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Recreational ice fishing on the large Lake Peipsi: socioeconomic importance, variability of ice-cover period, and possible implications for fish stocks

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Abstract. This article focuses on the socioeconomic aspects of recreational ice fishing and on the related pressures on the fish stocks of Lake Peipsi in changing ice conditions. Structured interviews conducted with anglers were combined with the assessment of the landings, the numbers of fishermen, and fluctuations in ice-cover periods. At weekends, up to 3000 anglers were observed on the Estonian side of the ice-covered lake. Respondents defined ice fishing as a hobby; however, financial gain from selling caught fish was an important incentive for retired or unemployed persons. Eurasian perch, *Perca fluviatilis* L., was the most important target fish. Catches amounted from 0 to 20 kg (mean ~4 kg) per day per angler. Depending on the length of the ice-cover period, which varied from a few days to four months, the total catch may differ about ten times. In the case of long ice-cover periods, anglers may fish out approximately 40% of the total catch of perch, roach, *Rutilus rutilus* (L.), and ruffe, *Gymnocephalus cernuus* (L.) in the lake. However, favouring recreational fisheries would help to maintain the traditional fisheries-dependent lifestyle and benefit socioeconomically less secured people around Lake Peipsi and beyond.

Key words: climate change, fluctuations in ice-cover periods, large shallow lake, recreational ice fishing, size of catches, socioeconomic incentives.

INTRODUCTION

Recreational fishery, although variable in nature, can be described as non-commercial fishing activities that are not an individual's primary resource for meeting essential nutritional needs (Arlinghaus and Cooke, 2009). There is a growing recognition of the economic, socio-cultural, and ecological importance of recreational fishing as part of the global fisheries sector (Cooke and Cowx, 2004; Arlinghaus et al., 2013). Recreational fishing is extremely popular worldwide, with average participation rates around 10% in many countries (Arlinghaus

and Cooke, 2009). Globally, the number of recreational fishermen is increasing (Granek et al., 2008). In Estonia, the number of recreational fishermen was estimated to be about 50 000 in the year 2008 (participation rate about 4% of the total population) (Ministry of Environment, 2008), but by 2010 this number had increased to 75 000 (participation rate about 6%) (Ministry of Environment, 2010).

Ice fishing (winter angling) is a major recreational activity, which can provide great social and economic benefits. However, similarly to commercial fishing, recreational fishing has the potential for negative impacts on fish stocks (Cooke and Cowx, 2004, 2006; Granek et al., 2008; Arlinghaus et al., 2013). In addition to the recreational fishing that takes place in open water, ice fishing is extremely popular in all Nordic countries.

Lake Peipsi on the Estonian/Russian border supports a significant fishery (yearly commercial catch from 2008 to 2671 tonnes in 2006–2012), providing 76–91% of the total freshwater fish caught in Estonia. However, the mean annual commercial fish catch from Lake Peipsi has declined about two times since the 1930s (Kangur et al., 2013). The valuable fish stocks of Lake Peipsi are important for both commercial and recreational fishery. Although commercial catches on the lake have been registered since 1931, there has been no clear monitoring of recreational fishing. On a global scale, the lack of monitoring and statistics on recreational fishing participation and harvest has hindered our ability to understand the magnitude and impact of this fishing sector (Cooke and Cowx, 2004). Inappropriate monitoring together with the diffuse nature of recreational fishing may lead to seemingly unaccountable fish stock declines (Post et al., 2002). In addition, the potential impact of climate change on recreational fishery has not been assessed (Ahn et al., 2000; Collares-Pereira and Cowx, 2004). Some studies (e.g. Lehtonen, 1996) suggest that climate warming will alter conventional fishing areas and periods. Moreover, the duration of the angling season may vary as the ice-cover period is projected to decrease (Shuter et al., 2013). More knowledge about the ecological and also socioeconomic aspects of recreational fishery on global and local scales is needed (Arlinghaus et al., 2013; Hunt et al., 2013).

This study focuses on ice fishing, where fish are caught with fishhooks through an opening in the ice on a frozen body of water. Ice fishing represents an important social and cultural activity in many countries (e.g. Canada, Finland, Latvia, Norway, Sweden, Russia, and Germany) with long cold winters (Aas, 2008). It is a favourite pastime in Estonia. Lake Peipsi and Pärnu Bay in the Baltic Sea are the most important regional locations for winter fishing (Ministry of Environment, 2010). In the summer period, by contrast, recreational fishermen are spread out on southern and eastern Estonia's smaller lakes that are more convenient for open-water angling than large lakes such as Peipsi (Ministry of Environment, 2013). In Estonia, everyone has the right to line fish with a single line, and no special permit is required for this (Fishing Act, 2010). However, until now there have been no ecological or socioeconomic evaluations of ice fishing carried out on Lake Peipsi in scientific publications. This has hindered any proper assessment of changes in the quantity of fish stocks in this large lake.

The present pilot study attempted to assess not only socioeconomic aspects related to ice fishing, but also the pressures of ice fishing on the fish stocks of Lake Peipsi. More specifically, this study aimed to (1) clarify the incentives for and expenses involved in ice fishing, (2) assess the quantities and species composition of fish landed by recreational ice fishing, and (3) estimate the possible impact of year-to-year variability in ice conditions on the intensity of ice fishing. Therefore, we integrated a sociological analysis with a quantification of fish caught by ice fishermen on Lake Peipsi.

STUDY AREA

Lake Peipsi (57°51′–59°01′N; 26°57′–28°10′E) is the largest transboundary lake in Europe, shared by the Republic of Estonia (44%) and the Russian Federation (56%). By its surface area (3555 km^2), Peipsi is the fourth largest lake in Europe after lakes Ladoga, Onego, and Vänern. The lake is shallow with a mean water depth of 7.1 m and a maximum depth of 15.3 m (Jaani, 2001).

Lake Peipsi consists of three parts. The northern part, Lake Peipsi *sensu stricto* (*s.s.*), is the largest (2611 km^2) and has the greatest mean depth (8.3 m). The southern part, Lake Pihkva, measures 708 km^2 and is on average 3.8 m deep. The strait between them is known as Lake Lämmijärv (236 km^2; mean depth 2.6 m). According to the OECD (1982) classification scheme, Lake Peipsi *s.s.* can be characterized as a eutrophic water body, while the trophic status of Lake Lämmijärv is close to hypertrophic and Lake Pihkva is a hypertrophic basin (Kangur and Möls, 2008). As in many shallow lakes in lowland areas, eutrophication continues to be the most serious environmental problem for this lake, influencing fish habitats and the whole lake ecosystem.

Situated in the northern region of the temperate zone, Lake Peipsi experiences variable weather conditions. The lake is, as a rule, covered with ice from December till April; however, the start dates of ice-cover and ice-off have been highly variable during recent years. The near-bottom water frequently suffers from oxygen deficiency when the lake is covered with ice.

With respect to its social significance, Lake Peipsi is a popular recreational area. Furthermore, fish stocks of the lake have been remarkably high, which makes it economically important for both commercial and recreational fisheries. However, it has been observed that fish catches have significantly decreased since the 1930s (Kangur et al., 2007, 2008). According to the Estonian state fishery statistics, from 2006 to 2012 most of the commercial catches were comprised of Eurasian perch, *Perca fluviatilis* L. (34%); pikeperch, *Sander lucioperca* (L.) (32%); common bream, *Abramis brama* (L.) (20%); and roach, *Rutilus rutilus* (L.) (9%) (Table 1). Less abundant commercial fish species represented were Northern pike, *Esox lucius* L.; burbot, *Lota lota* (L.); ruffe, *Gymnocephalus cernuus* (L.); and Peipsi whitefish, *Coregonus lavaretus maraenoides* Poljakow.

Table 1. Commercial catches of fish (tonnes), proportions (%) of individual species in the total catch, and fish yield (kg per hectare) on the Estonian side of Lake Peipsi in 2006–2012. Data source: Estonian state fishery statistics

Fish species	2006	2007	2008	2009	2010	2011	2012	Average 2006–2012		Mean, kg per ha
	tonnes							tonnes	%	
Pikeperch	1081	899	619	652	508	672	646	725.3	31.5	4.6
Perch	492	345	744	804	1205	756	1061	772.4	33.5	4.9
Bream	324	396	367	531	435	578	577	458.3	19.8	2.9
Roach	218	202	202	187	196	225	207	205.3	8.8	1.3
Pike	100	113	55	65	46	100	153	90.3	3.9	0.6
Ruffe	8	16	63	74	40	8	2	30.2	1.3	0.2
Burbot	18	33	25	27	26	30	21	26	1.1	0.2
Whitefish	0.6	2.0	0.8	2.7	0.5	0.2	0.3	1	0.04	0.01
Others	84	1.7	0.3	0.7	4.5	0.6	3.7	1.6	0.06	0.01
Total	2326	2008	2076	2344	2461	2370	2671	2310	100	14.7

MATERIALS AND METHODS

This pilot study combined sociological and ecological research methods to evaluate the position of winter angling and its possible effects on the fish stocks of Lake Peipsi. This paper is based on data collected from the Estonian side of the lake only.

In order to obtain an understanding about factors such as the duration of individual fishing trips, the incentives of the anglers, as well as the size and composition of their catches, ice fishermen were approached directly on the lake or on the shore. Structured interviews conducted with the ice fishermen were combined with a rough assessment of the quantity and species composition of the landed fish at the fishing site. Structured personal interviews are a recommended strategy when sensitive issues (e.g. unofficial gains) are studied (Creswell, 2009). According to the Estonian legislation, selling recreational catch is prohibited (Fishing Act, 2010).

Altogether six expeditions were undertaken from February to April in 2006, 2007, and 2009 in different locations across the shore of Lake Peipsi. A total of 67 random fishermen were interviewed in person in the Estonian or Russian language. The structured anonymous interviews were carried out according to the following plan. The first questions focused on the anglers' estimations of the weight and species compositions of their average daily catches. The second set of questions focused on the income that ice fishing may have generated and estimations of expenses incurred (e.g. travel, food, accommodation, and equipment). The third set concerned the individual's incentives for ice fishing trips. The interviewed anglers rated on a three-point scale (unimportant, important, or very important) factors such as the significance of the income generated from ice fishing, the additional food gained, the enjoyment of nature,

recreational value, the excitement associated with catching fish, and the enjoyment of the company of other anglers. The final set focused on the socioeconomic backgrounds of the fishermen: their age, employment, educational background, and place of residence.

Only a few anglers allowed more precise identification and measurements of the fish they had caught during the day. The total catches of the day were analysed in the evening when anglers returned from the lake to their cars, buses, or overnight stops. The landings of 63 fishermen were analysed in different locations of lakes Peipsi *s.s.* and Lämmijärv in winters 2006, 2007, and 2009. Their catch consisted of 233 specimens of perch, 614 roach, 241 ruffe, and 3 bream. Analysis of the catch included measuring the standard length of each individual fish to an accuracy of 1 mm and the total weight to an accuracy of 0.1 g.

In order to gain a measure of the intensity of winter angling, information was collected from the Eastern Region of the Estonian Police and Border Guard Board. All people going to the border lake are obliged to register at the Border Guard cordon, giving details of their vehicle and the number of fishermen. Although, some ice fishermen drive onto the lake without registering, the number of people registered daily by the Estonian Border Guard for winter angling on Lake Peipsi constituted the main data set used in this study for assessing the intensity of winter angling on the lake.

The total angling harvest for a year was assessed using the duration of the ice-covered period from the winters of 2004/2005 to 2011/2012, the number of anglers registered by the Border Guard, and the average quantity of fish caught by an angler during one fishing day (using data of daily catches from 2006, 2007, and 2009). Additionally, in order to gain an overview of the landings and potential pressure of different fishery sectors on the fish stocks of Lake Peipsi, we compared the quantity of fish we estimated were landed by winter angling with the commercial fisheries statistics routinely collected by the Estonian state authorities.

Ice conditions are considered to be the key limiting factor for ice fishing. Fishermen are permitted to fish on the lake only when the ice is thick (at least 14 cm) and sufficiently strong for safe movement on the ice. In this study, data on the ice conditions were gathered in order to analyse the year-by-year duration of the period when ice fishing was possible. Daily values of water temperature of Lake Peipsi in 2004–2012 measured at the Mustvee hydrometric station (58°50′N, 26°57′E) were obtained from the Institute of Meteorology and Hydrology of the Estonian Ministry of Environment.

A linear regression model was used to evaluate relations between the duration of the ice-cover period and the quantity of perch, ruffe, and roach caught by recreational ice fishermen in one ice-fishing season in the Estonian part of Lake Peipsi from the winters of 2004/2005 to 2011/2012. In the analysis, the daily number of anglers was taken into account. The model was used to predict the total catches in varying ice conditions from 2004/2005 to 2011/2012. A significance level of 5% was used. Analyses were carried out using procedures provided by program R version 3.0.0 (R Development Core Team, 2013).

RESULTS

Socioeconomic factors associated with ice fishing

Backgrounds of the fishermen

The ice fishermen interviewed in our study were mainly middle-aged (mean age 40.3 years, range from 14 to 68 years) men (93%). Two thirds of the anglers had a secondary school level of education and worked as mid-level specialists. The rest of the anglers had either higher or primary school education and had many different vocations. We could distinguish locals (living in the vicinity of the lake shore) and tourists (driving more than 50 km in order to get to the lake shore). The main difference between these two groups was that normally tourists stayed overnight close to the lake, and their activities tended to be confined to weekends. Other two types distinguished were ice fishermen with economic incentives and those with no economic interests.

Local people constituted approximately 20% of the ice anglers. Some locals mentioned economic benefits from the fishing while others claimed to fish mainly for fun. Even though selling fish on the market in Estonia requires a formal permit, some anglers (about 8% of the total questioned) admitted that they earned money by selling their fish catches to members of the community or someone collecting caught fish. The anglers that claimed economic benefits from fishing were mostly retired persons, schoolchildren with spare afternoons, unemployed people, or those employed only seasonally (e.g. fishing, horticulture). The mean daily income from winter fishing was estimated to be 20 €. This is about 7% of the minimal monthly wages or of the average Estonian old-age pension. The group of locals who did not claim any economic benefits from fishing tended to be living in towns close to the lake. Interviews showed that for those locals, ice fishing was a way of doing something purposeful while relaxing.

Of the ice fishermen (tourists) 80% had travelled long distances (mean 210 km). The large mean distance travelled by fish tourists was due to the significant number of Latvians that cross the border to reach Lake Peipsi. Altogether, Latvian nationals formed 46% of the ice anglers on the lake. Ice-fishing Latvians tended to be in groups of friends, co-workers, and families. The Latvian groups were distinguished by their generally good level of organization. They mostly travelled together in cars or in rented buses and they stayed overnight either in local unofficial housing or in the cars/buses in which they were travelling. The good organization reflected the fact that they were attempting to keep travel expenses low (ranging from 6.4 to 12.8 € per person per night).

The remainder of the ‘tourist’ group – people from longer distances than 50 km – generally came for only one day of ice fishing. These were generally Estonians, usually alone and only rarely in groups. They claimed that they were not looking for any financial benefits from fishing. As with the other groups, the interviews showed that their main incentive for ice fishing was to find relaxation from everyday worries. These tourist-anglers often had higher education levels.

Expenses and benefits involved in ice fishing

In Estonia, everyone is allowed to fish free of charge using a simple hand line between sunrise and sunset on a body of water owned by the state (Fishing Act, 2010). Recreational fishing with up to three hook gear is permitted on payment of a fee for the right to fish for recreational purposes. The official fishing fee is quite low; the fees are as follows: one day – 0.95 €; up to 1 week – 1.59 €; up to 6 months – 7.66 €; and up to 12 months – 11.5 € (Fishing Act, 2010; last amended 18.11.2012).

As for other expenses, most of the anglers used special ice fishing rods. Mainly large (up to 3-cm long) red-colour chironomid midge (e.g. *Chironomus* spp.) larvae were used as bait on the hooks; the larvae necessary for one fishing trip cost about 1 €. In many cases, locals used specific motorized vehicles (self-made derivatives of tractors, ATVs, or motorized sledges) to move about on the ice. They also often had plastic tents to gain cover from the icy wind. Based on the interview data, the average money spent on equipment by an ice fisherman was 64 € per year. As for the additional costs of tourist fishermen, travel expenses were on average 7 € per return trip, food costs were 3.2 € per day, and accommodation was 4.2 € per night. The anglers interviewed considered ice fishing a relatively expensive hobby.

Even though recreational fishermen were not permitted to sell the caught fish, the interviews demonstrated that ice anglers gained some economic benefits from fishing. The caught fish were used mainly for domestic consumption, or for exchange in a barter economy. Fishermen hinted that some of their fish were illegally sold to someone collecting caught fish from the lake. Perch was the most valuable species for the anglers to sell or exchange: the selling price of perch ranged from 2 to 3 € per kilo.

Ice fishermen were able to assess a variety of factors associated with winter fishing as either unimportant, important, or very important. For example, a third of the fishermen considered fishing important or very important in terms of a gourmet addition to their everyday food. Yet enjoying nature and the company of others, as well as the excitement of catching fish, were estimated as being more than twice as important as any food additions (Fig. 1). Overall, the most important driver for the fishermen appeared to be relaxation from their everyday worries.

In terms of wider social benefits, through offering local unofficial accommodation, people living in the villages near the lake have had an opportunity to earn some additional income. The prices for one night accommodation varied generally between 3.2 and 3.9 €, and in a few cases reached 6.4 € per person. Considering that Latvians were mostly in groups of four or five, the income from housing these groups could have been a substantial addition to any other sources of income. As most of the winter anglers brought their own food, they did not spend much money locally on food.

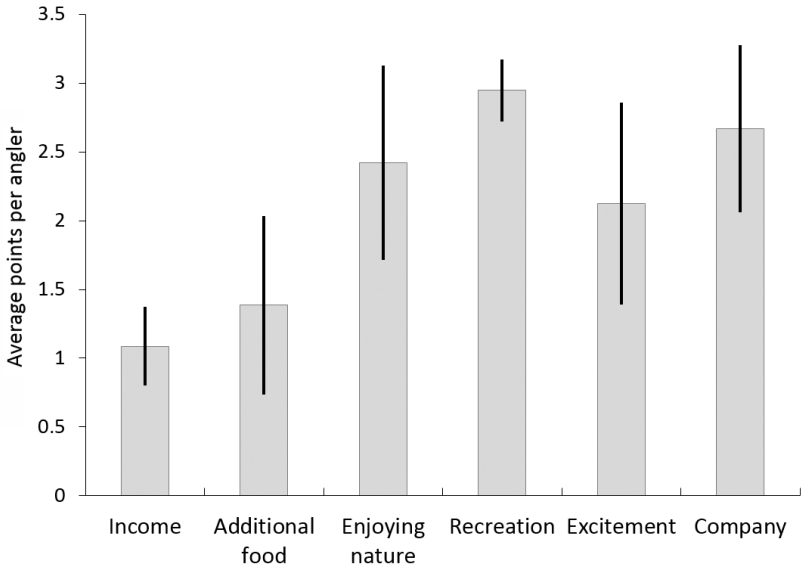

Fig. 1. Relative importance of incentives (±SD) for ice fishing based on the average points given by 67 respondents (scale from 1 to 3).

Dependence of recreational fishing on ice cover

As data from the most recent decade have shown, the start date for winter angling, as well as the duration of the ice-cover period, may vary considerably from year to year (Fig. 2). Our results indicate that the number of fishermen is the highest during the weekends (Fig. 3). The most popular periods for ice fishing are the last weeks of the ice-cover period, the end of February and the beginning of March (Fig. 3). At that time, due to longer daylight hours and warmer temperatures, it is more pleasant to stay on the lake as compared with conditions in December and January; this was also emphasized in the interviews. According to our observations, at the end of winter, many of ice fishermen gather around the cracks in the ice, where the water is more oxygenated and thus more attractive for fish.

The ice formation and ice-off dates vary greatly from year to year on Lake Peipsi, and thus the ice fishing period may last from a few days up to four months (Fig. 2). For example, looking at all the winters between 2004/2005 and 2008/2009, the ice cover period varied between 15 and 135 days. The first ice, which develops near the coast, is usually formed in early November; in some years, the ice-cover period may last even to the beginning of May. Winter 2007/2008 was the warmest ever recorded during the whole period of measurements (142 years) in Estonia (Jaagus, 2008). That winter, according to measurements by the Estonian Institute of Hydrology and Meteorology, the ice break-up started as early as 19 January 2008. Furthermore, the thickness of the ice varies from year to year, and this determines the possibility of moving across the ice. The ice can reach 75 cm or more in thickness in some years.

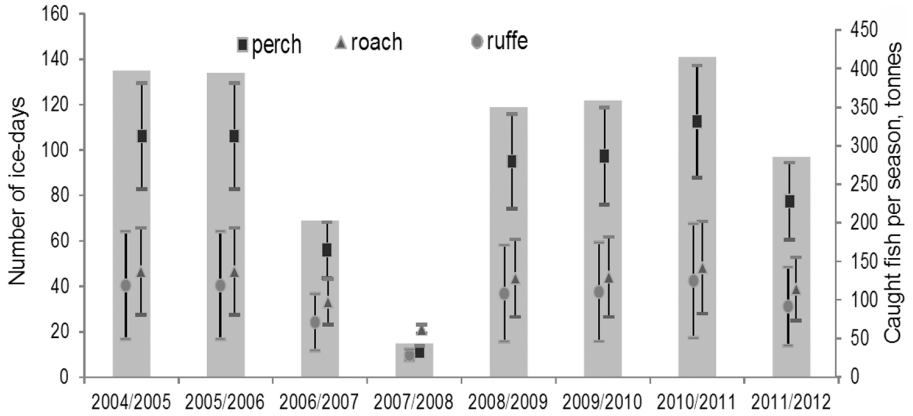

Fig. 2. Number of ice-days from the winters of 2004/2005 to 2011/2012 and recreational ice-fishing catches (±SD) of perch, roach, and ruffe per season on the Estonian side of Lake Peipsi.

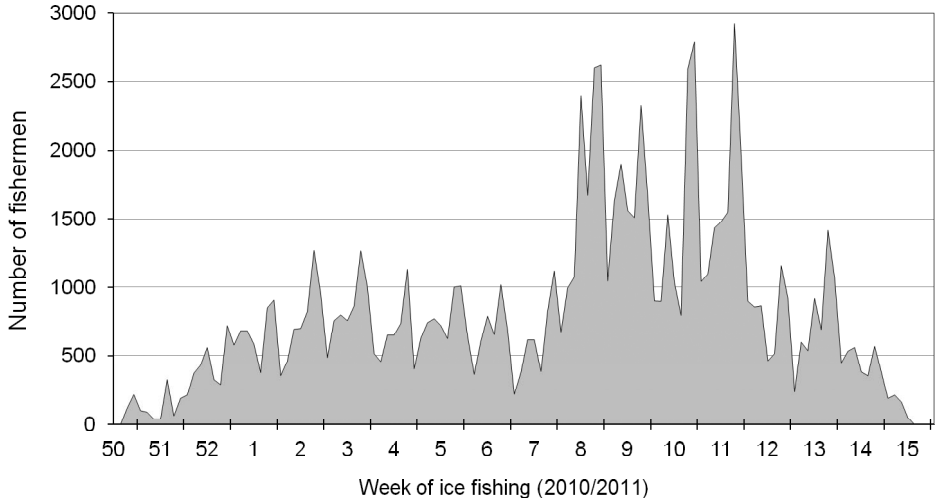

Fig. 3. Daily number of recreational ice fishermen registered by the Estonian Border Guard on Lake Peipsi in winter 2010/2011.

Winter angling and possible pressures on fish stocks

The number of fishermen

According to this study, during winter weekends the maximum number of recreational fishermen may reach ~3000 on Estonian part of the ice-covered Lake Peipsi. For example, over the period of 22 December 2009 to 25 January 2010 the Border Guard registered approximately 8000 anglers who had gone further than 1 km from the lake shore (Fig. 4). However, most likely the actual number was even higher than this. Despite the threat of fines (up to 800 €), according to

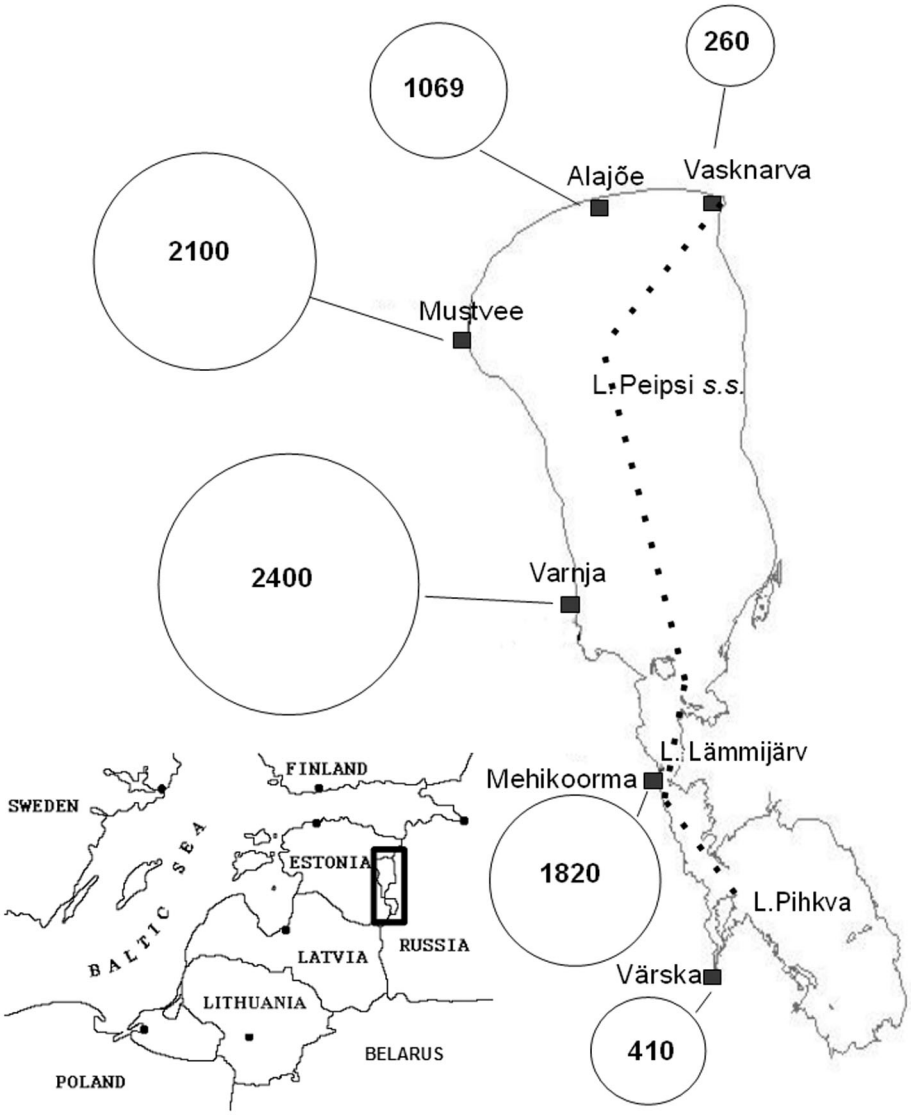

Fig. 4. Number of ice fishermen registered at Border Guard cordons from 22 December 2009 to 25 January 2010 on the Estonian side of Lake Peipsi. The border is indicated by a dotted line on the lake.

estimates by the Border Guard, unregistered fishermen may add an additional 30% to the numbers registered. Based on official statistics, on average there are ~700 fishermen on weekdays and ~1750 fishermen at weekends on the ice of Lake Peipsi. Taking into account the numbers of ice-days per year, we estimated the numbers of fishermen-days to be approximately 133 000, 132 300, 70 000, 14 000, 119 000, 122 000, 141 000, and 97 000 in the winters of 2004/2005,

2005/2006, 2006/2007, 2007/2008, 2008/2009, 2009/2010, 2010/2011, and 2011/2012, respectively.

Fishes caught and the size of catches

The daily catch of a fisherman, who used a fishing rod, varied considerably. For example, on 18 February 2007 the daily catch of 34 anglers varied between 0 and 6.4 kg (Fig. 5). According to the anglers' own approximations of their daily catches, given in the personal interviews, and the direct measurements of the catches, each fisherman caught on average 4±2 (±SD) kg of fish per day. In the catch, the main fish species were perch, roach, and ruffe, constituting up to 59%, 20%, and 18% by weight, respectively, of the total catch. Pikeperch and pike were less frequently caught. The ruffe caught were usually not taken from the ice. Perch caught were in the size range 6–30 cm (average ±SD: 16.4±3.5), ruffe 5–15 cm (9.4±1.6 cm), and roach 10–29 cm (18.5±3.1) (Fig. 6).

To assess the pressure of recreational ice fishing on fish stocks, the species composition and the size of daily catches of anglers, the number of ice-days, and the number of fishermen need to be taken into account. According to our rough estimations based on average daily catch per angler equal to 4±2 kg, the total catches of winter anglers constituted approximately 532±68, 528±65, 280±35, 56±7, 476±61, 468±62, 541±72, and 372±49 tonnes per season (3.4, 3.4, 1.8, 0.4, 3.0, 2.9, 3.5, and 2.4 kg per hectare, respectively) in 2004/2005, 2005/2006, 2006/2007, 2007/2008, 2008/2009, 2009/2010, 2010/2011, and 2011/2012, respectively. Thus, depending on the number of ice-days (from 15 to 141), between ~50 and ~541 tonnes of perch, roach, and ruffe could be landed during a

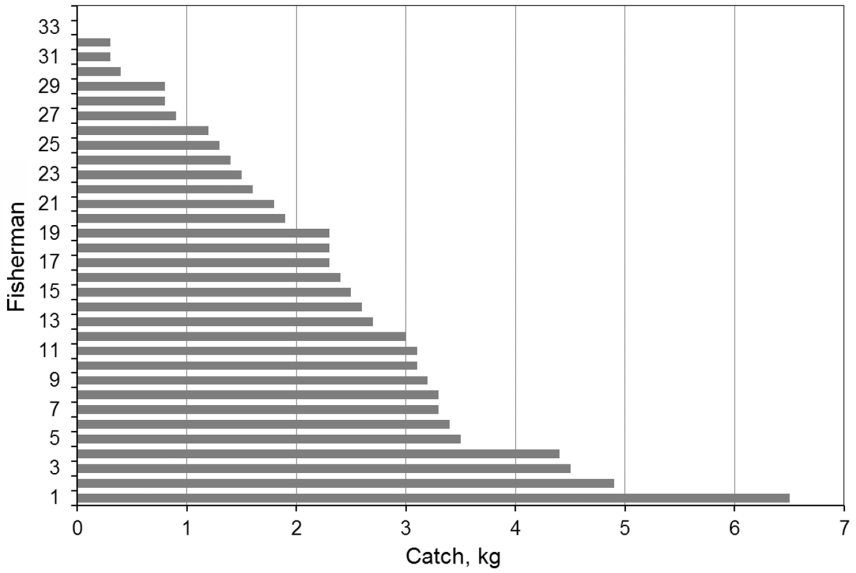

Fig. 5. Variations in daily catch of fishermen (34 anglers sampled) on 18 February 2007 on Lake Peipsi. The results are arranged based on the catch from the most successful fisherman to the least.

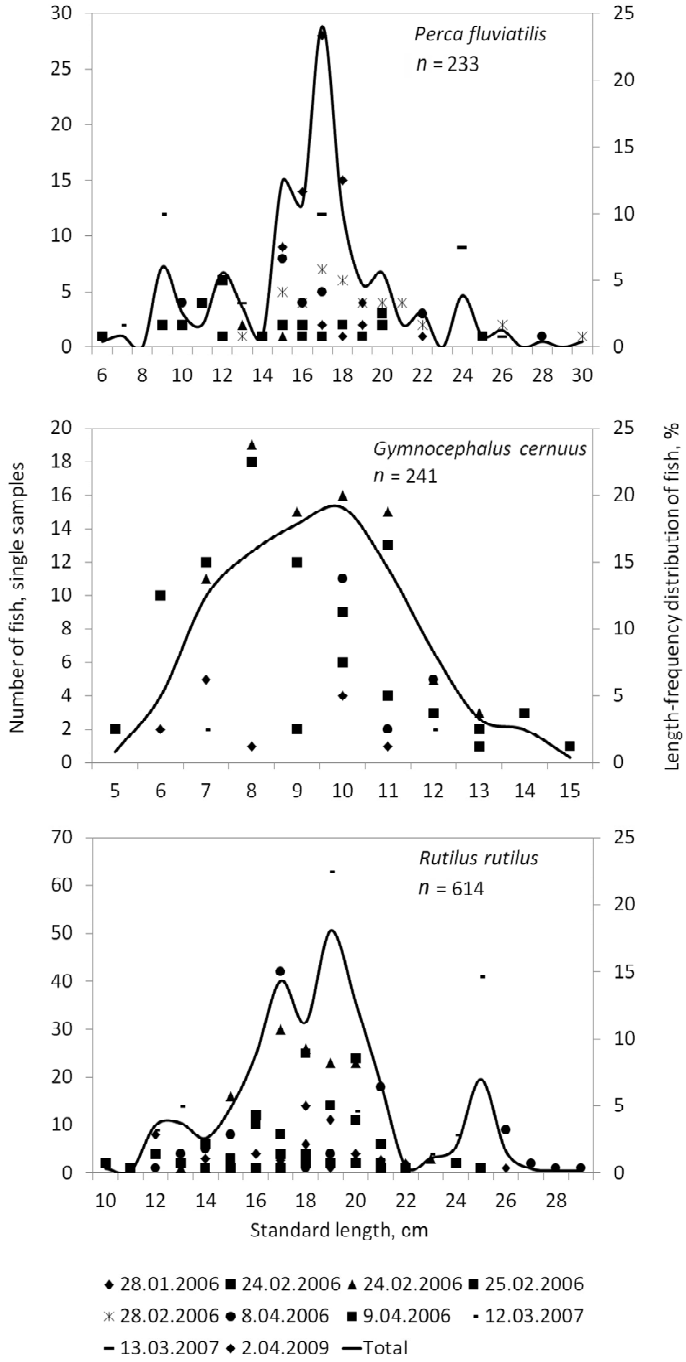

Fig. 6. The length–frequency distribution of *Perca fluviatilis*, *Gymnocephalus cernuus*, and *Rutilus rutilus* caught by different ice fishermen on the Estonian side of Lake Peipsi in winters 2006, 2007, and 2009. Fish caught by any one fisherman are represented by specific symbols. The line demonstrates the moving average length–frequency distribution (%) of all measured fish.

season by the recreational ice fishermen from the Estonian side of Lake Peipsi. Over the winters with a long ice-cover period anglers may fish out approximately 40% of the total annual catch of perch, roach, and ruffe in the lake. Hence, in the case of the long ice-cover years such as 2004/2005 and 2005/2006, winter angling catches of perch, roach, and ruffe were probably sizeable and may have constituted up to 50–60% of the weight of commercial catches of these target fish species during the same years (Table 1). In contrast, in the case of exceptionally mild winters, the weight of perch, roach, and ruffe caught during winter angling might constitute only 5% of the weight of commercial catches for these target species.

DISCUSSION

Recent studies (e.g. Arlinghaus et al., 2013; Hunt et al., 2013) indicate that instead of narrowly focusing on biological overfishing or on angler behaviour, looking at the feedbacks between the interacting human and ecological components gives a fuller understanding of the complex dynamics of recreational fisheries. Our study links sociological and ecological research to understand the human factors involved in ice angling and includes any climatic factors limiting this activity and the consequent pressures on fish stocks of Lake Peipsi. The study showed that climatic conditions affected the numbers of fishers.

The present study indicated that up to 3000 fishermen from Estonia and abroad may fish on the Estonian side of the lake in any one day. As also noted by research in other regions (e.g. Burger, 1998; Arlinghaus, 2004; Hickley and Chare, 2004; Toivonen et al., 2004; Arlinghaus et al., 2013), angling provides a major recreational activity, which offers great social and economic benefits, and this is also the case in Lake Peipsi. Our sociological analysis revealed that pleasure was a key reason why people wished to indulge in recreational fishing. Enjoying nature, the feeling of excitement from catching fish, and the company of other fishermen were estimated to be more than twice as important to anglers as other benefits (e.g. the financial or food gain from ice fishing). However, the interviews revealed that winter angling was an unofficial source of economic benefit in the coastal villages with few employment alternatives. Even though only 8% of the fishermen questioned admitted to some financial gain from ice fishing, in reality, fish caught is used in exchange for other services or sold unofficially.

According to this study, a third of the anglers on Lake Peipsi were Estonian tourists and approximately half were Latvian tourists. In general, recreational inland fishing is recognized to have considerable socioeconomic benefits not only for the individuals directly participating but also for others in both the local and wider communities (Peirson et al., 2001; Arlinghaus et al., 2002; Aprahamian et al., 2010). Recreational angling may contribute significantly to a local tourism industry (Winfield and Durie, 2004; Aas, 2008). However, the Peipsi case study

showed that winter anglers do not leave much money to local tourism and catering businesses, which is perhaps due to the relatively poor tourism infrastructure on the lake shore. This could be an area of further analysis.

In addition to its importance from social and economic standpoints, recreational ice fishing has the potential for negative impacts on fish stocks (Cooke and Cowx, 2004; Arlinghaus, 2006; Aas, 2008; Donaldson et al., 2008; Granek et al., 2008). The harvest from recreational fishing has been estimated at about 12% of the worldwide take for all fish (Cooke and Cowx, 2004). Our study on Lake Peipsi showed that the daily catch varied considerably between individual ice anglers. It also indicated a large inter-annual variation in landings of winter angling, depending principally on ice conditions and the number of ice-days. In the case of favourable ice fishing conditions (long ice cover periods), anglers may fish out approximately 40% of the total catch of perch, roach, and ruffe in the lake. Furthermore, it was estimated that 59% of the catch of ice fishermen was perch, and winter angling can be responsible for up to a third of the total catch of perch in Lake Peipsi. However, commercial catches of the main target species (perch, roach) are stable or even increasing in Lake Peipsi (Table 1). Moreover, in recent years perch has become the most abundant species in commercial catches, although pikeperch dominated some years ago (Ginter, 2012; Kangur et al., 2013). According to the recent fish stocks assessment, the stocks of perch and roach are in a good state in Lake Peipsi (Kalavarude uuringud Peipsi, Lämmi- ja Pihkva järves, 2013). Thus, although the landings of winter angling can be considerable, especially in years with a large number of ice-cover days, the pressure from ice fishing is smaller than the pressure from active commercial fisheries (e.g. bottom seining) (Kangur et al., 2007, 2013).

The possible pressure of winter angling on fish stocks may decline as the ice-cover period of northern lakes is projected to decrease (Shuter et al., 2013). Our case study supports the statements about climate change effects on recreational fishing. As climate change may result in considerable changes in northern European freshwater fish populations and fisheries (Lehtonen, 1996; Jeppessen et al., 2010), in the future the target species of recreational fishing might change.

The deficiencies in global monitoring and compiling of statistics on recreational fishing participation and harvest have limited our ability to understand the magnitude of this fishing sector (Post et al., 2002; Cooke and Cowx, 2004, 2006). This study showed the importance of a proper assessment of winter angling that, due to its diffuse nature, has been previously largely unaccounted for. Oral interviews combined with an assessment of the quantities of fish landed and data on the ice conditions, as used in this study, may give valuable information about the (sometimes sensitive) socioeconomic aspects of ice fishing as well as its impact on the fish stocks of northern lakes. However, potential biases in the interview results may occur, especially due to the delicateness of respondents' representations of the sizes of their catches or the unofficial financial gain from the fish landed. The current investigation, although based on a relatively small sample of ice fishermen, was a first step towards analysing the possible effects of winter angling on the fish stocks of Lake Peipsi. In further studies, the impact of angling

on the Russian side of the lake should be assessed. Further assessments of the levels of recreational fishing pressure on specific fish species would give an input for better regulation of fisheries.

CONCLUSIONS

The analysis in this study combined interviews with ice fishermen on Lake Peipsi and the assessments of their landings to clarify the socioeconomic importance of ice fishing and the possible pressures on fish stocks over years with different ice conditions. The study suggests that instead of commercial fisheries, where the benefits tend to concentrate in a few larger companies, promoting ice fishing (as well as recreational fisheries in general) could benefit more people in this deprived region at Lake Peipsi. Recreational fisheries help to maintain the traditional fisheries-dependent lifestyle and to ensure that the services offered by the ecosystem of Lake Peipsi reach also socioeconomically less secured (retired and unemployed) persons. The improvement of tourism infrastructure (e.g. transportation to the fishing sites on the lake, housing, etc.) would promote recreational fisheries as well as create more local employment opportunities.

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