysh 2a (Zhilin 2004), and the newly discovered site of Okhta 1 (Bazarova et al. 2010; Sorokin et al. 2009) (Fig. 1). At these sites, fishery constructions made of wood slats (planks) or branches were found in large quantities and in a good state of preservation, accompanied by a vast amount of fishing tools made of organic materials.

The aim of this article is to present the main elements of fishing economy at the Zamostje 2 site (Sergiev Posad district, Moscow region, Russia) and to introduce some new materials recently discovered at other sites in central and north-western Russia. Based on this, we propose a typology for wooden fishing structures and outline some emerging patterns of fishing strategies in central and north-western Russia during the Mesolithic and Neolithic periods.

2 Classification of fishery structures

In spite of a long history of ethnographical and archaeological investigations of fishery constructions among modern populations and at prehistoric sites, we did not have even a preliminary classification of these structures until today. In ethnographical works, authors usually describe their construction, ways of use, and local names (Zelenin 1991). Archaeologists often provide a general description of the found objects with some rough interpretation. Normally we encounter terms such as *fish fence*, *fish traps*, or *fish weirs*. In most cases, the definition given to these objects is almost intuitive or relies upon ethnographical analogies. However, it is vital to develop such classifications, because these structures – as we now understand it – could reflect the general conditions and special features of fishery activity at each individual site. Generally all these objects belong to the so-called 'passive' method of fishing, which presumes the absence of humans during the actual fishing process.

Fish fences. By the term *fish fence*, we mean a long-term structure consisting of one, two, or more rows of massive wooden piles (diameter from 5 to 15 cm), vertically hammered into the river or lake bottom. The space between piles is normally filled with wood branches or

Figure 1. Location of Mesolithic and Neolithic settlements mentioned in the article. Drawing: F. Myachin, modified by O. Lozovskaya.

separate wood splinters. In the centre or at the corners of this construction we always observe a space for fish trap baskets. Such a construction is very resistive to the environment and can withstand spring flooding on inland rivers and lakes. The purpose of the fences was to prevent any fish from moving up and down the river and to direct them into fish traps. Among ethnographical resources we have a large number of these objects; an excellent example was drawn by the Russian scientist N. Volkov in north Russia in 1947 (Lozovski et al. 2013a: Fig. 13). The length of these structures normally equals the width of the river. Archaeological remains of such a structure were found at Zvidze (Loze 1986), and possibly at Zamostje 2 (Lozovski et al. 2013b).

Fish weir structures generally replicate the idea of *fish fence* constructions with only one significant difference: these structures normally consist of one row of rather light stakes (standard diameter 2–4 cm) vertically mounted into the lake or sea shore bottom. The space between stakes is filled with horizontally lying, woven wooden branches or rods. We tend to define this system as 'semi-mobile' because, as opposed to *fish fences*, these structures can be easily mounted and are also easily broken by natural forces. Their length normally exceeds 30–40 m and they separate a rather large area. The idea behind building these weirs was the same as behind fences – to make fish swim into a separately mounted fish trap basket. Such constructions were widely spread in sea coastal regions and have been found, for example, in Denmark at the site of Oleslyst (Pedersen 1995: 78–80) and in recent excavations at Rødbyhavn (Museum Lolland Falster n.d.).

Fish screen constructions represent another type of stationary fishery equipment. In contrast to the two above-mentioned groups, these structures can be defined as completely mobile – which was also their main purpose of use. Fish screens consist of a long mat made of split wood slats, bound by tapes made of inner bark, birch bark, or other plant materials like common reed grass or bulrush (as at the Zamostje 2 site). The length of the splinters can reach 4–5 m. According to the ethnographical analogues published by Valdis Bērziņš, these 'Lathe screens could most easily be transported to the fishing location if they were rolled up, and this is the way they were stored between fishing seasons' (Bērziņš 2008: 249). Normally fishermen moved them to a fishing zone in the lake or river, and then rolled them out and mounted them vertically in the lake or river bottom, delimiting a separate zone a fish could enter but never leave. The shape of such a zone could vary and depended on local customs (Sabaneyev 1911). Remains of such structures have been found at a large number of sites and dated from the Mesolithic to the Late Neolithic, including the sites of Zamostje 2, Sārnate, Podzorovo, Marmugino, Purkajasuo, and Okhta 1 (Bazarova et al. 2010; Bērziņš 2008; Koivisto 2012; Lozovski 1999; Lozovski et al. 2013b) (Fig. 1).

Fish traps are the most common equipment for passive fishing. They are characterised by high mobility – they can easily be moved from one place in the river to another. Archaeologists have found these objects all over the world from Africa to the north of Russia. They vary in shape and method of production. The most common shape is basket-like, with a mouth and a funnel, which prevents fish from escaping after having entered the trap. Among modern ethnographic populations in Siberia and north Russia, the most popular material for fish traps was wooden branches or rods, and examples made of split wooden slats are found seldom (Zelenin 1991). The frame of fish traps normally consists of several hoops to which splinters are bound by bands made of inner bark or other plant materials. Their length varies from 0.50 to 3 m. Among archaeological materials from central and northern Russia, we have found only one fish trap made of wooden branches at the site of Stanovoye 4 (Zhilin 2004), the rest of the finds represent fish trap remains made of split wooden splinters – the sites of Zamostje 2, Sakhtysh 2a, Vis 1, and Šventoji 1a and 2b (Lozovski 1999).

Figure 2. Zamostje 2. Fish traps in the Early Neolithic layer, seen from the south. Photo: O. Lozovskaya.

Figure 3. Zamostje 2. Fish trap with a paddle in the Early Neolithic layer, seen from the west. Photo: O. Lozovskaya.

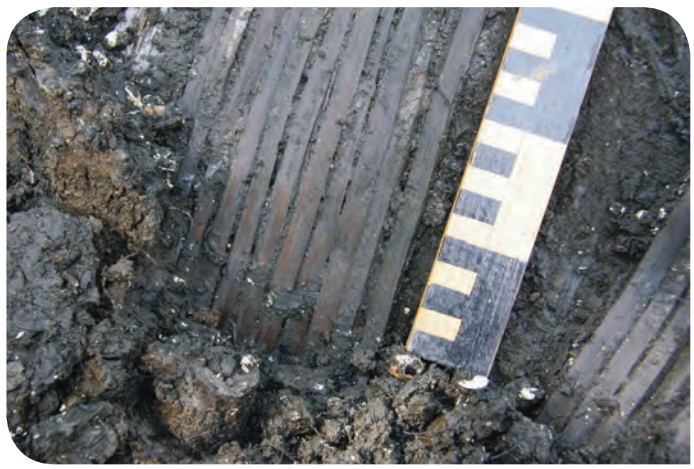

Figure 4. Zamostje 2. Detail of a fish trap with a part of binding, Early Neolithic layer. Photo: O. Lozovskaya.

3 Discovery of fishery constructions at the site of Zamostje 2

The Zamostje 2 site is situated in the northern part of the Moscow region, on the Dubna River, which flows into the Volga River. Long-term investigations (Lozovski 1996) at the site have revealed several episodes of Mesolithic and Neolithic human occupation: 7900–7700 BP (ca. 7000–6500 calBC) Lower Mesolithic layer; 7400–7100 BP (ca. 6400–6000 calBC) Upper Mesolithic layer; 7100–6900 BP (ca. 6000–5800 calBC) Final Mesolithic layer; 6850–6200 BP (ca. 5800–5200 calBC) Early Neolithic layer; and 5900–5500 BP (ca. 4900–4300 calBC) Middle Neolithic layer. In fact, the fishing occupation was practised at the site for over 2500 years and covered the whole Atlantic period.

According to the palaeoecological reconstructions (Aleshinskaya et al. 2001; Lozovskaya et al. 2013; Lozovski et al. 2014), during the entire Mesolithic and Neolithic periods, the life of the ancient people was linked to the lake and took place on a long narrow peninsula, bordered from one side by a large deep lake and from the other side by a shallow lagoon. There were periodical changes in the water level and lake size – accumulation of cultural layers took place during regression phases of the ancient lake. During these periods, human activity was focused on the exploitation of a low flat shore, which was periodically flooded. The process of peat accumulation began in the middle of the Sub-Boreal period (Sb2).

During the first (1989) and last (2010–2013) years of excavations at the site, five stationary wooden constructions – fish traps and fish screens − were found. The fish traps are cone-shaped baskets made of pine splinters (Figs. 2 & 3) (analysis by Maria Kolosova, State Hermitage, Russia). At the moment of their discovery in 1989, their length was 2 and 2.5 m, respectively (Lozovski 1999). Thin (1 cm) splinters were tightly bound with caulis rush (*Phrágmites austrális Trin.*; analysis by Ludmila Abramova, Moscow State University, Russia) (Fig. 4). The rope was twisted around each splinter at the perimeter. Re-excavations of fish traps in 2010 revealed a part of such binding (Lozovskaya et al. 2012). The construction was additionally strengthened with split wooden beams and long branches, one of which also had remains of tree bark binding. Fish traps were situated in water sediments with a slight decline towards the inflow. This shows that they were left in the 'working' position. Directly under the splinters of the eastern fish trap there was an accumulation of complete fish skeletons and mummified carcasses (mainly perch and ruffe, according to Elona Lyashkevich, Institute of History of the National Academy of Sciences of Belarus) (Table 1). The first ^{14}C dates obtained for fish traps (splinter with binding) are 6550±40 BP (Beta-283033; 5615–5468 calBC) and 6452±43 BP (CNA-1081; 5483–5331 calBC), and correspond to the Early Neolithic in this region.

During underwater excavations, several structures made of pine and willow splinters were also found in the Dubna riverbed. The remains of the first, slightly curved construction (around 4 m in length) made of several layers of sub-parallel pine splinters, were located 7–8 m to the south-south-east of the group of three fish traps, on the surface of a layer of light grey sandy gyttja with tiny interlayers of shells and wooden chips in the bed of the modern Dubna River (Fig. 5). The construction is synchronous with the Upper Mesolithic layer, as confirmed by datings: 7198±30 BP (CNA-1346; 6202–6002 calBC) and 7090±70 BP (Le-9535; 6081–5796 calBC).[1] A pile running through the splinters is dated to a later period. The second object was located deeper and was not fully exposed; in the opened part, which was more than 2 m in length, six well-preserved crossed weaves of plant fibre (bulrush, *Scirpus lacustris L.*; analysis by Ludmila Abramova, Moscow State University, Russia) were discovered (Fig. 6). The placement of the object in the direction from north-west to south-east, or across the modern riverbed, is its most important difference compared to the fish traps

Zamostje 2 (2011)	Taxons	Nr of bones	Nr of scales	
Monolith no 3	*Perca fluviatilis*	21	-	-
Monolith no 4	*Perca fluviatilis*	133	-	-
	Gymnocephalus cernuus	23	-	-
	Esox lucius	1	-	-
	Cyprinidae	1	-	-
Monolith no 5	*Perca fluviatilis*	29	-	-
	Gymnocephalus cernuus	22	-	-
	Esox lucius	9	-	-
	Cyprinidae	2	34	-
	Rutilus rutilus	1	-	-
	Indet.	7	-	-
Monolith no 6	*Perca fluviatilis*	739	-	-
	Gymnocephalus cernuus	337	-	-
	Esox lucius	77	-	-
	Cyprinidae	58	202	-
	Rutilus rutilus	3	-	-
	Carassius carassius	2	-	-
	Scardinius erythrophthalmus	2	-	-
	Tinca tinca	1	-	-
	Indet.	77	-	-
	Mummified carcasses of *Perca fluviatilis* and *Gymnocephalus cernuus* (fragm.)	-	-	+
Monolith no 6a	*Perca fluviatilis*	246	-	-
	Gymnocephalus cernuus	110	-	-
	Cyprinidae	17	50	-
	Esox lucius	14	-	-
	Rutilus rutilus	1	-	-
	Indet.	20	-	-
	Knot of a fishnet	-	-	1

Table 1. The contents of soil monoliths with fish remains extracted under the eastern fish trap (Zamostje 2, square 7, excavations 2011, Olga Lozovskaya). Based on data by Elona Lyashkevich 2012. + – present, but number not counted.

discovered in the surface excavations on the river shore and to the first structure located on the bottom of the river. This structure is dated to the late 7th millennium calBC (CNA-1348; 7267±31 BP; 6217–6064 calBC). Thus, both structures correlate temporally with the Upper Late Mesolithic layer of the settlement, and, as of now, are considered as mobile fish screens used in the fishery complex.

Usually fish traps were put in running water to close the exit in the fish fence – the construction of wooden piles and branches across the water stream. Any kind of fish could enter such a trap, but it could not hold a large amount of fish. The remains of such a fish fence may have been found close to the traps located in the first year of excavations. It consisted of some of the 29 deeply driven piles, which were bordered

by the fish traps in the north. Radiocarbon dating confirmed the synchronicity of some of the piles (five out of nine dated piles) with the Early Neolithic fish trap complex: 6637±38 BP (CNA-1344; 5630–5493 calBC), 6630±40 BP (Le-10268; 5626–5491 calBC), 6617±44 BP (Ua-50258; 5622–5488 calBC), 6600±40 BP (Le-10099; 5617–5485 calBC), and 6440±50 BP (Le-10267; 5482–5322 calBC).

A second group of 18–20 piles is situated 4–5 m to the south of the fish traps and runs in the south-west–north-east direction. The rest of the excavated area (a total of 162 m^2) did not demonstrate any regular system of sunken piles. In 2010–2013, the underwater prospection of the Dubna riverbed close to the excavation zone on dry land was carried out (Lozovski et al. 2013b). In an area of 90 m^2, 150 new piles with a diameter of 5–10 cm were discovered. Some of these new piles are undoubtedly connected with the fish fence found earlier. Other piles are dated to the Late Mesolithic and Middle Neolithic periods and can be associated with the fishery constructions as well.

4 Tools for fishing from Mesolithic and Early Neolithic layers of the Zamostje 2 site

There is a large diversity of fishing tools collected at Zamostje 2. Harpoons or barbed points are most effective for fish hunting in the shallow water, especially during spawning season when fish become less fearful. These tools were found in all layers (11 items in the Lower Mesolithic layer, 38 in the Upper Mesolithic layer, 36 in the Early Neolithic layer, and 165 in the Middle Neolithic layer). Harpoons differ in size, proportion, and the number and shape of the barbs (Lozovski & Lozovskaya 2010; Lozovskaya & Lozovski 2013). Most of these tools have a sharpened conic or flattened tang.

There is direct and indirect evidence regarding the use of fishnets. This includes floats made of bark (three items) and wood (one item), bone needles for net making, and small pieces of rope from Mesolithic layers. Small knots of nets, amounting to more than 70 pieces, have also been recently found by sieving (for more details, see Lozovskaya & Lozovski, this volume). In any case, it is clear that small species of fish – especially such as the carp family – are much easier to catch with fishnets or fish traps. The highest diversity of fish belonging to the carp family (six species; see below) is observed in the Mesolithic layers. In the Early Neolithic, the decreasing number of fish species (crucian carp, roach, and ide) did not affect their share in the food circle.

Boats were the main means of transport on the lake for fishing with harpoons or fishnets. The finds of wooden paddles prove their wide use. In Mesolithic layers, we have at least 10 pieces of paddle blades – narrow ones with a blunted and sharpened point, as well as wide ones with a massive double-edged end and asymmetrical stops. Such a diversity of paddle types could point towards the exploitation of different kinds of water sources.

Finally, other means of fishery are revealed by fish hooks (56 items). They are also represented in all layers, although they differ in typology (Lozovski & Lozovskaya 2010: Fig. 5; Lozovski et al. 2013a: Fig. 4). These items include pieces of classic curve-shaped as well as flat bi-pointed fish hooks with a hole in the middle (17 items) (Fig. 7b). Early Neolithic fish hooks are represented by a standard series (13 items) made of bone blades by double-sided burin cut, with a thin point or barb separated from the straight shank by a drilled hole (Fig. 7a).

The way of using the latter implements indicates another method of fishing. Generally fish hooks are used for fishing predator species, such as catfish or pike-perch, large individuals of which were found in the Lower Mesolithic layer. In the Early Neolithic period, fish hooks could have been used for fishing pike – the only predator species found in this layer. Experimental and use-wear analysis of fish hooks (Maigrot et al. 2013; 2014a; 2014b) revealed differences in traces left by the teeth of different fish species (particularly perch, pike-perch and catfish/trout). Accordingly, a large fish hook from the Lower Mesolithic layer demonstrates traces like those of pike-perch,

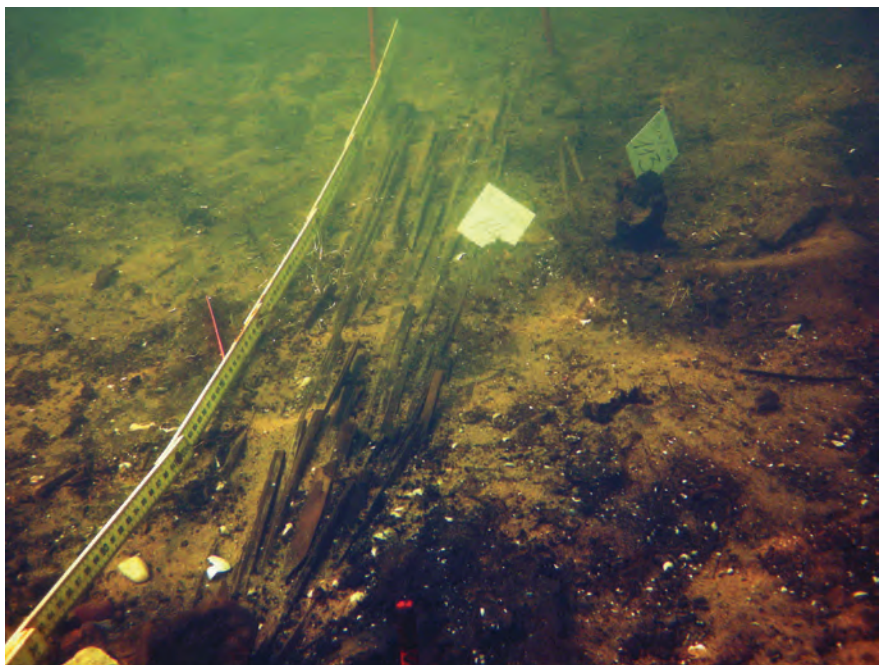

Figure 5. Zamostje 2. Fish screen in the Dubna riverbed, in the Upper Mesolithic layer. Seen from the north-east. Photo: A. Mazurkevich.

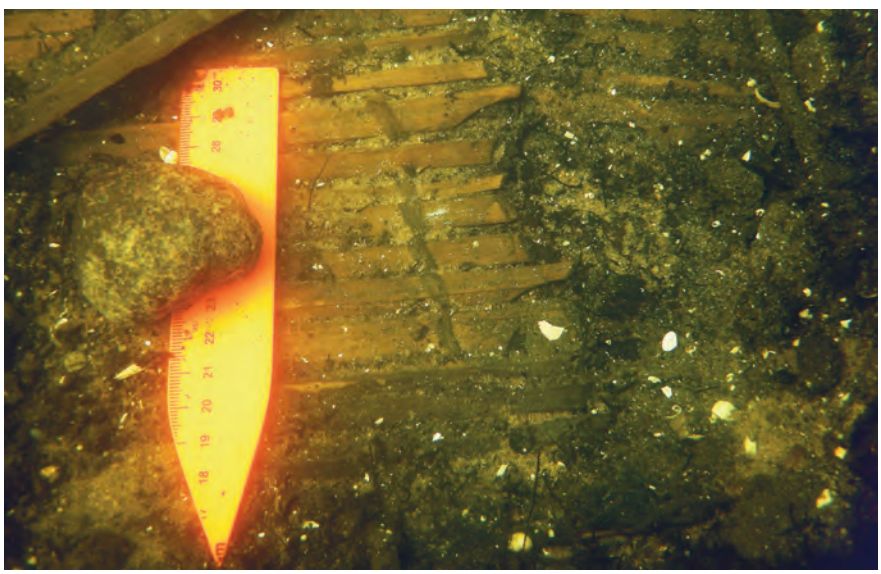

Figure 6. Zamostje 2. Detail of a fish screen with a part of binding in the Dubna riverbed, in the Upper Mesolithic layer. Seen from the north-east. Photo: A. Mazurkevich.

and similar traces were found on a fish hook from the Early Neolithic layer. Perch may have been caught with fish hooks from three different layers (including two small, figured hooks). Thin scratches on a broken fish hook from the final Mesolithic layer could be regarded as traces made by catfish or trout teeth; however, the trout family is not known among the fish remains found at the Zamostje 2 site (whitefish is identified at Ozerki 5, vendace at Ivanovskoye 7; see Zhilin 2004). The results are still preliminary: it is particularly necessary to clarify some differences in the data regarding use-wear and ichthyological analyses.

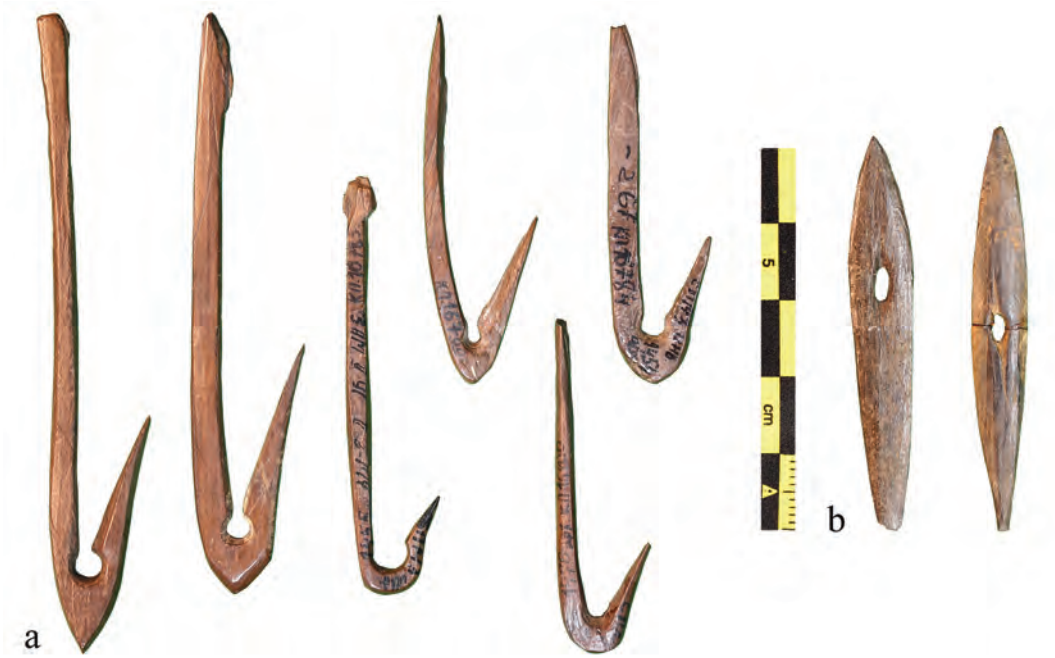

Figure 7. Zamostje 2. Fish hooks: a – Early Neolithic layer; b – Upper Mesolithic layer. Photos: O. Lozovskaya.

The fish processing tools can be seen to include a large number of knives made of elk ribs in the bone inventory. The use-wear analysis of 64 items from the Upper Mesolithic layer showed traces on several large tools (15 items), which could be interpreted as fish scaling (Clemente Conte & Girya 2003). This indicates fish treatment in the process of cooking (or for storage).

Generally, we can trace some changes in the fishing strategy from the Late Mesolithic to the Early Neolithic. In the Mesolithic layers, we found evidence of the following fishing methods: fishing from boats on the lake (or during spring on flooded areas of the ancient valley) using fishnets and different kinds of harpoons, as well as the use of fish hooks, including bi-pointed types in the Upper Mesolithic layer, on predator species of fish. For the Early Neolithic period, we can point out the active use of harpoons during the spawning season, the building of a fish fence with fish traps in the running water, and also a more regular use of fish hook fishery.

5 Recent finds of other fishery constructions in central and north-western Russia

5.1 Stanovoye 4

The new finds made during the last 10–15 years in the peat-bog settlements of north-west Russia and in the Volga–Oka region allow for some comparisons and generalisations to be made in regard to the organisation of fishing in the Mesolithic and Neolithic economy. Only one construction at the site of Stanovoye 4 (excavation 3, layer IIIa; Zhilin 2004: 54 Fig. 27) can be attributed to the Early Mesolithic. Made of split osier rods (8 mm in diameter) with transversal bindings and remains of the base hoop, this find is interpreted by the excavator as the lower part of a fish trap, preserved *in situ* in the lake sediments. It should be noted that there is no visible narrowing of the structure, which raises some associations with a fish screen. Nearby, a large flat weight stone with traces of binding was found. The layer

includes bones of three pikes and one perch. A chain of birch and aspen piles was revealed in the overlying layer III. It cut across the old channel of the distributary (or river) and can be regarded as the remains of a fish fence. One pile is dated to 9220±60 BP (GIN-8375; 9230–8810 calBC; Zhilin 2004: 55).

5.2 Sakhtysh 2a

The remains of two fish traps were discovered in 1999 in the Late Mesolithic settlement of Sakhtysh 2a (excavation 2, layer IIIa; Zhilin 2004: 54 Fig. 28). As at Zamostje 2, they consisted of thin, split pine splinters. Another small piece of fish trap preserved a fragment of binding with a stripe of lime bast. At one end, the splinters were collected into a bunch. In the same layer, other wooden, presumably fishing-related objects and many fish bones were found as well. The age of the large fish trap was determined as 7390±40 BP (GIN-10860; 6392–6106 calBC).

5.3 Serteya I

At the site of Serteya I (excavations in 2010–2012 by Ekaterina Dolbunova), an economic fishing zone from the second half of the 3rd millennium calBC was investigated (Dolbunova 2014). The wooden structure, located *in situ*, included vertically-standing small pine splinters connected to each other with ropes. Their lower ends are pointed. In ancient times, according to the author, they partitioned off a narrow channel connecting two lakes. Another construction, much more poorly preserved, consisted of horizontally lying long (3 m) spruce splinters sharpened at both ends. It dates from the end of the 3rd to the beginning of the 2nd millennium calBC. Undoubtedly the two structures should be referred to as fish screens. In the same area, a net with weights attached to it (83 items) was also found, but only a few pike bones were collected.

5.4 Okhta 1

The discovery of sediments with Stone Age materials in the centre of St Petersburg was a surprise for all specialists: the remains of a Neolithic site were unearthed during rescue excavations (2008–2009 by Petr Sorokin; 2010 by Nataliya Solovyova) on the promontory of the Great Okhta and Neva Rivers. Palaeogeographical reconstructions revealed that in the Neolithic period, this area was a littoral of the ancient seashore with shallow water and was affected by the Litorina sea transgression (Shitov et al. 2010). Available ^{14}C dates put the period of the site's existence approximately within the 4th to 3rd millennia calBC, that is, within the Neolithic and Early Metal periods (Kul'kova et al. 2010; Gusentsova & Sorokin 2011).

Thousands of split pine and spruce planks, most of them with one sharpened end, formed parallel or basket constructions (Fig. 8). Many of them could be interpreted as remains of fishing screens. Splinters are connected together by bands of inner bark 1.5–3 cm wide (Fig. 9); bindings are arranged at equal intervals: one such mat has bindings from inner bark in seven places, which were spaced 50–60 cm from each other. Some of the constructions were found in a horizontal/flat position, while others had been rolled up, and some were traced by post holes that they had left, which indicates their vertical position in the ancient sea (Bazarova et al. 2010). The remains of the most complete fish screens consist of 44 and 51 planks. The longest construction was 4.5 m long and 2.25 m wide. Unlike items from Zamostje 2 or Sakhtysh 2a, the planks typically have different dimensions: a width of 2–5 cm and a thickness of 1–1.5 cm. The splinters and planks normally have a sub-rectangular and (rarely) a rhombic cross-section.

In some cases, the fish screens are bordered on both sides by long (4.68 m) and thin (2 x 5 cm) piles. It seems that these piles served as a basis for mounting fish screens in a vertical position. Finds of fish screens were also often associated with separate, vertical wooden

piles. Several hundreds of such wooden piles and their post holes were found. The average diameter of the piles ranges from 6 to 16 cm; the length of the vertical piles is 1.2–2.5 m, but piles found in a horizontal position were up to 4–5 m long (Gusentsova & Sorokin 2011). From the rest of the fishing equipment, sinkers of various shapes and birch bark floats have been preserved.

6 Analysis of fish remains from the Zamostje 2 site and other sites in the Volga–Oka region

Hunting and fishery were the basis of the economy both in the Late Mesolithic and Early Neolithic at Zamostje 2. The main game species were elk (*Alces alces*) and beaver (*Castor fiber*), along with fur species [pine marten (*Martes martes*), badger (*Meles meles*), otter (*Lutra lutra*), and fox (*Vulpes vulpes*)]; in the Neolithic period, the role of wild boar (*Sus scrofa*) increased (Chaix 1996; 2003). The analysis of bird remains (Mannermaa 2013) shows the preference of wader and waterfowl hunting, which accompanied fishery. According to the age of some individuals (elks) and the hunting seasons (e.g. birds), we can consider the settlement to have functioned year-round. However, the most numerous finds are represented by fish bones and fish scales. A preliminary count made by Professor Louis Chaix (Geneva, Switzerland) estimates the total number of fish remains at 2 million bones (Lozovski et al. 2014).

For ichthyological analysis (Radu & Desse-Berset 2012; 2013), faunal remains were obtained from two columns sized 25 x 25 cm: altogether six and seven 5-cm-thick samples were taken from the most representative parts of the columns. In addition, five out of nine samples collected through sieving (with a 5-mm mesh) from one of the excavated square metres (excavations 1995–2000) were analysed. This very limited quantity of samples resulted in a total of 13,364 fish remains – thus, the sample does not reflect the amount of consumed fish, but only the species composition and the approximate percentages. Eleven species of fish were identified, among which the most important were northern pike, the carp family, and European perch (*Esox lucius, Perca fluviatilis,* and *Cyprinidae*). The carp family includes the following species: roach (*Rutilius sp.*), crucian carp (*Carassius carassius*), and ide (*Leuciscus idus*) found in all layers; carp bream (*Abramis sp.*), common bleak (*Alburnoides sp.*), and tench (*Tinca tinca*) found sporadically. Pike-perch (*Sander lucioperca*) and catfish (*Silurus glanis*) are represented only in the Lower Mesolithic layer samples featuring the largest diversity of fish species.

The small size of individual fish is a distinctive feature of the Zamostje 2 ichthyological complex. In particular, the size of the studied pikes varies between 14 and 62 cm (Table 2), but 90% of individuals from the Lower Mesolithic layer are about 50 cm long (weighing up to 800 g), which equates to small and medium young individuals not older than 3 years (Radu & Desse-Berset 2013: 200–202). The maximum size of perch is up to 36 cm (up to 700 g). Fish like roach, crucian carp, and ide are represented by adult individuals of medium size. In the Lower Mesolithic layer, pike-perch and catfish measured from 51 to 88 cm (up to 6.5 kg) and from 1 to 1.5 m (6.5–26 kg), respectively, but they are very rare in these samples.

Comparison with materials from other Mesolithic sites in the Volga–Oka region (apart from Zamostje 2, all other analysed materials derive from non-sieved assemblages) demonstrates a significant difference in the size and age of such important species as pike and catfish for sites of the Pre-Boreal and Boreal periods (Stanovoye 4, layers III and IV; Ivanovskoye 7, layers III and IV; Nushpoly 11, layer IV; Zhilin 2004: 48–52 Table 3), while the data for the beginning of the Atlantic period (Ozerki 5, layer IV; and Nushpoly 11, layer III) is quite comparable to that of Zamostje 2 (Table 2). The largest individuals and the maximum diversity of species are typical for the older layers of the Mesolithic sites. In general, as this consistent

Figure 8. Okhta 1. Fish screen in the Neolithic layer. After Bazarova et al. 2010: 169 Fig. 5.

Figure 9. Okhta 1. Fish screen, detail with binding, Neolithic layer. After Bazarova et al. 2010: 169 Fig. 4.

pattern can be traced not only at Zamostje 2 but at many sites, it probably reflects some palaeoecological peculiarities or could be explained by a different fishing strategy. However, it should be noted that the standardised production of splinters for fish screens or fish traps is accounted for especially in the periods of the Late Mesolithic and Early Neolithic.

7 Analysis of coprolites from Mesolithic and Neolithic layers at the Zamostje 2 site

In the samples studied for fish remains (in total, bones from only 1.5 m^2 have been analysed; see above), we have found very few traces of anthropic influence – in particular, traces of fire were found only on 0.5% of the bones (Radu & Desse-Berset 2013: 211). This has given rise to the question of the ways in which the ancient population consumed fish. The results obtained through the analysis of coprolites (from Mesolithic and Early Neolithic layers), mainly from dogs but

also from humans, show a high presence of helminth eggs (in 27 of 34 samples, from 1 to 600 eggs in 1 g of sample): *Diphylobothrium latum*, *Opisthorchis felineus* (typical both for human and dog), *Alaria alata*, and *Capillariidae gen.sp.* (typical for predators) (Engovatova & Khrustalev 1996). These samples also include small fish scales and bones. The biotopes of *Diphylobothrium latum* are shallow and well-warmed water basins with a slow stream. The infection of humans and dogs is linked to the consumption of infected fish (pike, pike-perch, perch, ruffe, etc.) without necessary thermal treatment (uncooked, fermented, or slightly fire-treated). The source of infection by eggs of *Opisthorchis felineus* points towards the carp family (ide, carp bream, roach, etc.). The absence of other animal remains (fur or animal or bird bones in dog coprolites) is remarkable, and confirms a high percentage of fish in human and dog diets and the consumption of untreated fish.

8 Conclusions

Taking into account all the new materials, we can draw some very important conclusions. Fishery was one of the main elements of economic activity in the Mesolithic and Neolithic and impacted the choice of settlement location: on the coast of a lake, a river (Zamostje 2, Sakhtysh 2a, Stanovoye 4, Serteya I), or a sea (Okhta 1 site). The water basins were actively exploited with fishing constructions. At the Zamostje 2 site, we can show that human settlements were year-round with continuous economic activity, including fishing in the spawning season. Also, the list of caught fish species did not change significantly during the 1.5 millennia of the site's habitation: the main fish species were pike, perch, and fish of the carp family. The widest diversity of fishes is observed in the Lower Mesolithic layer, where the remains of large catfish and pike-perch were found. Unfortunately no such data is available for the Sakhtysh 2a and Okhta 1 sites. At Zamostje 2, the main means of fishing were fish fences, harpoons, and net fishing from boats in the Mesolithic, different types of fish hooks, including bi-pointed ones in the Upper Mesolithic layer, and fish traps with a fish fence in the Early Neolithic (and, possibly, in the following periods). We can see the very important role of wooden fishery constructions also at Okhta 1 during the Neolithic period. Fish hooks were used, according to the use-wear traces revealed on the materials from the Zamostje 2 site, for fishing pike, perch, and catfish; it is assumed that the shape of fish hooks could be linked to their specialisation. According to the analysis of coprolites from the Zamostje 2 site and the low percentage of burned fish bone found at the site, fish was consumed uncooked or slightly fire-treated. However, a large amount of knives made of elk ribs points to the habit of fish scaling in the treatment process – taking into account the year-round habitation mode of the settlement, we can suppose some special way of fish storage (drying, fermentation?).

In general, when we analyse the materials of any waterlogged site from eastern Europe dated to the Mesolithic and especially the Neolithic period, almost in each case we observe the presence of some kind of fishery constructions (fish traps, fish screens, fish fences): they are present in Sārnate, Zvidze (Latvia), Šventoji (Lithuania), Purkajasuo (Finland), Stanovoye 4, Zamostje 2, Sakhtysh 2a, Okhta 1, Serteya I (Russia), and so on. This means that fishing played a very important role in prehistory – in fact, we think that fishery was the basis of the ancient human subsistence and settlement strategy.

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	Ivanovskoye 7	Ozerki 5	Okayëmovo 5*	Nushpoly 11*	Zamostje 2*	Zamostje 2*	Zamostje 2*	Zamostje 2*
	Late Mesolithic, layer IIa	Late Mesolithic, layer IV	Late Mesolithic, layer III	Late Mesolithic, layer III	Late Mesolithic, lower layer	Late Mesolithic, upper layer	Early Neolithic	Middle Neolithic
Taxons	NB / TL	NB / TL	NB / TL	NB / TL	NI / TL	NI / TL	NI / TL	NI / TL
Esox lucius	129 / 19–136 cm	252 / 31–35 cm, up to 65 cm	85 / 12–90 cm	449 / 24–90 cm	23 / 21–62 cm	58 / 14–54 cm	12 / 25–55 cm	17 / 23–60 cm
Perca fluviatilis	-	2	6 / 25–30 cm	22 / 15–30 cm	22 / 15–31 cm	21 / 16–29 cm	3 / 17–29 cm	6 / 16–36 cm
Sander lucioperca	-	-	4 / 66 cm	10 / 50–70 cm	3 / 51–88 cm	-	-	-
Gymnocephalus cernuus	-	-	1	-	+	+	-	-
Silurus glanis	18 / 110–150 cm, up 250 cm	-	-	8 / 136–204 cm	3 / 96–152 cm	-	-	-
Carassius carassius	-	109	22 / 20–25 cm	9 / 25–30 cm	4	8	2	2
Rutilus rutilus	-	54	2	1 / 20–30 cm	28 / 11–21 cm	54 / 10–21 cm	24 / 12–21 cm	18 / 10–26 cm
Abramis brama	-	-	3 / 40 cm	10 / 40–50 cm	3	-	-	-
Leuciscus idus	-	-	6	1 / 36 cm	4	4	2	1
Tinca tinca	-	-	3 / 40 cm	4 / 34 cm	-	1	1	-
Alburnus alburnus	-	-	-	-	1	-	-	1
Coregonus albula	32 / up to 32 cm	-	-	-	-	-	-	-
Coregonus lavaretus	-	12	-	-	-	-	-	-
Aspius aspius	-	-	2 / 60 cm	-	-	-	-	-
Squalius cephalus	-	-	1	1 / 23 cm	-	-	-	-
Leuciscus leuciscus	-	15	-	-	-	-	-	-
Cyprinidae	125	-	45	-	-	-	-	-

Table 2. Comparative data on the sizes of fish found at Mesolithic sites in the Volga–Oka region and dating to the beginning of the Atlantic period; based on data by Mikhail Zhilin (2004: 49) and Valentin Radu & Nathalie Desse-Berset (2013) and modified by Olga Lozovskaya. NB – number of bones, NI – number of individuals; TL – total length; * – site located on the shore of the Dubna River; + – species present, but number and size not counted.

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Note

1 Calibration by OxCal v4.2 (Bronk Ramsey 2009); r5; IntCal13 atmospheric curve (Reimer et al. 2013).

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