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GO WITH THE FLOW: STATIONARY WOODEN FISHING STRUCTURES AND THE SIGNIFICANCE OF ESTUARY FISHING IN SUBNEOLITHIC FINLAND

Abstract

We still lack basic knowledge of the intensity and character of fishing as subsistence among the Stone Age populations of the northeast shores of the Baltic Sea. In locations where direct evidence of fish utilisation is insufficient, various forms of indirect evidence play an essential role. Generalisations about the importance of fishing are mainly based on shore-bound site locations, fragmentary burnt fish remains, and fishing-related artefacts recovered at archaeological sites. The remains of stationary wooden fishing structures preserved in wetland conditions have not been properly utilised previously in Finland to study prehistoric subsistence practices and diet. The interplay between the archaeological and ethnographic materials is well-grounded, because similar structures have been used for several millennia. This paper combines the wetland archaeological data, fish remains, and ethnographic analogy based on environmental and climatic considerations to examine the fishing methods and subsistence base among the Middle Subneolithic (non-agricultural Neolithic) populations of northwest Finland c 3000 calBC. Several factors, including site location, requisite woodworking skill, the quantity of the wooden structures, and the labour contribution allocated to fishing all underline the high significance of aquatic resources for the hunter-fisher-gatherer populations occupying the mouth and the banks of the Iijoki River during the mid-Holocene productivity peak of the Baltic Sea.

Keywords: stationary fishing structures, Finland, Stone Age, fish bones, subsistence, ethnography

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Received: 15 Jun 2015; Accepted: 2 Sep 2015; Revised: 23 Oct 2015

INTRODUCTION

There is a growing interest in research topics concerning prehistoric subsistence strategies and diet in coastal Baltic Sea areas (e.g. Tauber 1981; 1986; Lindqvist & Possnert 1999; Eriksson 2003; Fischer 2007; Fischer et al. 2007; Olson 2008; Craig et al. 2011; see also Kriiska 2003; Hertell 2009). The concept of variation between marine and terrestrial foods has been topical, especially in studies applying stable isotope data (e.g. Eriksson 2003; Fornander et al. 2008; Olson 2008). It has been noted that humans' innovative and adaptive ability to conquer new ecological niches and to respond to environmental stress have led to diet changes and the invention of new technologies, including new ways of procuring, preparing, and storing food. These studies have revealed what people actually consumed at different periods and locations, and that food habits were strongly culturally governed. Isotope and lipid analysis on organic residues from pottery have shed light on the consumption and utilisation of marine and terrestrial products, in addition to adaptations in storing and processing (e.g. Craig et al. 2007; 2011; Evershed 2008; Heron et al. 2013; Cramp et al. 2014; Taché & Craig 2015; see also Leskinen 2003).

Research on prehistoric fisheries preserved in wetland conditions has revealed information on the variety of fishing methods practised by prehistoric populations. Fishing gear was designed for catching certain species in a specific habitat. Several types of the stationary fishing structures known from both archaeological and ethnographic records seem to have remained unchanged for several millennia (e.g. Pedersen 1995: 81). The sharp shift in diet from aquatic to terrestrial foods thought to have occurred at the dawn of the Neolithic, as suggested by the stable isotope signatures of human bones (Schulting & Richards 2002; Milner et al. 2003; Richards et al. 2003a&b; Richards & Schulting 2006), has been in conflict with the evidence derived from stationary fishing structures and submerged coastal sites (Fischer 2007). For example, a significant level of fish consumption in coastal Neolithic Denmark has been suggested on the basis of refuse faunal assemblages and the assumption that several wooden weirs have apparently been functioning simultaneously. Fishing with stationary structures seems to have constituted an essential part of subsistence in the Middle and Late Mesolithic and Neolithic periods in the Danish archipelago (Fischer 2007: 54). A certain degree of forest management, including coppicing, was also practised in Mesolithic northern Europe to support the construction of functional fishing structures, typically manufactured of hazel rod wattle-work and wicker screens (Christensen 1997: 151–6; Myrhøj 1999: 167; McQuade & O'Donnell 2007: 574, 581; Klooß 2015: 332).

In spite of the clear shore-bound settlement pattern of the hunter-gatherer populations of Subneolithic Finland (c 5100–2000 calBC), the archaeological signal confirming the significance of fishing is relatively weak. Direct evidence for the utilisation of fish in prehistoric Finland is problematic, because fish remains are relatively seldom recovered in archaeological contexts. The poor preservation of organic materials in the acidic soils, the fragmentation and brittleness of burnt bones, and the excavation and recovery methods used all hinder the taphonomic and taxonomic study of prehistoric refuse faunal assemblages (Ukkonen 1996a; 2004; Mannermaa 2008: 40; Nurminen 2007; 2015a; forthcoming and in preparation). Several studies dealing with fishing were already written decades ago (e.g. Pälsi 1916; 1944; Edgren 1967; 1970). In publications concerning site location, archaeofaunal assemblages, and subsistence strategies, fishing has been studied as one among many other topics (e.g. Pälsi 1916; 1920; 1944; Äyräpää 1950; Edgren 1973; Carpelan 1999; Ukkonen 1996a; 2004; Mökkönen 2001; Kankaanpää 2002; Leskinen 2002; Nurminen 2004; 2007; Núñez 2009). However, fishing methods as a central theme have only been explored in recent decades (Minkkinen 1999; 2000; Naskali 2004; Koivisto 2012), and an osteoarchaeological study of fish remains from Stone Age Finland is currently underway (Nurminen 2004; 2006; 2007; 2015a and in preparation).

A large number of the archaeological assemblages found in Finnish wetlands originate from stationary wooden fishing structures, e.g. traps, lath screen panels, and weirs that have been constructed in river estuaries, inlets, coves, and in shallow lake bottoms (Koivisto 2011). Surprisingly, the majority of these well-preserved wooden assemblages have not been properly studied, even though several of the examples have returned prehistoric dates. The aim of this paper is to contribute to a more detailed analysis of the Middle Subneolithic (non-agricultural Neolithic) wood material of Purkajasuo in Yli-Ii, northwest Finland (Koivisto 2012). Here, the main focus is on the fishing methods, as well as in revealing the mode of subsistence among the coastal hunter-fisher-gatherers occupying the estuary and banks of the Iijoki River between c 3500–2900 calBC. The paper combines the archaeological data with ethnographic analogy based on environmental and climatic considerations, including the habitat preferences of certain fish. In addition, the burnt fish remains recovered at the contemporary settlement sites near the Purkajasuo fishery have been reanalysed. This is because in some of the previous osteological analyses the fish vertebrae have not been identified on the family or species level.

MATERIALS AND METHODS

Stationary wooden fishing structures

To further explore the quantity and characteristics of stationary wooden fishing structures in the Finnish archaeological record, we collected data from the archives of the National Board of Antiquities (NBA) concerning archaeological and ethnographic collections. In addition, informa-

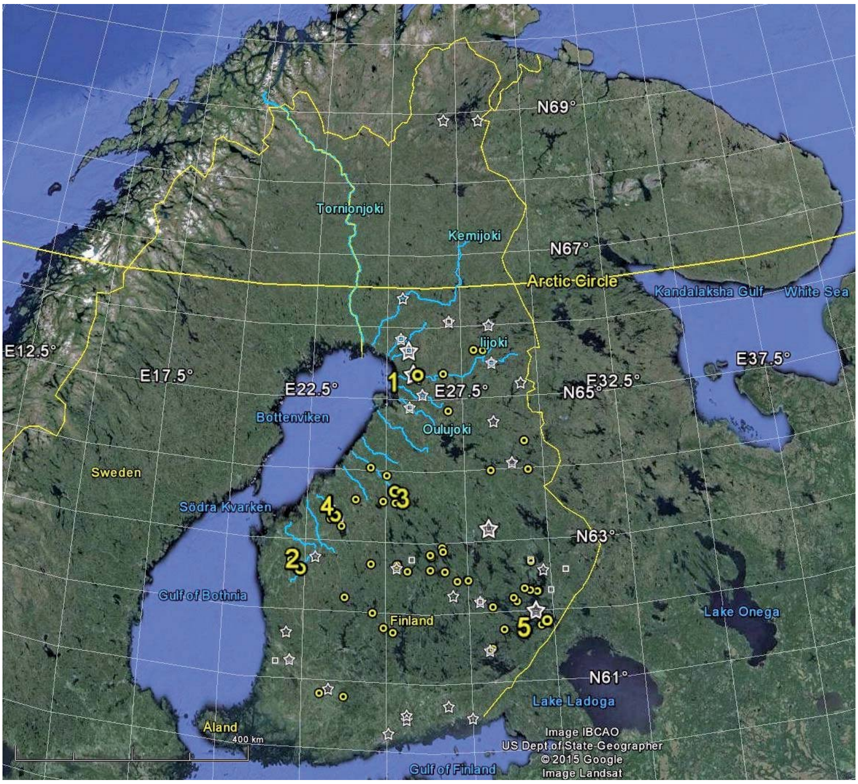

Fig. 1. Map of Finland and the neighbouring areas. Yellow dots indicate sites with stationary wooden fishing structures. The larger dots represent the securely-dated structures: 1 – Yli-Ii (three samples); 2 –Kurikka; 3 – Haapajärvi; 4– Evijärvi; and 5– Kesälahti (two samples). Blue lines indicate the major Ostrobothnian rivers mentioned in the text. White symbols represent the burnt Salmonid fish bone taxa: family Salmonidae (small star), species Salmo salar (big star), and genus Coregonus (small square). Background map by Google Earth. Archaeological data provided by the National Board of Antiquities and the Finnish forest administration. Illustration: S. Koivisto.

tion collected by the Finnish forest administration (Fi. Metsähallitus) was added to the total number of stationary structures, such as wooden fish traps and weirs manufactured of vertical pine lath frames bound together with birch bark strips, twigs, or root bindings and supported with piles. Circa 50 sites were included in the fishing structure dataset. These sites are plotted in Figure 1. Only eight wood samples taken from the structures have been radiocarbon dated (see highlighted sites in Fig. 1), but, quite surprisingly, seven of them have yielded prehistoric dates ranging from the Middle Subneolithic period to the Early Iron Age (see Table 1). Apparently many of the stationary structures have been manufactured and used in historical times, as can be deduced from the ethnographic record. However, a number of the sites have been discovered to be associated with prehistoric settlements and burials, or have been dated by means of other materials or shore displacement chronology. Furthermore, a number of the fishing structures are situated under thick layers of alluvial sand and peat, not in proximity to present day water systems, and are thus most probably prehistoric (Koivisto 2011).

A case-study – Purkajasuo in Yli-Ii

Purkajasuo, in the western fringe of the Kierikki Subneolithic site concentration (25°53’23”E, 65°22’08”N), is located in Yli-Ii, Northern Ostrobothnia (see Fig. 1). The topography of the research area is rather flat, with low moraine ridges, sandy ancient shoreline formations, and large

Lab. ID	Site	Context	Wood sample	^{14}C-age (BP)	Calibrated age (2σ)	References
Hel-2740	Yli-Ii Purkajasuo	fish trap	worked lath	4770±130	3934–3111 BC	Koivisto 2011; 2012
Beta-331814	Haapajärvi Lamminoja	fish trap	worked lath	4560±30	3487–3107 BC	Koivisto et al. forthcoming
Hel-3918	Yli-Ii Purkajasuo	fish trap / weir	unworked wood	4460±100	3489–2900 BC	Koivisto 2011; 2012
Hel-3282	Kurikka Hiipakanluhta	fish trap	worked lath	4390±120	3493–2681 BC	Jungner & Sonninen 1998; Koivisto 2012
Hel-3917	Yli-Ii Purkajasuo	fish trap / weir	worked stake	4340±100	3349–2681 BC	Koivisto 2011; 2012
Hela-1400	Kesälahti Hiidenniemi	fish weir	worked stake	2820±45	1114–847 BC	Forsberg et al. 2009; Koivisto 2012
Hela-1399	Kesälahti Hiidenniemi	fish weir	worked stake	2180±35	366–118 BC	Forsberg et al. 2009; Koivisto 2012
Su-3341	Evijärvi Lake Sulkajärvi	fish trap	worked lath	400±40	AD 1432–1633	Koivisto 2012

Table 1. Radiocarbon dates of the wooden stationary fishing structures in Finland. All ages in the paper have been calibrated with IntCal13 (Reimer et al. 2013) in OxCal v4.2.4 (Bronk Ramsey 2009).

peatland areas representing the earlier stages of the Baltic Sea. The eastern coast of the Bothnian Bay is an area of rapid isostatic uplift; the earth's crust is still rebounding from the impact of the last deglaciation at the uplift rate of nearly 90 cm per a century (Eronen et al. 2001: 18). The rate of this phenomenon has not always been constant, but has varied notably during different periods of time (Núñez & Okkonen 1999; 2005). The research area emerged from the Baltic Sea during the Litorina stage, c 3500–2900 calBC, when the water level was 50–60 m higher than today. Bays, inlets, and coves formed between new land areas, and the new bodies of water were very shallow and sheltered due to the low-lying terrain.

The Subneolithic settlement complex of Kierikki by the mouth of the River Iijoki is unique in many respects. Riverbank settlements with numerous housepit clusters, imported materials (including southern Baltic amber, early copper finds, flint, and asbestos-tempered ceramics) and abundant resources characterise the groups of people inhabiting the area between 3500–2000 calBC. Several studies have been published on the settlement pattern, social dynamics, environmental reconstructions, and other characteristics of the Kierikki sites (e.g. Siiriäinen 1967; Núñez 1995; 2009; Koivunen 1996; 2002; 2006; Halinen et al. 1998; Núñez & Okkonen 1999; 2005; Karinen 2000; Costopoulos 2002; 2005; Costopoulos & Vaneeckhout 2005; Tranberg 2006; Costopoulos et al. 2006; Hulse & Costopoulos 2007; Vaneeckhout 2008; 2009a&b; 2010; Okkonen 2009; Viljanmaa 2009; see also the critiques by Mökkönen 2009; 2010 and Damm et al. 2010). The Iijoki estuary has been suggested to have formed one of the most stable of such areas between c 4000–3000 calBC, and it is the site of one of the largest Stone Age housepit concentrations in northern Finland: over 300 houses and other pit structures are known from the Middle Subneolithic mouth and banks of the river (Pesonen 2002; National Board of Antiquities 2015). The long multi-room housepits of Kierikki have been seen as an indication of increased social communality (Okkonen 2003; Núñez & Okkonen 2005; Vaneeckhout 2008; 2009a&b; 2010) and reflected the idea of a longhouse borrowed from contemporaneous Neolithic cultures further to the south (Mökkönen 2011: 67). Since the land uplift rate is rather well-known, a rough site chronology has been developed based on the location of shore-bound sites and radiocarbon datings, although a certain degree of re-use of old housepit structures has also been recorded (e.g. Halinen et al. 1998; Núñez & Okkonen 2005; Mökkönen 2009; 2010).

An extensive collection of waterlogged wood was discovered in the western fringe of the Kierikki area, in peatland environment situating by the Stone Age mouth of the Iijoki River, covering in total an area of nearly 13 hectares (Núñez 1995; Schulz 1997; 1998a&b; 2000; 2001; Koivunen & Viljanmaa 2004; Koivisto 2011; 2012) (Fig. 2). A number of wooden artefacts had already been found during the draining of the peatland agricultural fields in the 1950s, but the age and the scientific value of the Stone Age fishery was not fully recognised until later. All of the radiocarbon samples yielded Middle Subneolithic dates ranging between 3934–2681 calBC (see Table 1), but the relative dendrochronological dates indicate a distinct activity phase of only 19 years (Zetterberg & Kinnunen 2007; 2009: 17), before the area was covered by alluvial sediments and the shoreline receded further west due to isostatic uplift. Evidently a severe flood broke the stationary fishing structures, covered

Fig. 2. Wood find area (Leualanpelto 1–2) of Purkajasuo during the excavations in 1996. Photo: H.-P. Schulz.

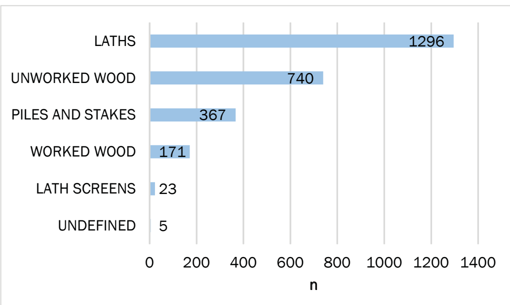

Fig. 3. The total number of wood find categories from the wetland excavations at Purkajasuo in 1996–9 and 2004.

the area in alluvial sand, and rendered the shallow bay unusable for fishing. Over 2600 wooden finds were uncovered and documented at the site during wetland excavations in 1996–9 and 2004. All the finds were found in a horizontal position under more than a metre of sand deposited by the sea and, possibly, the Iijoki River.

A detailed analysis of the Purkajasuo wood material, its deposition and dating has been published elsewhere (Koivisto 2012), and therefore in this paper a summation of the waterlogged assemblage is presented (Fig. 3). The majority (71%) of the material has been worked with various methods. The most numerous of the find categories consists of separate laths (50%), most plausibly representing building material for the lath screens of the fish trap panels and weir fences. A total of 26 lath screen sections were discovered in the area (Fig. 4). The laths have been bound up with narrow strips of birch bark, with a twig or a narrow lath underneath securing the binding. In addition, several wooden piles and stakes, net floats made of bark and wood, perforated planks, pieces of leisters, a wooden pole with a hooked end, a piece of a sledge runner, and a curved, notched piece of wood, possibly a boat rib, were identified in the material (Koivisto 2011: 40–2; 2012).

Ethnography and analogical reasoning

Numerous ethnographic studies on fishing in historical times have been published in Finland, stressing the great significance of this livelihood among past generations. Fish have not only played an important role in the subsistence base, but also in material culture (e.g. in clothing and utensils), in folk art, and in folklore. Much of these data

Fig. 4. Lath screen section, manufactured of pine laths with birch bark strip bindings, in situ in a test pit in Purkajasuo. The scale bar blocks are 5 cm. Photo: H.-P. Schulz.

have been collected through questionnaires and fieldwork carried out in different parts of Finland and among Finno-Ugric peoples in Russia and Siberia. U.T. Sirelius began the tradition by studying fishing methods among Finno-Ugric peoples in the early 20th century, and completed an exhaustive, three-volume monograph on fishing in Finland (Sirelius 1906a; 1907; 1908), as well as an analytical study on net fishing among Finno-Ugric peoples (Sirelius 1906b). K. Vilkuna (1974) continued the work and completed a monograph on salmon fishing on the Kemijoki River, southern Lapland, where he also discussed environmental factors, settlement history, and division of labour. Fishing rights and the social organisation of fishermen in eastern Karelia have been studied by E.A. Virtanen (1950). Pioneering works on fishing folklore and traditions among the Finno-Ugric peoples have been carried out by A. Kannisto (1908) and K.F. Karjalainen (1914) among the Ob-Ugrian Khanty and Mansi people of western Siberia, by T.I. Itkonen (1936; 1937; 1944; 1948) among the Sami people of northern Fennoscandia, and by U. Harva (1914a&b; 1942; 1948) among the Mari and other Finno-Ugric peoples. These ethnographic studies show how long-lived and universal most fishing methods are. The designs of various kinds of fishing gear are based on functionality; nearly identical equivalents of archaeological finds can usually be detected in the ethnographic record.

Northern peoples have not only profited from fish as a subsistence base. According to ethnographic data, all parts of fish would have been commonly utilised. In addition to the flesh, the bones, offal, roe, fins, and skins were used for various purposes. The skins and scales were commonly processed for making glue. Burbot skins have been used for making pouches and straps, and salmon skins have been described as being used for making sacks and garments, including caps and shoes among the Sami and several groups of eastern Siberia (Leem 1767; Berg 1984). Burbot skins have even been used as windows (Castrén 1855), and the Khanty of eastern Siberia, Eskimos, and people of northern Asia have sewn summer clothes of fish skin (Hämäläinen 1938). The most frequently used species for these purposes have been burbot and salmon.

The advantages of studying prehistoric fishing by means of ethnographic analogies derives from the verified long duration of similar methods and equipment adapted to a specific habitat. However, time and the use of ethnoarchaeological analogy has to be considered, especially when studying phenomena of long duration (see e.g. Steward 1942: 339–40; David & Kramer 2001; Lyman & O'Brien 2001). Binford's (2001) middle range research reflected the static record of the present onto the dynamics of past societies. The uncertain middle range, linking arguments between present and past, was strengthened by way of using independent ethnographic and environmental data to explore the relationships of patterning. Ethnoarchaeology has been esteemed as offering useful tools in understanding the complexity of archaeological facts (Roux 2007: 155), since the manifestations and dynamics of different archaeologically investigated phenomena are not neces-

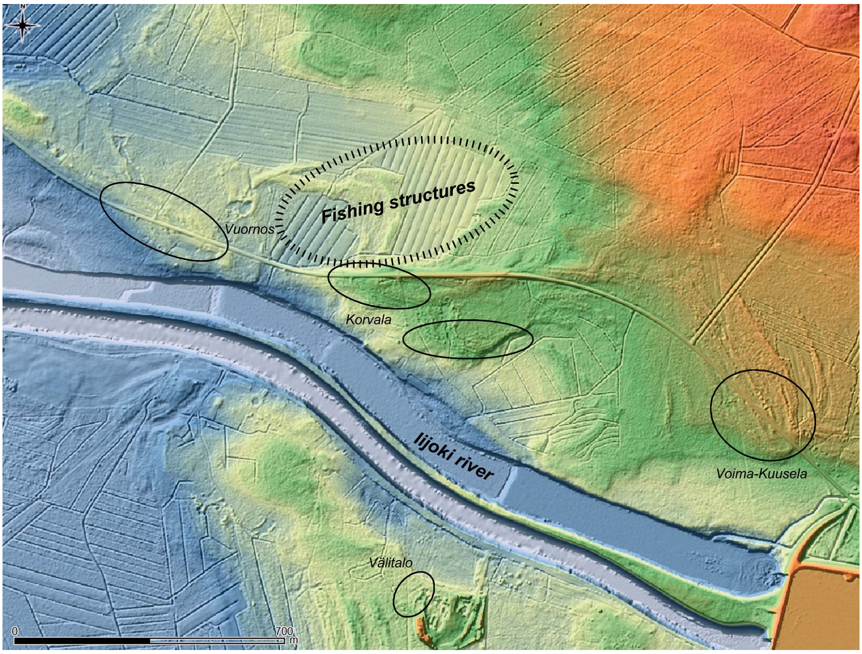

Fig. 5. Digital elevation model (DEM) of the western fringe of the Kierikki Subneolithic site concentration showing the housepit sites of Vuornos, Korvala, Voima-Kuusela, and Välitalo (black circles), and the wood find area of Purkajasuo (highlighted) between c 3200–2900 calBC. LiDAR-data provided by the National Land Survey of Finland. Illustration: S. Koivisto.

sarily what they first seem to represent.

In this paper, we have combined the archaeological data with information from ethnographic sources on stationary fishing structures, relying on similar principles to project the technology back to the Subneolithic period and evaluate its significance. The characteristics and the technological features of the fishing structures have been compared with their ethnographical counterparts, and the results have been evaluated both in the light of environmental and climatic data and of archaeological sites with comparable assemblages in the Baltic Sea region.

RESULTS AND DISCUSSION – COASTAL HUNTER-FISHER-GATHERERS

Fishing at Purkajasuo

Based on the Purkajasuo wood material, at least three fishing methods were practised in the shallow bay situated in a narrow channel by the Stone Age mouth of the Iijoki River (Fig. 5). Both active and passive methods were used: (1) weir fishing with a fence, and possibly traps, made of lath screen panels, (2) net fishing, and (3) spear fishing. An essential structural part of the fishing method was based on lath screen weirs or fishing fences set in a narrow channel between the ancient island of Vuornos and the cape of Korvala, hindering the passage of fish and guiding them towards the primary trapping systems, i.e. the lath screen traps and/or nets. Fishnets could have been used independently in a narrow channel, or they may have been attached to the stationary lath screen fences. Similar structures may be seen at the Ob-Ugrian Khanty and Mansi fish weirs of western Siberia, where the fences were designed to block the entire river or inlet channel with one or several traps attached in the openings of the weir wall (Sirelius 1906c: 46–7) (Fig. 6). Due to the relatively small excavation area at Purkajasuo, it is impossible to say whether this structure may have stretched across the whole channel of Purkajasuo, c 150 m in width, or if it had one or several openings in the weir fence.

The wood material for producing durable laths for fishing structures had to be straight, almost branchless, and dense in texture. According to the ethnographic record (NBA 1961), the best pine trees for these purposes grew by bogs, wetlands, and coastal flats. Laths were traditionally manufactured in tandem with splints. The winter seasons were utilised for material collection, transportation by sledge, and the making of utensils. Pine trunks were first dried inside the house, and sometimes even heated in the oven, before the making of splints and laths. The trunks were split parallel to the wood fibres with the help of a knife or a special wooden splitting stick used to produce long and flexible laths.

According to ethnographic parallels (NBA 1961), the lath screen panels were set in shallow water in late winter from a boat, through a hole in the ice, or by way of wading in the water. The earlier the setting of the traps took place the more abundant the catch. If there was a fear of ice that would break the relatively delicate structures, the setting was accomplished later in the spring from a boat or a raft. In places where conditions were harsh, the traps were always dismantled before winter, but in calm waters trap fishing was profitable even in wintertime, especially when burbot (*Lota lota*) was pursued. In calm waters the traps could have been in full capacity for several years without dismantling. Sometimes only broken parts were mended and replaced. However, a general belief seemed to be that a freshly made, brand new fish trap would lure fish better than an old and worn-out one. In an estuary habitat, like at Purkajasuo, it would have been essential to dismantle the trap panels before winter. Especially the birch bark bindings used by the Middle Subneolithic fishermen would not have withstood the hard-packed ice of the Bothnian Bay, and the flooding from the melt waters. The spring floods must have been severe in the flat estuary habitat, and according to the wood find distribution at Purkajasuo the traps had been set in sheltered areas, e.g. behind the tip of the cape Korvala (Koivisto 2012).

Lath screen modules represent a relatively common type of wetland archaeological material in the eastern Baltic Sea region and western Russia. Laths made of pine wood with bast, wicker, and birch bark binding seem to be the most typical material used for making stationary fishing structures (e.g. Levenok 1969; Vankina 1970; Burov 1972; 2001; Loze 1979; 1988; 2001; Kraynov 1991; Rimantienė 1992; 1998; Lozovski 1999; Bērziņš 2008; Koivisto 2012; Lozovski et al. 2013). The piles supporting the lath screen traps and weirs were made from several types of wood; possibly what was locally available and best suited for waterlogged settings. Interestingly, the most typical binding material for the trap panels was lime bast, even though birch bark was available and utilised as entire sheets in other parts of the fishing structures (Lozovski 1999). At the Russian Zamostje 2 site in the Upper Volga region, typically bulrush (*Scirpus*) rather than bast or birch bark was used for lath screen bindings (Lozovski et al. 2013). Hence, it seems that the birch bark strip as binding material was a Finnish adaptation in the lath screen fishing tradition. In addition to the Purkajasuo finds, the Subneolithic lath screen

Fig. 6. A traditional Ob-Ugrian Khanty fish weir from the tributary of the Ob River in western Siberia. The weirs were placed in the most productive fishing grounds in order to catch the anadromous species returning from their yearly migration upriver to spawn. A fish trap made of willow twigs has been attached to the weir fence with the mouth towards the stream. Photo: U.T. Sirelius, 1898–1900/ NBA.

structures of Hiipakanluhta and Lamminoja, western Finland, had birch bark strip bindings (Koivisto et al. unpublished). Furthermore, the fishing structure from Nivala, Northern Ostrobothnia, had bindings made of birch bark, though the structure has not been securely dated (Koivisto 2011). The pollen data from Purkajasuo indicates that the most common tree species in the area were pine and birch at the time the fishery was active (Karinen 2000).

Active fishing methods, using leisters and spears, constitute one of the simplest ways of catching fish. Spear fishing can be practised during the night or in the daytime, during the spawning season in sheltered bays and rivers. In warm weather the fish bask in reedy shores and can easily be caught with this method. Traditional late winter fishing of spawning burbot has been performed through thin ice with a wooden club or a three-barbed wooden hook. Night fishing with torch and leister has been widely practised in Finland from the shore, a raft, or a dugout boat (Sirelius 1906a: 41–55; Järvisalo 2004). Among Native North Americans, leisters have even been used for catching waterfowl (Curwen 1941) or in taking fish out of traps, as has been recorded among the Inuit groups of the Arctic coast of Canada (Stewart 2005: 349).

In the southern Baltic area, it has been suggested that leisters with relatively broad wooden side prongs were designed to catch eels (*Anguilla anguilla*) (Meurers-Balke 1981: 147; Bērziņš 2008: 252–53; Klooß 2015: 218–39). Similar branched eel leisters with short points made of iron are also known from the Finnish ethnographic record (Sirelius 1906a: 40). The best-preserved archaeological example has been found in Šventoji Lithuania (Rimantienè 1995; Bērziņš 2008). Barbs could have been attached with birch bark pitch, rawhide strips, sinew, birch bark bindings, or plant fibre. Partly fragmentary parallels have also been found in Denmark, northern Germany (Meurers-Balke 1981; Skaarup 1995), and arguably in Purkajasuo, Finland (Koivisto 2012). During the Holocene Thermal Maximum (HTM), c 6000–2500 calBC, temperatures have been a few degrees Centigrade higher than today (Heikkilä & Seppä 2003), and this may have caused some fish species, such as eel and some Cyprinid fish, to adapt to warmer biotopes and led to a much wider distribution than is seen today (Nurminen 2006; 2007; Enghoff et al. 2007: 167). However, the possibility of using this type of leister especially for catching eels in coastal Northern Ostrobothnia c 3000 calBC calls for further study.

The relative dendrochronological dates of the wood samples from Purkajasuo reveal some interesting aspects concerning the manufacturing and use-period of the fishing apparatus. According to the dendrochronological dates, all the wood samples (n=10) were felled during the cold season, a time span of nine months between August/September and May/June (Zetterberg & Kinnunen 2007: 4; 2009: 17). This can be seen as an indication of winter as a preferred season for wood cutting, which is in line with the information provided by the ethnographic record. In addition, a wooden sledge runner fragment (KM 31836:47) can be seen as indicating wintertime travel in the area, either by a visiting task force or a more sedentary group occupying the area during the winter seasons. The felling of trees for making fishing structures was practised in the Purkajasuo area for at least for 20 years. All the samples were felled within a relatively short period of 19 years (Zetterberg & Kinnunen 2009: 18), although the cutting dates cannot directly give us information about the life spans of the wooden fishing structures, since usable parts could have been stored and/or re-used for a few years, as can be suggested based on the ethnographic record.

The mode of subsistence

The fishing economy of the Bothnian coast in historic times has long been based on the utilisation of river mouths with all their resources, especially anadramous fish (e.g. Vilkuna 1974). Fishing was practised in river mouths exclusively far into the 20th century. In the Bothnian Sea area, fishing was divided into two clear-cut procurement seasons: spring and fall. In the early summer Atlantic salmon (*Salmo salar*) was the most desired species, and later in the summer whitefish (*Coregonus lavaretus*) was the main catch. Varying ice conditions hindered the exercise of winter fishing and seasonal variations regulated fishing in the long term. Salmon, whitefish, Baltic herring (*Clupea harengus membras*), vendace (*Coregonus albula*), brown trout (*Salmo trutta*), and European perch (*Perca fluviatilis*) were caught with seine and fyke net, as well as weir and trap fishing methods. Fyke net was the most effective method, especially in early spring soon after thawing season. Spawn-fishing of adult perch was profitable in good locations. The salmon season began when the waters turned warmer. The yearly salmon run to streams and rivers reached its peak in June. The timing of sealing and salmon fishing went perfectly together; when the sealing season was about to end, the yearly salmon run was only beginning. In the 19th century, the salmon season by the Ostrobothnian rivers lasted approximately six months (Vilkuna 1974).

In the previous archaeological studies dealing with the Subneolithic Kierikki sites, the implications of site location by the banks of the Iijoki River, and especially by the estuary, have only been partially examined. The dominance of seal in the faunal assemblages recovered at the Kierikki sites has provided a basis for determining the mode of subsistence during the Subneolithic (e.g. Halinen et al. 1998). The quantity and quality of the stationary fishing structures of Purkajasuo suggest that fishing has been an important activity, and played an essential role in the whole of the subsistence economy and diet. The production of large quantities of wood required extra work and an extensive forest area to exploit. In addition, the construction of the fishing apparatus, and the fishing itself with all its procedures, required considerable technology and organisation. The high technological skill, the timber selection, and the manufacturing of the wooden fishing structures year after year, season after season, points to a significant contribution to the utilisation of aquatic resources. This material also points to a high degree of reliance on fishing. The costs and the benefits of the undertaking have obviously been in an adequate balance in relationship to the whole of the subsistence strategy and diet. The climatic conditions during the use-period of the Purkajasuo fishery prior to the cooling trend starting c 2500 calBC could have been especially advantageous for the development of a procurement strategy needed for the extensive utilisation of the coastal and riverine resource base (Table 2).

In areas with better preservation conditions for organic materials, the diversity of the equipment used in marine exploitation increased during the Late Mesolithic period (e.g. Andersen 1995: 41; Fischer 2007). Similar assumptions concerning the subsistence of the Late Mesolithic coastal populations have also been made in Finland and Estonia on the basis of site location, settlement pattern, and faunal assemblages (Siiriäinen 1981; Nuñéz 1996; Lõugas 1997; Kriiska 2001; 2003; Kriiska & Tvauri 2007; Mannermaa 2008; Tallavaara & Seppä 2012). During the HTM, 6000–2500 calBC, the local flora and fauna have obviously differed as to both the range of species and their distribution as compared with the current situation. Unburnt bones from this time period do not preserve in the acidic Finnish soils, and our burnt bone assemblages do not allow the use of stable isotope studies due to the deterioration of bone collagen. This has had an impact on the study of subsistence and diet, as determinations focus on an often incomplete archaeological record.

A total of c 2930 burnt bone fragments have been identified to the species level from the temporarily overlapping Subneolithic housepit sites of Purkajasuo/Korvala, Korvala, and Kuuselankangas (Ohtonen 1995; Ukkonen 1996b–d; 2002a–e, Heinäaho-Miettunen 2006[i]; Nurminen 2015b–d), situated within a c 3 km radius from the fishery of Purkajasuo. Seal dominates by far, constituting almost 70% (n=2043) of the total faunal assemblage. Only 5.7% (n=166) of the fragmented bones could be identified as fish (*Teleostei*), and only 84 fragments have been identified to the family or species level: 30 pike (*Esox lucius*), 11 Cyprinidae, one burbot, 28 whitefish, three salmon and/or trout (*Salmo salar*/*Salmo trutta*), seven Salmonidae and four perch. However, it has already been observed in other Baltic Sea areas with better preservation conditions for osteological materials that marine mammals are more frequently found in archaeological contexts than small and fragmented fish bones (Lindqvist 1997; Eriksson 2003; Olson 2008; see also Vaneeckhout et al. 2013). Therefore, it is justifiable to consider that the proportion of fish remains in the archaeofaunal assemblages of Kierikki is unrepresentative. Furthermore, according to ethnographic data, all parts of fish have been commonly utilised and, therefore, the direct evidence for fishing may be extremely difficult to trace with the help of only burnt and fragmented fish remains. However, the fish species identified through osteological analyses may refer to certain fishing methods used by the prehistoric populations.

Logistically, the setting of the Kierikki sites is especially advantageous, located by the coastal waters and along inland river routes leading to the interior of Finland and as far as the White Sea Karelia in Russia (see Fig. 1). The river routes also served as channels of communication and contacts between coastal

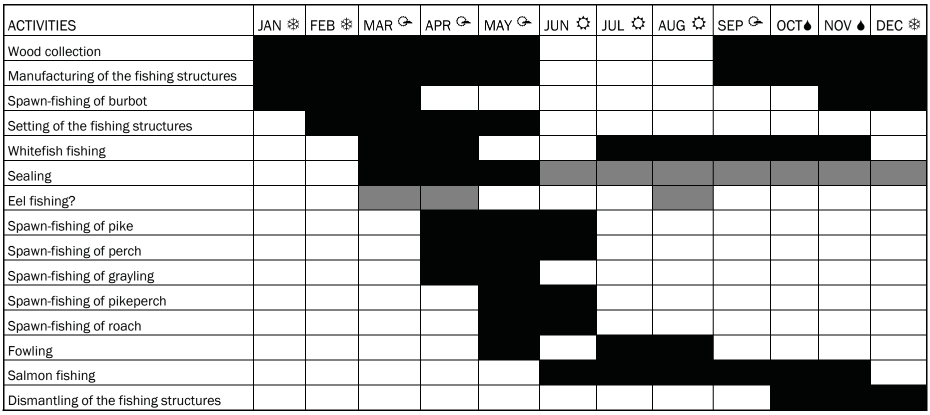

Table 2. An annual scheme of seasonal activities in the Iijoki estuary between ca. 3500–2900 calBC based on this study. Ethnographic information on the procuring seasons by Vilkuna (1950; 1974) and Talve (1997).

Ostrobothnia and the large lake area of Finland, rich in contemporary settlement sites and sources of important raw materials. Watercraft, skis, and sledges were used as means for transport along the well-established routes, based on, e.g. the distribution of contemporary asbestos-tempered ceramics (e.g. Carpelan 1999; Mökkönen 2008: 116). Like the mobile fishermen of historic northern Fennoscandia (Vilkuna 1974), the Subneolithic populations may already have harvested in season the riverine and estuary resources of coastal Ostrobothnia even from far-off locations, e.g. to catch salmon and trade with the more sedentary groups occupying the area. In the early stages, beginning during the Early Comb Ware period, c 5000 calBC, the fishing in Kierikki may have been integrated into the more seasonal occupation of the Ostrobothnian fishing stations. After, or perhaps already during the Typical Comb Ware period, c 3950–3500 calBC, the utilisation of the estuary resource base may have gained importance and necessitated a more permanent occupancy by the reliable procurement areas. Residential corporate groups have been suggested to have emerged under conditions where access to important resources was restricted, and/or where there was a frequent need of collective labour to exploit the resources most effectively (see e.g. Hayden 1990). Residential mobility may have gradually reduced and approached full sedentism by the abundant estuary fishing waters of coastal Ostrobothnia during the mid-Subneolithic.

In locations where direct evidence of the utilisation of fish is insufficient, various forms of indirect evidence play an essential role. Settlement patterns, site location, fishing technology, and resource specialisation may be seen as forms of indirect evidence of the utilisation of fish as a food source, either for immediate or delayed consumption or as a source of raw materials. The Finnish Subneolithic cultures have been described as aquatically oriented. It has been observed that after, or perhaps already during, the Typical Comb Ware period the settings of the housepit sites seem to differ from those of the preceding periods, concentrating on new ecological niches by the major Ostrobothnian rivers, especially at the river mouths and in the archipelago along the Bothnian coast (Mökkönen 2011). This has been suggested to have occurred as a result of changes in subsistence strategies, with river communities relying on salmon fishing, while other coastal populations specialised in sealing. However, the archaeofaunal evidence confirming this is inadequate.

As expected, archaeological salmon bone taxa do not support this assumption. A total number of only c 1100 Salmonid remains have been recovered in the whole of Finnish archaeological sites (Nurminen 2004; 2006; 2007 and new fish vertebrae analyses by Nurminen 2010a–f; 2011; 2012a–k; 2015a–e) (see Fig. 1). Only six of the fragments have been identified as Atlantic salmon (*Salmo salar*) by species, while most of the taxa are whitefish (*Coregonus lavaretus*) (n=767), or they simply belong to the family of Salmonidae (n=304). The incredibly small portion of salmon remains in Finnish archaeofaunal assemblages may be due to other factors than the commonly suggested poor preservation and excavation techniques, and call for further discussion (Nurminen forthcoming). For example, the recovery and identification of fish remains rapidly increased in Japan from the mid-1970s and onward, when the wet-sieving of shell middens became popular (Matsui 2005: 58). The number of fish bones recovered multiplied, but the volume of recovered unburnt Salmonid remains has still been less than that of other fish species.

Large numbers of fish teeming upstream in the river would hardly have been overlooked by the prehistoric foragers of the major Ostrobothnian rivers. When dealing with resources that are caught in large numbers and with products that spoil rapidly, investigating the possibility of storage technologies is essential, because these factors may have dramatically affected the preservation and the proportion of fragmentary remains in the archaeofaunal assemblages.

The evidence of storage technology, especially with fish, is archaeologically difficult to trace. It has been observed, however, that the storage economies among the hunter-fisher-gatherers were developed most intensively in the northern latitudes as an over-wintering strategy (Sakaguchi 2009). Archaeological features connected with storage techniques can involve pits in house floors, post holes for aboveground warehouses, and small pit features on the margins of the settlement sites (Chatters 1995). In addition, storage adaptations for various fish species are in a central role in studies concerning taphonomic histories. Certain body parts of processed fish have been seen as evidence of storage techniques. Salmon remains, consisting of vertebrae and ribs but no head bones or pectoral girdle parts, are the remains of meat bearing portions of butchered fish. Storage should have been a sufficiently advanced part of the resource utilisation strategy for dried fish for them to last through the winter months. Therefore, environmental factors are crucial, and have to be taken into consideration when tracing the frail evidence for Stone Age storage technologies.

The environmental and climatic conditions

The wooden fishing structures of Purkajasuo have been radiocarbon dated to the late Atlantic or the early Subboreal chronozone of the Baltic Sea (c 4000–2000 calBC), when the climate was slightly warmer than today. The palaeoclimatic history of Fennoscandia during the Holocene is relatively well-known, and several studies have demonstrated that the climate evolved gradually to more favourable conditions after the last deglaciation, reaching the HTM in 6000–2500 calBC (Heikkilä & Seppä 2003: 551). The end of the activity phase of the Purkajasuo fishery falls towards the end of the HTM, to 3000–2000 calBC, a period that was characterised by high temperatures and low humidity (Hyvärinen & Alhonen 1994; Almquist-Jacobson 1995; Hammarlund et al. 2003; Korhola et al. 2005; Sohar & Kalm 2008; Seppä et al. 2009). The pollen-based climate reconstructions demonstrate a clear cooling trend starting c 2500 calBC, and the earlier phases were characterised, at least in southern Finland, by high midsummer temperatures and low effective humidity. Nowadays, the southern boreal vegetation zone boundary in Finland and Sweden, which is clearly dependent on temperature, runs along 60°N, but it has been suggested that in 6000–2500 calBC it was located roughly at 63°N (Heikkilä & Seppä 2003: 549–51), near the southern limit of the province of Ostrobothnia (see Fig. 1).

Thus, the climatic conditions during the activity phase of the Purkajasuo fishery, located by the northern border of the southern boreal zone boundary, were very advantageous. The shallow bay with its coves and inlets offered a particularly suitable environment for various local fish species, especially during the spawning seasons. The inlet was very shallow, only c one metre in depth while extant, and filled with brackish water (Karinen 2000: 67–9). The wooden fishing structures were erected in shallow water rich in aquatic vegetation, constituting a suitable spawning arena for a wide array of fish species. The fishing activity at Purkajasuo ended catastrophically when a severe flood broke the stationary fishing structures, covered the area in alluvial sand, and rendered the shallow bay unusable for fishing (Koivisto 2012).

The utilisation of marine resources has been closely related to the temperature and marine influence of the Baltic Sea, and thus affected population dynamics (Tallavaara et al. 2010). In eastern Fennoscandia, the increased aquatic productivity during the mid-Holocene has been suggested to have played an important role in the rapid growth of hunter-gatherer populations (Tallavaara & Seppä 2012: 7). In order for the prehistoric communities of coastal Ostrobothnia to have begun to exploit fish on a larger scale, they must have developed the necessary production facilities, boats, weirs, and storage technology to make the most of the resource.

Environmental factors are essential when investigating prehistoric storage technology for foods that spoil rapidly and for species that are caught for food in large numbers (e.g. Matsui 1996; 2005; Binford 2001; see also Sakaguchi 2009; Nelson 2010; Cunningham 2011). Climate change at the end of the HTM would have meant changes in riverine productivity (see Tallavaara et al. 2010), and the populations may have needed a well-designed strategy for extending seasonally available resources, including adequate harvesting and storage adaptations. Settlements could have been logistically organised by/into procurement and handling areas in order to exploit seasonally abundant resources most effectively. The suggested intensification of fishing by the mouth of the Iijoki River could have been caused by the gradual climatic cooling trend, which may have manifested as increased resource seasonality and necessitated the populations finding a way to cope with the environmental challenge by stabilising their subsistence base. In terms of resources, we suggest that the Kierikki hunter-fisher-gatherers would have adapted their site location strategies to maximise fishing by the mouth and the banks of the Iijoki River.

However, we do not have very much information on the prehistoric fish species of coastal Ostrobothnia. At the least, we know that the major rivers were excellent habitats for the fry of anadromous fish species, for instance Atlantic salmon. Long-term monitoring records on water level fluctuations and fish catches of the major Ostrobothnian rivers are available from the 16th century onwards (e.g. Vilkuna 1974; Nissilä 1990). Today, several of the rivers have been harnessed for hydroelectric power, but earlier the rivers draining at the head of the Bothnian Bay, i.e. the Rivers Oulujoki, Iijoki, Kemijoki and Tornionjoki (see Fig. 1), contributed hundreds of thousands of young salmon to the Baltic Sea per year (Vilkuna 1974). In addition, whitefish and river lamprey (*Lampetra fluviatilis*) migrated to spawn in the Ostrobothnian rivers. Other migratory fish species, at least in the southern parts of the study area, have been grayling (*Thymallus thymallus*) and East European bream (*Vimba vimba*). Interestingly, young eels have also been recorded as far north as the River Kemijoki in southern Lapland in the historic period. Several coastal species have also been present; e.g. smelt (*Osmerus eperlanus*), roach (*Rutilus rutilus*), ide (*Leuciscus idus*), bream (*Abramis brama*), pike, and perch (Luotonen & Ohtonen 1986), utilising estuaries like at Purkajasuo as spawning areas.

Based on the environmental and climatic factors, in addition to the location and composition of the Kierikki sites, we would suggest that the Purkajasuo fishery served as an everyday fishing ground, and offered some extra nutrition in addition to other foods including stored fish and meat. The main fishing activity have presumably been performed on the river, and specifically targeted migratory fish. Anadromous species are most vulnerable to capture during their migrations into freshwater streams to spawn. Fishing in the sheltered inlet of Purkajasuo could have been very productive, especially during the spawning seasons of e.g. pike, perch, bream, pike-perch (*Sander lucioperca*), and burbot. Migratory species, such as salmon, whitefish, even eels, may have ended up in the Purkajasuo lath screen weirs and traps while seeking their way upriver to spawn. The lath screen panels could not have been used in salmon weirs in the river, because their delicate structures would not have endured the heavy stream velocity. According to the ethnographic record (e.g. Vilkuna 1974), coastal salmon fishing was typically net fishing. Salmon travel in large numbers along fairly well-defined routes upriver. The weir method has an especially high efficiency rating in these circumstances, and the stationary wooden salmon weirs of historical Finland were manufactured of branchy birch trunks and sturdy piles that were set in the most prominent areas of the river.

The large catches of fish have typically been seen as indicating larger (human) population sizes, assuming that the catch was utilised locally, either fresh and/or stored. The increasing population may also have constrained foraging territories and resulted in resource stress and greater emphasis on storage adaptations (Chatters 1995: 359). One of the key economic resources for many oceanic hunter-fisher-gatherer groups throughout the world has been salmon (e.g. Cohen 1985; Chatters 1995). In mass harvesting localities, the resource has been collected and processed for storage on-site. Cooperative labour has been needed to construct all the harvesting facilities and to conduct fishing with all its procedures. Fishing in Kierikki may also have aimed at making a surplus. Delayed consumption of fish would have needed storage technology adjusted to local procurement conditions, including seasonality and environmental concerns. The high-resolution palaeoclimatic and palaeoenvironmental records point to the warmth and relative dryness of the mid-Holocene period (Tallavaara & Seppä 2012: 4), which may have enabled the success of storage techniques such as sun- and air-drying, smoking, and fermenting of delicate products like fish. The availability of salmon and other migratory species could have meant seasonal activity and extra surplus for the Subneolithic populations inhabiting the mouth and the banks of the Iijoki River, especially when the mid-Holocene productivity peak of the Baltic Sea was increasing the abundance of fish.

CONCLUSIONS

In this paper, we suggest that fishing played an essential role in the economy of the Middle Subneolithic populations inhabiting the mouth and the banks of the Iijoki River. The woodworking skill required, the quantity of the wooden artefacts, and the labour contribution allocated to fishing all underline the high significance of aquatic resources for the coastal hunter-fisher-gatherers of Northern Ostrobothnia. Especially during the spawning seasons, the catch procured within the stationary wooden fishing structures fitted in the shallow channel of Iijoki estuary would have been abundant. The daily fish 'reserve' of Purkajasuo may have had a foundation role in the whole of their subsistence economy and diet. However, the prime resources at this specific location for a hunter-fisher-gatherer population equipped with the necessary technological skills have presumably been migratory fish species by the river. The burnt faunal assemblages recovered at the nearby settlement sites are in disagreement with this assumption, but the proportion of fish remains recovered at archaeological sites may have been biased by excavation and preservation issues in addition to prehistoric processing and storage adaptations. We suggest that the preservation techniques used already by the prehistoric populations of Iijoki, in addition to taphonomic and field methodological issues, have left no evidence confirming the importance of this resource to the river economy.

This paper also suggests that fishing in the Stone Age estuary of Iijoki was a communal undertaking. Changes in the settlement pattern in the contemporary housepit sites from c 3500 calBC onwards can also been seen as indicating increased social communality, and allowed joint initiatives in resource procurement. Fishing was evidently a significant and profitable, but at the same time very demanding, labour-intensive, and organisational livelihood. Wood and binding materials were needed in substantial numbers every year. Fishing in Purkajasuo may have primarily targeted resident fish species, such as pike, bream, perch, pike-perch, and burbot, in a sheltered shallow bay, on a daily basis. In addition to the technological level achieved in fishing, the populations of Iijoki River may also have developed techniques for processing and storing fish.

Climatic and environmental factors governed the abundance and seasonality of resources in the estuary. The productive fishing grounds may even have been the prime motive for the initial stage of settlement in the area, beginning during the Early Comb Ware period, c 5000 calBC. However, the economic importance of other resources, such as seals, land mammals, and waterfowl, cannot be excluded. Climatic conditions may have been especially advantageous for these adaptations at the end of the HTM, a period that was characterised by high temperatures and low humidity. The effects of the cooling trend starting c 2500 calBC may have been evident even earlier, and necessitated the populations focusing on mass harvesting methods, utilising regular migrations of specific species, investing in storing techniques, and in bearing surplus for exchange. The climatic and environmental change probably affected the local resource base and foraging strategies on a larger scale.

What happened by the river is another question, and a good direction for future investigation. The riverbank housepit sites of Kierikki, especially Kuuselankangas situated by the Kierikkikoski Rapids and the island settlement of Kierikkisaari with its remains of wooden pile rows at its westernmost tip, which bear many similarities to ethnographic salmon weirs, offer some alluring materials to begin with. In addition, the quest for the direct evidence of fish as a food source, the preservation, representation, and recovery of fish bones in the archaeological assemblages situated by the banks of the major Ostrobothnian rivers, calls for multidisciplinary research in addition to technical excavation experiments and statistical approaches.

NOTES

[i] Osteological analysis reports of the Kuuselankangas materials of 1993–6 by the University of Oulu were not available on file at the National Board of Antiquities, Helsinki (except Ohtonen 1995). Therefore only the summary of these materials provided by Heinäaho-Miettunen 2006 was used in this article.

ACKNOWLEDGEMENTS

Satu Koivisto's contribution to the preparation of this paper was supported by the Finnish Graduate School for Archaeology, Institute of Archaeology at the University of Helsinki, and the Finnish Cultural Foundation. I also owe many thanks to the personnel of the University of Oulu, the National Board of Antiquities, the Finnish forest administration Metsähallitus and the Kierikki Stone Age Centre in Yli-Ii for all the help, information, and practical arrangements during the research process of this article. Very special thanks go to my supervisor, PhD Jarmo Kankaanpää, for not letting me through too easily and for helping in expressing my ideas and interpretations and the usefulness of ethnographic materials. We both would wish to thank Professor emeritus Milton Núñez, Professor Mika Lavento, Lic. Phil. Petro Pesonen and MA Santeri Vanhanen, and two anonymous reviewers for their valuable comments on earlier versions of this manuscript, Hans-Peter Schulz for excavation photos, and Christopher TenWolde for language revision. Any errors or misinterpretations, of course, are ours.

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