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River Lamprey *Lampetra fluviatilis* (L.) Fishing in the Area around the Baltic Sea

ABSTRACT The river lamprey (*Lampetra fluviatilis*) was previously caught in large numbers in Europe when migrating up in the rivers during autumn for spawning the next spring. It was used as food and was also used as bait in cod fishing in the North Sea. Today the river lamprey has decreased in numbers over much of it's distribution range, but in the Baltic Sea area, the population is still at a fairly good level, and fishing for lampreys as food (a tradition going back to at least the fifteenth century) is still going on in northern Swedish and Finnish rivers, as well as in coastal rivers in the southern Baltic Sea area. In this article the current situation as regards river lamprey fishing in Sweden, Finland, Latvia and, to some extent, Estonia, Lithuania and Poland is presented.

KEYWORDS river lamprey, *Lampetra fluviatilis* (L.), Baltic Sea area, lamprey fishing, lamprey fishing gears

Introduction

The river lamprey has a distribution range from Southern Norway, into the Baltic Sea, and further along the Continental coast, around the British Isles and into the Mediterranean Sea, where a population still may exist along the west coast of Italy (Imam *et al.* 1958; Gaygalas & Matskev-

ichyus 1968; Hardisty 1986a; Hardisty 1986b; Maitland 2003; Saat *et al.* 2003; Igoe *et al.* 2004; Freyhof & Kottelat 2008; Thiel *et al.* 2009). It is also present in some large lakes, so called *land-locked populations*, for example in the lakes Vänern and Vättern in Sweden (Tjernberg & Svensson (eds.) 2007), and in Finland in large lakes of the watercourses of the rivers Vuoksi, Kymijoki and Kokemäenjoki (Tuuniainen *et al.* 1980). Populations of many anadromous fish, including lampreys, have declined in European waters since the mid-twentieth century (Renaud 1997; Kelly & King 2001; Hardisty 2006).

Fishing for river lamprey has a long tradition in Europe. It has been used for consumption in England and on the Continent, and was previously also used as bait for cod fishing on a large scale at Dogger Bank by Dutch fishermen (Lanzing 1959; Hardisty 1986a). The tradition of using lamprey for food goes back at least to Roman times (Root 1978), although then it could be confused with the sea lamprey (*Petromyzon marinus*). However, the fishing in such major rivers as the Rhine, the Weser, the Elbe, the Oder and the Vistula decreased dramatically or ceased totally in the twentieth century, as in many other rivers in heavily industrialized areas (Lanzing 1959; Hardisty 1986a). The reason is exploitation of the rivers for many different purposes (e.g. building hydroelectric power plants), but water pollution has also played a role.

Today it is mainly in the Baltic Sea area that the tradition of river lamprey fishing for food consumption is concentrated. Lamprey fishing still exists in Northern Sweden and Northern Finland along the coast of the Gulf of Bothnia, and in the Baltic States and Poland along the coast of the Gulf of Finland and the Baltic Proper. Here too, however, many of the large rivers are regulated and utilized for hydroelectric purposes, where the dams prevent the river lampreys from reaching their spawning grounds further upstream in their migration from the sea (Witkowski 1992; Hardisty 2006; Ljunggren 2006; Soler & Nathanson 2006; Witkowski 2010; Aronsuu 2011a; Aronsuu 2011c).

This article deals with the present situation for the river lamprey in the Baltic Sea area and reviews fishing for lampreys, particularly the situation in Sweden, but also in Finland and Latvia, and to some extent in Estonia and further south in the Baltic Sea area. In a subsequent article, the focus will be on the fishing gear types used for lamprey fishing in the same region.

Study Area, Material and Methods

In 2010 twelwe rivers in Sweden where river lamprey fishing is still performed were visited in the autumn fishing season. Nine lamprey rivers were visited in Finland and four lamprey rivers in Latvia. In the autumn of 2011 the same rivers were revisited, and along the Swedish coast 15 river lam-

prey fishermen were interviewed about their fishing activities, based upon a questionnaire with 58 questions about the lamprey fishing in the rivers where they were working as fishermen. Because official statistics about lamprey fishing are not collected in Sweden any longer, each fisherman was asked to estimate the total average catch of lampreys in their respective rivers, as well as the number of fishermen and the number of gears they use. If the answers differed among different fishermen, their figures were averaged. Of course the figures cannot be exact, except in rivers where the only catches are made in connection with a hydroelectric plant dam, where personnel from the hydroelectric plant or related fish farm are responsible for the fishing. Individual fishermen are not required to report their catches to any authorities. However, the number of fishermen in each lamprey river is low, and they know each other, so they have fairly good information about the number of fishermen, catches, and gears. Each interview was performed at personal meetings and during the same year, thus avoiding comparisons of catches between rivers that could appear between years.

On the Finnish side of the Gulf of Bothnia two lamprey fishermen were interviewed based on the questionnaire and information from seven more persons with knowledge about the lamprey fishing provided information, but there the questionnaire was not used for linguistic reasons. On the Finnish side there is also information available from environmental and fishery authorities, and the figures presented about lamprey catches are mainly based on published data.

In Latvia the fishing of river lampreys was studied in rivers emptying in the Gulf of Riga in the eastern part of the country and in rivers emptying into the Baltic Proper in the western part in 2010 and 2011 during the autumn fishing period. Besides interviews with local fishermen, information was collected from people who processed lampreys, from the heads of the museums of Salacgriva and Daugava, from representatives at the Fisheries Department and from information about lamprey fishing in Latvian literature and official statistics. In Estonia lamprey fishing was studied in the River Pärnu, emptying into the Gulf of Riga, in the autumn of 2011. Information was further collected from experts at the University of Tartu, and from Estonian literature about river lamprey fishing. Data about lamprey fishing in Lithuania, Poland and Germany is based on official statistics and published information.

Biology

The river lamprey has an eel-shaped body form. Instead of bones, they have cartilage (Maitland 2003). The lamprey belongs to the family *Petromyzon-*

tidae (Kullander 2011) and is characterized by a round sucker-like mouth with which it can attach to for example a stone in the river (compare Fig. 1) or to a fish during the parasitic growth period in the sea. In the mouth and on the tongue they have teeth with which they rasp the surface of attacked fish (e.g. Maitland 2003).

The larvae spend four to six years in the bottom sediment in a river, and when they are about 9–13 centimetres long they metamorphose to the adult phase (e.g. Fogelin 1972; Tuunainen *et al.* 1980; Sjöberg 1980; Valtonen 1986). They then actively or passively go with the water flow to the sea, where they live a parasitic life on herring (*Clupea harengus*), sprat (*Spattus sprattus*) and other fish species (Eglite 1958b; Hardisty 1986a). When they enter the rivers again, mainly in the autumn after a further half a year or more (Aronsuu 2011c), they have reached a length of about 30 centimetres and a weight of about 50 grams. However, there are substantial geographic and seasonal variations (Witkowski & Kuszewski 1995; Bartel *et al.* 2010). In Gdansk Bay in Poland, for example, the mean weight is as much as 149.5 grams, and there is a gradient with increasing length and weight from north to southwest (Bartel *et al.* 2010). The river lampreys migrate upstream the river during the night. They spend the winter in the river without eating, and after the spawning in spring when the water temperature reaches about 10°C, they die (e.g. Maitland 2003, Hardisty 2006).

In the Baltic Sea area there exist three species of lampreys, the river lamprey, the sea lamprey (*Petromyzon marinus*), and the brook lamprey (*Lampetra planeri*). It is the river lamprey that is fished for food. The brook lamprey is too small to utilize as food, and the sea lamprey is too rare in the region, but it has been fished for further west on the Continent. For detailed information about the biology of lampreys see e.g. Hardisty & Potter (eds.) 1971; Maitland 1980; Maitland 2003; Hardisty 1986a; Hardisty 1986b; Hardisty 2006.

Fishing for Lampreys

The river lamprey is an anadromous species, that is, it spends some time in the sea while it grows to adulthood, but migrates up in the rivers for spawning. In all the bigger rivers emptying into the Baltic Sea region, that is, the Baltic Proper in the south, the Gulf of Finland to the east and the Gulf of Bothnia to the north, fishing for anadromous fish species has been important. At least in the northern rivers, the most important species has been the salmon (*Salmo salar*), along with the whitefish (*Coregonus lavaretus*) and sea trout (*Salmo trutta*). However, the river lamprey fishing has also been important as shown by the fact that even as far back as the sixteenth century it was an object of official taxation in Sweden and Finland (Nordberg 1977; Storå 1978).

Lamprey Fishing in Sweden

In Sweden, river lamprey fishing has been performed in most of the rivers from the River Dalälven and northwards. The catches have been in the order of 10 tons, that is, approximately 200,000 fish per year for example in the River Dalälven and in the River Umeälven (Berg 1960; Sjöberg 1980; Öhman 2000), but the situation worsened in the middle and late twentieth century because of construction of hydroelectric power plants in many of the main rivers (Soler & Nathanson 2006). Nowadays there are hardly any professional lamprey fishermen. Those who still perform lamprey fishing are mostly elderly men who fish as a leisure-time activity and to keep the tradition alive, and much of the catches are used for private consumption by family and neighbours. Only in five of the Swedish rivers are the catches of lampreys of such a size that they could be of some economic importance for the fishermen.

In a 2006 inventory, Soler and Nathanson (2006) concluded that lamprey fishing was performed in 25 rivers shortly after 1950, but had been reduced to 14 in the early 2000s. Among them, the following rivers had the most important catches: the River Ljusnan, the River Öreälven, the River Rickleån, the River Kalixälven and the River Torneälven (Swedish side). Approximately 50 persons were active as lamprey fishermen, and they used about 700 traps. The total catch per year during the period 1993–2003 was estimated to be approximately between 11,000 and 19,000 kilos. Assuming that the mean weight of a single lamprey is 50 grams in the region, the total number of the mean catch is between 220,000 and 380,000 lampreys. It is striking to compare these catches to the times before the rivers were exploited for hydroelectric power plants. For example, the mean catch was greater than nine tons in the River Dalälven alone during the period 1937–1948, and in the River Umeälven further north the mean catch was almost ten tons per year corresponding to about 200,000 lampreys during the period 1942–1951 (Berg 1960; Sjöberg 1980). These two rivers are just two of many which were exploited for power plants, where dams prevented the lampreys from reaching their spawning areas further upstream. Consequently, there has been a sharp decrease in the lamprey fishing during the last few decades, and in many rivers the lamprey fishing has ceased. There are no general restrictions against or rules for lamprey fishing in Sweden. It is up to the organizations or persons who have the fishing rights to decide about the fishing.

In 2010 and 2011 lamprey fishing was still performed in about 14 rivers, and fishermen along the main rivers estimated the total number of persons fishing for lampreys to be around 50–55, that is, similar figures as Soler and Nathanson (2006) presented for the period 1993–2003. The number of traps

in 2010 and 2011 was around 420 and the total catch was estimated to be about 7,500 kilos, or approximately 150,000 lampreys. Thus, the number of traps in use is much lower, and the total catch is reduced to just about half of the figures presented by Soler and Nathanson (2006). However, it ought to be noted that the investigation in 2010–2011 is based on interviews with different numbers of lamprey fishermen in the different rivers, and not on the total number of fishermen. As described in detail in the Methods section, the fishermen were asked to estimate the total number of fishermen, traps and catches in the rivers where they fish and are thus familiar with.

Lamprey Fishing in Finland

According to Hurme (1966) the lamprey stock was plentiful in all the rivers emptying in the Gulf of Bothnia at that time and the lamprey fishing was practised on a commercial basis, and partly for home consumption. The harmful effects of civilisation had not usually reached the spawning lampreys in the lower parts of the river, so the stock had been maintained so far. Later on Tuunainen *et al.* (1980) also wrote that formerly most Finnish rivers flowing to the Baltic Sea supported river lamprey stocks, but because of for example dams, pollution and timber floating, many stocks had been destroyed or weakened.

The total catch in the early 1970s was around 2.7–3.0 million individuals, corresponding to about 130 tons and for 1980 the figure was calculated to be 2.0–2.5 million, corresponding to c. 100 tons. For example, in 1978 the figure was 2.3–2.5 million (Tuunainen *et al.* 1980). For the year 1988, the catch of river lampreys was 1.8–1.9 million (Mäkelä & Kokko 1990).

In contrast to Sweden, Finland still collects statistics on their catches of river lamprey, although here too the data may vary widely in precision among rivers (see for example Kaski & Oikarinen 2011 for details). In the 2000s the total mean figures were close to 1.1 million river lampreys with a variation from the maximum of 1.8 million in 2000 to the minimum of 0.55 million in 2003. Between the years 2006 and 2009 between 0.8 and 0.9 million individuals were caught yearly according to information based on catches from about 15 watersheds, covering the most important lamprey rivers. The figures are estimated to cover about 95 per cent of the total yearly catch in Finland.[1]

In a recent report, Aronsuu (2011c) estimated that the average catch is about 900,000 individuals. The figures indicate that the river lamprey catches seem to have decreased in Finland too in the latest decades.

Although the most important recent catches mentioned above are from 15 rivers, Lehtonen (2006) estimates that river lampreys are fished commercially in at least 33 rivers. There are at present roughly about 400 lamprey fishermen in Finland (Aronsuu 2011c). Most of the lamprey fishermen are semi-profes-

sionals or catch lampreys for their own needs. Just a minority is professional, but lamprey is never their main target (Aronsuu 2011c; cf. Katajisto 2001).

Lamprey Fishing in Latvia

Back in 1958 the river lamprey migrated up in all Latvian rivers, and they were caught in large numbers particularly in the rivers Salaca, Gauja, Daugava and Venta (Eglite 1958a). During the period 1948–1960 the mean catches per year of river lamprey in the Latvian SSR was 67 tons (Ryapolova 1960). Between 1974 and 1979 the mean catches in Latvia were 147 tons, while in the 1980s, 1990s and 2000s the number was 58, 128 and 99 tons, respectively. The lowest catch during the whole period was eight tons 1980, and the highest was 270 tons 1975 (Riekstiņš *et al.* (eds.) 2010). To get an idea of the importance of lamprey, these figures can be compared with the total catch of other fish species in Latvian inland waters. In 2003 for example, that catch was 381 tons. The same year the catch of lampreys was 112 tons (Riekstiņš *et al.* (eds.) 2010), that is, corresponding to approximately 1.3 million lampreys (based on the assumption that the mean weight of a lampreys is 82.0–95.5 grams in the Riga Bay) (Bartel *et al.* 2010). In the main lamprey rivers, there is a restriction period for fishing from 1 February to 31 July and in lamprey rivers of less importance the restriction period is from 1 February to 31 October.

Lamprey Fishing in Estonia

Lamprey fishing is quite important in Estonia. The river lamprey enters most of the rivers that empty into the Baltic Sea. The largest catches are from the River Narva, emptying in the Gulf of Finland, and the second river of importance is the River Pärnu, emptying into the Pärnu Bay (Saat *et al.* 2003; Oras (ed.) 2007). According to Saat *et al.* (2003) the catches have decreased over the last 60–70 years and they fluctuate considerably among years. The biggest annual catches were recorded between 1928 and 1938 with an average of 67 tons, and from the periods 1959–1968 and 1969–1988 the mean values were 21 and 26 tons, respectively (Saat *et al.* 2003). During the period 1994 to 2005 the biggest catch was 63 tons (Oras 2007). There is a closed season for lamprey fishing from 1 April till 30 June (Saat *et al.* 2003).

Lamprey Fishing in Lithuania, Poland and Germany

Gaygalas and Matskevichyus (1968) described the situation for the river lamprey in the basin of the River Nyamuas in Lithuania as being in an excellent state at that time. They suggested that if fishing could be organized properly, the annual catch could reach 30,000 to 50,000 kilos. They refer to literature that describes previous catches from the area, for example dur-

ing 1930–1933 catches ranged from 30,100 to 52,700 kilos. However, during World War II and some years after that, no lampreys were caught in the area, but river lamprey fishing was then resumed and rose from 800 kilos in 1958 to 11,200 kilos in 1966 (Gaygalas & Matskevichyus 1968). During the spawning season river lampreys are observed in 17 rivers (Kesminas & Švagždys 2010).

Witkowski (1992) wrote that in Poland the river lamprey enters the rivers in the northern part of the country and at that time it was still locally abundant, although a distinct tendency to decrease could be seen. Between the wars and after World War II, over 100 tons of river lampreys were caught in the Vistula near Gdansk. However, at the end of the 1950s the catches were so low that fishing ceased (Witkowski 1992; Witkowski & Kuszewski 1995). Later, Witkowski and Jęsior (2000) and Witkowski (2010) stated that the occurrence of river lampreys in Polish rivers was low due to environmental pollution, overfishing and river damming. The river lamprey was concentrated to the lower Vistula basin. There the catches from 1990 to 1999 varied from 1.8 tons in 1998 to 8.3 tons in 1995.

In former times there was an important river lamprey fishery in the German rivers emptying into the southern Baltic Sea (e.g. Imam *et al.* 1958; Sterba 1962; Hardisty 1986a), but there seems not to be any lamprey fishing there now (Thiel *et al.* 2009).

Gear Types Used for Lamprey Fishing

The fishing gears which have been used for river lamprey fishing in the Baltic Sea area can be divided into the following types: hollowed out tree-trunk (Fig. 2), log-like structures made from boards (Swedish *nättingstock*) (Fig. 3), baskets, often of willow or juniper (Swedish *nättingkasse*) (Fig. 4, 5), pots made of laths (Swedish *tinor*) (Fig. 6), finely-woven fyke nets (Swedish *nättingryssja*) (Fig. 7, 8) and other designs, for example large milk pots and plastic pipes. Sometimes these traps are equipped with a lifting frame, and in that case they are often attached to a wooden construction built some metres out in the river from the river bank (in Finnish and Swedish *pata*; also known by some as *pato*) (Fig. 9, 10, 11, and 12) (cf. Storå 1978; Sjöberg 1982). Trap types are adjusted to the stream condition and water level in the rivers. Except for the fyke net trap, the gears described from Sweden and Finland are used in connection to rapids or streaming sections.

Some types of fishing gear are no longer in use in Sweden, and in the last few decades the materials in the traditional trap types have been replaced by other types of material. However, some of the methods known from former times have been in use until quite recently. For example, the lamprey trap described by Linnæus back in 1732 during his journey in the

County of Norrbotten in the northernmost part in Sweden (Linnæus 2003 [1732]) was made of tree-trunks split into halves, hollowed out and then put together again. A similar model was in use up to the middle of the last century in for example the River Piteälven and the River Gideälven (Fig. 2). It is easy to think that the wooden model made of boards and still in use in the River Rickleå (Fig. 3) and the River Öreälven is a direct descendant of the hollowed out trunk model.

In 1772 Juvelius (1772) described a lamprey trap in Ostrobothnia in Finland constructed of twigs or shoots of willow. River fishing has been done in the rivers in the area for hundreds of years, and they are adjusted to the conditions in the rivers. Thus, it is still possible to see this type of trap in use for example in the River Simojoki in the southern part of the province of Lapland (Fig. 4). However, in the 1980s the traditional type of baskets constructed of willow shoots began to be replaced by baskets built from plastic coated wire netting, plastic nets, or later on even by fibreglass in Finland (Fig. 13 and 14), and a bit later also in Sweden, where even metallic nets are used. Some wooden trap types (other than those made of wooden boards), for example the traps made of wooden laths, are still in use in the River Torneälven, although in recent years they are being replaced more and more by a trap of similar shape but made of glass fibre. Otherwise, a significant difference between the fishing gears in Finland and Sweden is that fyke nets are nowadays frequently used in most of the Finnish lamprey rivers, but not at all in Sweden (apart from tests in two rivers). In Finland they were used in the River Kalajoki for a short period in the 1940s, but from the mid 1960s the use of fyke nets increased rapidly, and from there it spread to other rivers (Tuomi-Nikula 1986). For example, in the early 2000s there were approximately 70 fyke nets in use in the River Kalajoki and 90 per cent of the catch was caught by them, while in 2010 the number of fyke nets was 35 and their proportion of catch was 78 per cent (Aronsuu 2011c). According to Aronsuu (2011c) the number of traps has been restricted by the owners of the fishing rights in almost all of the Finnish lamprey rivers because of decreasing populations.

In Latvia fishing gears of traditional materials are still used (Fig. 12). However, baskets made of willow shoots or spruce are no longer in use. Spruce was preferred when available, but in the River Daugava the traps were made of willow, because spruce is not common in that area. According to the fishermen, the wooden traps used at the weirs in the River Salaca had been successively abandoned since the early 1980s and about 15 years ago they all seem to have been replaced by traps with nets. During the transition period the fishermen compared and evaluated the two types of traps in practice. They have not been replaced by plastic or metallic netting materi-

als. Fyke nets are used in Latvia (Fig. 8), but without the wings typical of the nets in Finland.

In Estonia lampreys are mostly caught in fyke nets (Oras (ed.) 2007), but fishing gears formed as cones, made of plastic, are also used. Kangur *et al.* (2005) mention "lamprey bags and small traps." When Gaygalas and Matskevichyus (1968) described the situation for the river lamprey in the basin of the River Nyamuas in Lithuania in former times, they also mentioned that different types of net traps and osier cone traps were used for catching lampreys.

Organization of the Fishing

Generally, fishing rights in Swedish and Finnish rivers belong to the landowners along the river in question (Storå 1978; Storå 1986). However, in reality the lamprey fishing is often performed as a community activity, and a fishing site can also be leased, as is done in for example the River Piteälven in Sweden and in the River Lestijoki in Finland. In some cases the fishing is locally quite strictly regulated, as in the rapids near to the river mouth in the River Rickleå. There the fishing is divided into 256 *skäl*, an old measurement for grain, etcetera but also regarded as a measurement of taxation assessment based on the acreage, position, etcetera of the farm. The fishing is done by teams of two persons. Every night two teams fish, one on each side of the river. The fishing implements are utilized in common by all members of the community and every fishing team is supposed to keep a certain number of *nättingstockar* available. There can be a total of up to 70 *stockar* in use in the rapids every night. In practice, this organization is restricted to the lower part of the river. Further upstream every member of the village can fish for lampreys anywhere in the river. Similar strict organization of the lamprey fishing was also in use in the formerly important lamprey rivers Dalälven and Umeälven in Sweden (Berg 1960; Ehn 1970; Ehn 1986; Öhman 2000).

Similarly, in Finland the landowners also own the fishing rights, but today the organization can differ among rivers. For example in the River Simojoki the landowners still have access to the best fishing sites, while for example in the River Perhonjoki all persons living in the community have the right to fish for lampreys, but the number of fishing gears allowed to be used is regulated. Each person has the right to use one fyke net or ten pots. It is very likely that the fairly late introduction of fyke nets as fishing gear for river lamprey has changed the previously strict regulation of lamprey fishing: fish traps (like baskets) are placed in rapids, and thus in restricted areas along the river, while the fyke nets are normally placed in the water

between the mouth of the river and the first rapid. For more detailed descriptions of the organization of lamprey fishing in the different northern Finnish rivers, see for example Tuikkala 1986; Tuomi-Nikula 1986; Kaski & Oikarinen 2011; and for more detailed information about fishing rights in Finland in general, see: www.fao.org/fi/oldsite/FCP/en/FIN/body.htm. The river lamprey-fishing season starts on 16 August and ends on 31 March. In practice, however, fishing ends at the end of October or November when ice begins to cover the rivers (Tuunainen *et al.* 1986; Lehtonen 2006).

The lamprey fishing in Latvia is commercial; no fishing for recreational purposes is allowed. The Fishery Department of Latvia decides in what rivers lamprey fishing is allowed, and the type and number of fishing gears are also decided by the Department, based on historical experiences gained from practising fishermen. Then the responsibility for the fishing is delegated to the municipalities on the rivers, and fishermen can apply for a license to the municipality. A licence can then cover a period of for example 15 years. In 2011 17 rivers were open for lamprey fishing. As in Sweden and Finland, one may not completely block the river with nets or traps, but a certain fraction of the river must remain open. This is to ensure that some fish can pass the gears.

Economic Importance

In the autumn of 2011 fishermen in Sweden received about 2.5 SEK (approximately 0.27 Euro) per lamprey, while at the market in Umeå in Northern Sweden the price for ten vacuum-packed cold-smoked lampreys was 120 SEK, that is, about 13 Euro, and in a grocery shop the price for one cold-smoked lamprey from Klabböle in the River Umeälven was 15 SEK, that is, about 1.6 Euro. In Finland, the fishermen in the River Perhonjoki got 50 Eurocents each for the fresh lampreys during the autumn of 2011, while for example in Ii in Northern Finland the cost of one grilled lamprey was two Euros (as of 11 December 2011, the exchange rate was one Euro to 8.99 SEK).

If the present catch of lampreys in Finland is approximately 0.9 million (Aronsuu 2011c) and the potential value of one lamprey is 50 cents to the fishermen, as in the River Perhonjok in 2011, then the approximate total value of the lamprey fishing would be about 450,000 Euros, but Aronsuu (2011c) estimates the value of fresh lampreys at about 0.5 million Euros per year and as refined about 1.5 million Euros (the prize for one kilogram of grilled lamprey at the market places is usually 20–50 Euros). Kaski and Oikarinen (2011) estimated the number of lampreys caught in the rivers between Tornionjoki and Perhonjoki in Northern Finland (it

is from this area that 80–90 per cent of the total catch of lampreys in Finland comes) to be between 660 and 850 thousand in the last few years with a weight of between 28 and 50 tons, given a value of 0.4–0.5 million Euros (the mean value for one kilo of fresh lampreys in 2010 was 10–11 Euros). The most important rivers are Tornionjoki, Kemijoki, Iijoki, Siikajoki, Pyhäjoki, Kalajoki and Lestijoki. Other important rivers are Simojoki, Kiiminkijoki and Perhonjoki. In 2010 297 persons fished with 193 fyke nets and 1926 traps within the region according to a compilation made by Kaski and Oikarinen (2011) (see also Seppälä & Sarell 2002).

A similar estimate of the Swedish value (based on a total catch of approximately 0.15 million lampreys and a potential value of 2.5 SEK each) yields a total value of approximately 0.38 million SEK, or about 42,000 Euros for fresh lampreys.

The general impression among the fishermen in Latvia is that the demand for lampreys is higher than what they can deliver, and the prices for lampreys are at the higher end of the scale for fishes. At the Central Market in Riga in November 2011, the price for one kilo of grilled river lamprey was about eight Latvian Lats (equal to 104 SEK or 11.24 Euros as of the exchange rates at that time). At the same time the price the fishermen got was 2.5–3.5 Lats per kilo. If the total catch in Latvia is about 100 tons, the total value of the catch would be approximately 4.2 million SEK or approximately 467,000 Euros. In the market the retail price in 2011 for fresh lampreys (i.e. the price for one kilo of fresh lampreys at the fish market) was starting from 4.9 Lats per kilo.

The Market for River Lamprey

During the season, that is, mostly during September and October in Sweden and Finland, river lampreys are sold in grocery stores and at markets in the vicinity of the fishing sites. However, in some areas the lampreys are prepared for the market on a larger scale. In Sweden, the towns of Umeå and Gävle are such places, and in Finland Ii, Oulu, Kalajoki, Himanka and Pori along the coast of the Gulf of Bothnia are similar centres. In these areas, resellers of lampreys collect lampreys from different rivers having a surplus of lampreys. In Latvia the towns of Carnikava and Salacgriva in the eastern part of the country are centres for preparation of lampreys.

In Finland the structure of lamprey fishing and lamprey markets has been studied by Katajisto (2001) from the fishermen's viewpoint, as well of the lamprey consumers and buying behaviour along the rivers Tiukanjoki, Kyrönjoki , Perhonjoki and Lestijoki. It was concluded, based on a questionnaire, that the lamprey purchasers are usually middle-aged and of varying

social and economic status, and in general people were satisfied with the supply of processed lamprey and the price of the products. Furthermore, the fishermen sell the main part of the yearly catch unprocessed, and most of the catch is directly sold to the processing companies or their purchasers. None of the fishermen intended to stop fishing because of low prices (Katajisto 2001).

As mentioned above, the interviewed fishermen in Latvia regarded the market for river lamprey as good. During a part of the season in 2011 unsuitable winds in the Baltic resulted in smaller numbers of migrating lampreys than normal in the rivers, and the prices for lampreys were unusually high (www.ej.uz/xi5u). Still the consumers bought the products, and the fishermen regarded the demand for lampreys as bigger than the catches. In the Central Market in Riga there were at least 17 different sellers in the fish section who offered grilled river lampreys for sail (just one offered smoked lampreys).

At least eleven companies in Latvia are involved in processing lampreys and most of them are located in the town of Carnikava east of Riga (www.delfi.lv).

How Lampreys are Prepared for Food

The lampreys are consumed as cold-smoked, warm-smoked, grilled, pan-fried, boiled or as an ingredient in soup. There are regional differences in preference, as described for Finland by Tuomi-Nikula (1977), but in general in the northern part of coastal Sweden, smoked lampreys dominate, while further south grilled lampreys are more common. Along the Finnish coastal region of the Gulf of Bothnia, grilled lamprey seems to be preferred today (sometimes marinated), and Latvia is similar.

The preparation of the river lamprey for consumption also varies among different river valleys and regions. In most geographic areas, the abundant slime that the lampreys secrete is removed before preparation (Fig. 15). This is achieved by placing the live fish in water to which ash or lime has been added, as is done along the rivers Rickleå and Umeälven, or in salt, as along the River Torneälven and the Lestijoki and Perhonjoki valleys in Finland. The lampreys are then carefully washed in fresh water. In the Rickleå district the lampreys are then put in salt brine for 24 hours, after which they are ready for smoking. Alder wood is used, sometimes with the addition of juniper wood to yield another colour and taste. (For a detailed description of the former fishing in the River Nykarleby in Finland, see Juvelius 1772; Storå 1978; Storå 2008; and for River Dalälven in Sweden, see Ehn 1970; Ehn 1986.)

In Latvia most of the lampreys are consumed fried or grilled, but it is also possible to buy smoked lampreys (Riekstiņš 1999). In Latvian homes the lampreys are mostly eaten grilled or fried, and smoked lampreys are not

common. The slime is not always taken away before preparation, but when it is done, salt is normally used.[2]

Fig. 1. Eric Andersson at the River Rickleå, province of Västerbotten, Sweden, demonstrates how a river lamprey can attach to objects like his hand by their sucking mouth. The scientific name *Lampetra* means 'stone licker,' referring to its habit to attach to stones in the river (Kullander 2011). 30 August 2011. Photo: Kjell Sjöberg.

Fig. 2. River lamprey stocks, each of them cloven in two parts, hollowed out, and then put together again, were commonly used in the River Gideälven, province of Västernorrland, Sweden, until the middle of the 1950s. 19 September 2011. Photo: Kjell Sjöberg.

Fig. 3. Eric Andersson and Greger Roos emptying traditional lamprey fishing gears made of wooden boards (Swedish: *nättingstockar*) in the River Rickleå, province of Västerbotten, Sweden, 30 August 2011. Photo: Kjell Sjöberg.

Fig. 4. In the River Simojoki in the southern part of the Finnish province of Lapland, traditional lamprey traps constructed of willow shoots still dominate, although the use of modern materials like fibreglass is increasing here too. In this river the fishing gears dry during the day after emptying them in the morning. In the evening they are put back into the river. The reason is that the baskets are quite fragile and last just a few years, and also because leaves and other organic materials drifting in the river are attached to the fishing gears and slow down the water flow through the gears if they are exposed around the clock. Furthermore, the lampreys only migrate during the night, so few are missed when the traps are out of the water. 27 September 2011.
Photo: Kjell Sjöberg.

Fig. 5. The River Kalajoki in the southern part of the province of Northern Ostrobothnia, Finland. A mix of traditional baskets and modern material is used in the river. In the river wooden weirs or barriers are seen, where the traps, equipped with lifting frames, are attached. 27 September 2011. Photo: Kjell Sjöberg.

Fig. 6. Because of the unusually high water levels in many of the northern Swedish and Finnish rivers in the end of September 2011, some of the fishing gears for lampreys was temporarily brought to the shore, as shown here in the River Torneälven (Finnish: River Tornionjoki), the river dividing Sweden and Finland. The fishing gears in the front are constructed of wooden laths. 26 September 2011. Photo: Kjell Sjöberg.

Fig. 7. In the River Lestijoki in the province of Middle Ostrobothnia, Finland, fyke nets, as shown here, are today the dominant lamprey trap type. 29 September 2011. Photo: Kjell Sjöberg.

Fig. 8. Normunds Lode emptying his river lamprey fyke nets in the River Užava in Western Latvia, 17 November 2010. Photo: Kjell Sjöberg.

Fig. 9. On the Finnish side of the River Torneälven along the border between Sweden and Finland, river lamprey fishing is still carried on with traditional methods with baskets on lifting frames attached to wooden barriers along rapids in the river. In this river there are no obstacles in the form of hydroelectric power plant dams, and lampreys can be caught in rapids as far as 40 kilometres upstream from the mouth of the river. View of a wooden construction called *pata* (or *pato*) in the Kukkola rapid in the River Torneälven (Finnish side), 26 September 2011. Photo: Kjell Sjöberg.

Fig. 10. On more simple wooden constructions lamprey gears are attached in a row out from the shore. Here, the Finnish side of the Kukkola rapid in the River Torneälven, 26 September 2011. Photo: Kjell Sjöberg.

Fig. 11. Helge Blomlid and Bertil Niska emptying their lamprey traps attached to a *pata* (or *pato*) along the Swedish side of the River Torneälven, early in the morning of 26 September 2011. Photo: Kjell Sjöberg.

Fig. 12. A weir in the River Salaca in eastern Latvia with gears designed for river lampreys, 18 November 2010. Photo: Kjell Sjöberg.

Fig. 13. Present-day fishing gears for river lamprey fishing in the River Perhonjoki in the province of Middle Ostrobothnia, Finland. Note that traditional gear design is still used, but willow shoots have been replaced by metallic nets covered by plastic (the light green traps in the foreground), or by plastic nets (the dark green traps in the background). 28 September 2011.
Photo: Kjell Sjöberg.

Fig. 14. The traditional river lamprey traps constructed of wood are more and more being succeeded by similar traps made from other materials, like here in the River Torneälven (Finnish side), where the use of wooden lath traps (Fig. 6) is changing to glass fibre traps. 26 September 2011.
Photo: Kjell Sjöberg.

Fig. 15. Sven Öberg is preparing river lampreys for cold smoking by mixing them in a solution of salt in water, after their slime has been removed by rotating them in a mix of lime and water for some minutes, and then carefully rinsing in water. The River Öreälven, province of Västerbotten, Sweden, 16 September 2011. Photo: Kjell Sjöberg.

Activities to Improve Lamprey Populations in the Rivers

Improvement of Fish Ways

Hydroelectric power plant dams are regarded as one of the most important reasons for the decline of river lampreys (e.g. Fig. 16). For example, regulation of the water flow can dry out larval habitats and spawning sites, or cause damage due to changes in water level. However, another problem for the lampreys is that they cannot normally pass a power plant dam even if a waterway or fish way is constructed, because they are mainly designed for salmonid fish, and not for relatively weak swimmers like the lamprey. For that reason studies and experiments have been made to evaluate and improve the situation for the upstream migration of lampreys (Laine *et al.* 1998; Larinier 2008; Lucas *et al.* 2009). When brushes were added in the lower end of slots, lampreys were able to swim through vertical slot sections of the fish way in the River Kemijoki and the results seem promising (Aronsuu 2011b).

Fig. 16. The nowadays more or less dry rapid Baggböleforsen in the River Umeälven, province of Västerbotten, Sweden, is an example of the effect on lamprey habitats by construction of a hydroelectric power plant station. This rapid was once one of the best fishing sites for lamprey fishing in Sweden. Back in the 1970s about ten tons of lampreys were caught annually, that is, about 200,000 lampreys. Now the water in the river is by-passed and the water runs in a tunnel in the ground, emptying downstream of the nearly dry rapid which is shown above, and leaving this section of the river with just a trickle of water in the middle of the river.
18 October 2011. Photo: Kjell Sjöberg.

Transportation of Lampreys above Migration Barriers

To make it possible for the lampreys to reach reproduction areas and habitats above power plant dams, transportation of lampreys above such migration barriers is performed at least in the following Finnish rivers (Aronsuu 2011b): the River Kemijoki, 100,000 adult lampreys per year; the River Iijoki, 60,000 adults per year; the River Oulujoki, 50,000 adults per year; the River Perhonjoki, 10,000 adults per year; the River Kokemäenjoki, 5,000 adults per year. In the River Perhonjoki, 576,118 adult lampreys were transported over a dam between 1981 and 2010 (Vikström 2011a). According to Aronsuu and Tuohino (2011) there has been no detectable increase in response in the number of lampreys migrating upstream, which can be clearly attributed to these actions, but they suggest that this might be due to the lack of homing behaviour of the lampreys, resulting in migrating to other rivers instead of their home river.

Transportation of lampreys around barriers like dams has been performed in Sweden although at a smaller scale than in Finland; currently such transportation is performed in the River Dalälven and the River Ljusnan. In the River Dalälven some thousand per year are caught at Älvkarleby. During the period 2006–2009 in total 14,466 lampreys were caught, with a weight of 1,037 kilos, that is, a mean value of 71.7 grams per lamprey, and 12,271 of them were transported over the dam at Älvkarleby. For example, in 2008, 6,173 lampreys were caught, with a weight of 392 kilos,[3] thus with a mean weight of 63.5 grams. In the River Ljusnan lampreys have been caught and transported around a hydroelectric power station dam close to the river mouth since 1989. In total, 5,231 kilos of lampreys were transported in that way between 1989 and 2010, giving a mean value of 238 kilos per year.[4]

Artificial Production and Release of Larval Lampreys

Artificial production of river lamprey larvae was tried for the first time in Finland in the early 1980s and has been performed in the River Perhonjoki and other rivers since that time (Vikström 2002; Aronsuu 2011b; see also Tuohino 2011a; Tuohino 2011b). At present two million larvae per year are released in the River Iijoki, and 15 million per year in the River Perhonjoki. Between 1997 and 2010 a total of 210 million lamprey larvae have been released in the river Perhonjoki and its tributaries (Aronsuu 2011b; Vikström 2011a). Some of the results seem to be promising and release of larvae has increased larval densities in one of the tributaries, which was earlier blocked by damming. However, in the main river larval densities are still at a low level (Aronsuu & Tuohino 2011). River lamprey larvae have also been released in the rivers Kyrönjoki, Lappväärtinjoki, Tiukanjoki Lestijoki and Perhonjoki (www.miljo.fi or www.ymparisto.fi).

Nothing of this kind is done in Sweden, but in Latvia artificial production of river lamprey larvae is performed as in Finland, and during the period 2003–2009 a mean number of 14.2 million larvae were produced and released in eight Latvian rivers, among them the Daugava, Gauja, Salaca and Venta (Riekstiņš *et al.* (eds.) 2010). In Estonia, fertilized river lamprey eggs have been reared in fish hatcheries since the 1950s (Saat *et al.* 2003).

Water Quality, Spawning Sites and Larval Habitats in Lamprey Rivers

In Finland, the effect of water quality on the river lamprey has been studied in the River Kyrönjoki (Mäenpää *et al.* 2000) and in the River Perhonjoki, where Myllynen *et al.* (1997) investigated the effects of the prevailing water quality on the hatchability of lamprey roe and survival of newly hatched larvae. They found that the survival of lamprey at early life states can be markedly affected by water quality. In particular, high iron concentrations, together with acid pH appeared to reduce the hatchability of fertilized eggs and increase the mortality of newly hatched larvae.

In the rivers Kalajoki, Perhonjoki and Pyhäjoki the effects of river regulation on lampreys were studied by Eklund *et al.* (1984) and Niemi and Kauppinen (1986). In the River Kalajoki they found a close connection between the effects on water quality of a water reservoir and a decline (and subsequent recovery) of the lamprey stock. In the River Perhonjoki a dam is blocking lamprey migration 32 kilometres from the sea. Much of the lower course has been dredged, and thus made largely uninhabitable for larval lamprey (*ammocoetes*). Their conclusion was that the river lamprey population was likely to collapse unless spawners were transported over the dam. Ojutkangas *et al.* (1995) studied the abundance of lamprey larvae in the River Perhonjoki and concluded that thick ice cover was formed on the most important production sites in the river below the dams as a result of short-term water regulation. Thick ice cover and fluctuations in water flow increased erosion, and therefore decreased both the quality and quantity of the production sites. Further studies in the River Perhonjoki have indicated that river regulation measures and short-term fluctuations in the water level below the power plant have rendered this section almost totally unsuitable for larval production (Aronsuu & Tuohino 2011).

Larval habitats have been studied in the River Kalajoki and there are less suitable habitats near a power plant due to short-term regulation and also in embanked and dredged sections of the river (Aronsuu & Tuohino 2011). Based on the conclusions from these studies (and others), restoration work has been done in both the River Kalajoki and the River Perhonjoki. For example, spawning habitats have been restored by transportation of sieved

gravel to riffle areas and new spawning habitats have also been similarly created. Furthermore, big piles of gravel have been left in the uppermost parts of restored riffle areas so that gravel is spread downstream over time with the help of floods (Aronsuu 2011b). Larval habitats have been restored by modification of the straightened river banks and fish ways and artificial rapids have been constructed in the River Kalajoki (Aronsuu 2011a; Aronsuu 2011b). Similar activities and studies have also been performed in other Ostrobothnian rivers in Finland (for more information, see www.miljo.fi or www.ymparisto.fi).

The Future of Lamprey Fishing

Among those fishermen interviewed along the Swedish side of the Gulf of Bothnia in this study, most have learned and taken over the fishing tradition from their fathers. They are thus continuing a tradition that is several hundred years old. For most of them there is no great profit in the activity; they fish for tradition and for their own households and for neighbours. However, only a few of them have successors to take up the tradition when they stop fishing themselves. Furthermore, because most of the fishermen are elderly (many are in their 60s or 70s), the future for lamprey fishing in Sweden seems to be quite uncertain at present.

The situation in Finland appears to be better than in Sweden. The fishing is more extensive, there are more active fishermen, they use more efficient fishing gear, the market for the fish is more developed, and studies about the quality of river lamprey as food are performed (Merivirta 2007). There are also ongoing restoration activities to improve the situation for the lampreys in the rivers, for example on the spawning grounds.

In Latvia the situation seems to be even better than in Finland. There still exist about 50–100 professional river lamprey fishermen[5] and there is a more industrial scale in the operations producing lamprey products for the market. According to local fishermen, it is not difficult to recruit new fishermen to lamprey fishing at present. Furthermore, the river lamprey is still a well-known food among the Latvian people, and the price for the lamprey in the market is towards the higher end of the scale among fish species (Fig. 17).[6] For example, at the Central Market in Riga, the price for a kilo of fresh river lamprey was 4.90 Lats per kilo, and the price for fresh pike perch was 3.80 Lats per kilo on 9 November 2011.

Discussion

River lampreys were once a widespread species along the coastal areas of Europe, and during spawning migration up the rivers, they were caught in

Fig. 17. River lamprey products for sale at the Central Market in Riga, 9 November 2011. Photo: Kjell Sjöberg.

large numbers for food (e.g. Sterba 1962; Hardisty 2006). Today there is essentially no river lamprey fishing for food performed in the British Isles (Igoe *et al*. 2004; Kelly & King 2001), and that seems to be the case also in Germany (Thiel *et al.* 2009). However, river lampreys are still caught in the tidal Ouse in North-East England, where for example almost 40,000 lampreys were caught in 2003–2004, but they are sold to anglers for use as bait (Masters *et al.* 2006).

In the northern part of the Baltic Sea area, the tradition of river lamprey fishing for food still lives on. In addition, in Lithuania in the Southern Baltic Sea area, river lamprey fishing still exists and particularly so in Estonia and Latvia. However, the catches have decreased in Sweden as well as in Finland during the last few decades, even though the fishing gear used there has become more efficient and easier to handle (Ojutkangas *et al.* 1995). There could be multiple interacting reasons for the decline including a decrease in the lamprey populations, overfishing, a reduction in fishing effort, and/or changes in the market demand for river lampreys.

It seems reasonable to assume that the construction of hydroelectric power plants in the middle of the last century had a negative effect on river lamprey populations, because large areas of lamprey spawning and larval habitats are no longer available in many of the larger rivers in the Baltic Sea area (e.g. Tuunainen *et al.* 1980; Soler & Nathanson 2006; Nathanson & Liby 2007).

Constructions of hydroelectric power plants in the lower parts of rivers are barriers for the anadromous river lamprey when it enters the rivers from the sea to spend the winter in the river and for spawning the next spring. Such barriers are impossible for the lampreys to pass, and even if there are fish ways (fish ladders) constructed in connection to a dam, the lampreys are normally too weak swimmers to be able to pass even then (fish ways are mainly designed for salmon and trout). Short-term regulation of water levels and dredging of the rivers, which influences the larval and spawning habitats are other effects of hydroelectric power plants (e.g. Kainua & Valtonen 1980; Eklund *et al.* 1984; Ojutkangas *et al.* 1995). Additional reasons for a decline are changes in the quality of river water due to contamination as well as other aspects like the pH level (Myllynen *et al.* 1997; Edén *et al.* 1999).

In HELCOM's (Helsinki Commission) red list of threatened and decreasing species in the Baltic Sea (HELCOM 2007), the river lamprey was listed as a species with high priority in 2005, and with the notation that the species is of global importance. It was also defined as a *key species*, that is, as a species that has a controlling influence on a community. It is regarded as a species that is decreasing in number and this decrease is classified as being of importance regionally, particularly in the southern Baltic Sea. In the northern part of the Baltic Sea it is classified as *Near threatened* (NT), but here there is only a moderate decrease (HELCOM 2007).

In Sweden the river lamprey was included in the national Red List Book in the 2005 edition as *Near threatened* (NT), but in 2010 it was deleted and the population was given the definition *Least concern* (LC) (Gärdenfors (ed.) 2005; Gärdenfors (ed.) 2010). In the Finnish Red List it was concluded that the river lamprey has decreased in number recently and that the number of larvae fluctuates. Therefore the category *Near threatened* (NT) was retained in that list (Urho *et al.* 2010). In the national Red List of Germany it is regarded as *Critically endangered* (CR) and as *Vulnerable* (VU) in the Polish list (HELCOM 2007), but in the IUCN category as *Endangered* (EN) (Witkowski 2010).

Overall, there seem to be different levels of threats to the river lamprey in different parts of the Baltic Sea area. However, the fact that there are attempts to improve the situation for lamprey, for example by transporting them over barriers in the rivers emptying into the Baltic Sea, release of lamprey larvae, and restoration of spawning and larval habitats certainly indicate some level of concern. In the rivers Kalajoki and Perhonjoki in Finland, there seems to be a negative trend in the number of up migrating lampreys, although the catches have fluctuated widely from year to year since the late 1970s (Kaski & Oikarinen 2011). In the River Perhonjoki, studies have also shown that the number of lamprey larvae has decreased signifi-

cantly since 1982 due to river regulation measures (Ojutkangas *et al.* 1995; Aronsuu 2011a).

Could overfishing be a reason for decreasing lamprey populations? Only one study has been performed in Sweden where the number of river lampreys migrating into a river was calculated (by the mark-release-recapture method) in relation to the number of fish caught (Asplund & Södergren 1975). However, that study was performed just for one year and rather a long while ago (data collection in 1973). This study calculated that the catch comprised 43 per cent of the total population.

In Finland, in the River Kalajoki, the catches have been related to the estimated total number of migrating lampreys since the late 1970s (Aronsuu 2011a). There were great variations among years. For example in 1981 the catch efficiency was 49 per cent, but values up to 60 per cent were calculated for single years. Valtonen (1980) estimated the fishing mortality to be above 80 per cent for the end of September and middle October in the River Kalajoki, but then it decreased rapidly because ice on the river prevented most of the trap net fishing and some fishing with baskets. In the River Pyhäjoki the rate of exploitation was calculated to between 50 and 60 per cent at the beginning of October. In a similar study in the River Perhonjoki for 1981, the catch efficiency was 44 per cent (Eklund *et al.* 1984), but in the last decade the figure is about 31 per cent, according to a compilation by Vikström (2011b). However, when including all the years since the 1970s, Aronsuu and Tuohino (2011) calculated the mortality in Kalajoki at 50 per cent on average, and in Perhonjoki at 43 per cent, and they found that in the last decade the catches and migrating stock of lampreys were at a low level. The fishermen at the River Kalajoki have voluntarily decreased the number of fishing gears in the last few years[7] and generally the catches are regulated for example by rules for how many gears the fishermen are allowed to use. In the River Perhonjoki the number of traps was 107 in 2009 but 77 in 2010, and the number of fyke nets was 38 in 2009 but 17 in 2010 (in 1980 the number of traps was 275 and the number of fyke nets was six) (Vikström 2011b). At least along two rivers in Northern Finland the fishermen have decided not to use the efficient fyke nets. Thus, with the present levels of catches, and with knowledge about the age structure among the fishermen, the judgement is that the river lamprey populations are not threatened (Kaski & Oikarinen 2011).

From the River Vistula in Poland, Witkowski (1992) refers to catches of river lampreys between the wars and after the Wold War II, when over 100 tons of lampreys were caught. At the end of the 1950s, however, the catches were so low that the fishing ceased. The result was regarded as depending on very strong fishery exploitation of lampreys migrating to their spawning grounds.

Even if the present situation for the river lamprey populations might be acceptable, at least in some rivers, the situation for lamprey fishing could still be different in the future. Particularly in Sweden the number of fishermen is low and is likely to continue to decrease, because most of the fishermen are elderly (and they fish for lampreys for tradition and leisure, rather than for economic reasons). The situation is similar in Finland, although not as pronounced as in Sweden. In a study of lamprey fishing in the river valleys of Lappväärtinjoki-Isojoki, Tiukanjoki, Kyrönjoki, Perhonjoki and Lestijoki in Finland, 42 per cent of 45 fishermen were over 60 years old, and only 2.2 per cent of them were younger than 20 years old. Just 4.5 per cent of them regarded themselves as full-time professional lamprey fishermen, while 18.2 per cent regarded themselves as part-time (i.e. 50 per cent) professionals. The other persons fished for lamprey for their own household or for recreation (Katajisto 2001). The best situation seems to be in Latvia, where there still exist 50–100 professional river lamprey fishermen.[8]

What about the expected future market for river lampreys? The interviews in this study indicated that although the fishermen say that they can currently sell their catches on the market, it is important to note that also the consumers of lampreys are mostly elderly people, and many among the younger generation have no tradition or history of eating river lamprey (cf. Katajisto 2001; Nathanson & Liby 2007). Thus, as most of the Swedish fishermen have few successors and their consumers are ageing, in Sweden the prognosis for the future of river lamprey fishing does not seem to be promising. The situation appears to be better in Finland and even more so in Latvia, where there still exist professional lamprey fishermen, and in these countries the tradition of river lamprey eating seems to be more strongly kept than in Sweden.

However, today fishing for river lampreys occurs in at least 16 Swedish rivers, and in at least 20 Finnish rivers. In Latvia licences for lamprey fishing are available in 17 rivers. Thus, in conclusion, although certainly decreasing in importance, the tradition of river lamprey fishing in the Baltic Sea area is still alive!

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NOTES

[1] A. Huhmarniemi, RKTL, Finnish Game and Fisheries Research Institute. Personal communication 2011.

[2] M. Strazds, zoologist, Riga, Latvia. Personal communication 2010.

[3] B. Ragnarsson, Swedish Board of Fisheries, Head of unit. Fisheries Research Station Älvkarleby. Personal communication 2010.

[4] S. Uppman, Ljusne Strömmars Fiskodling. Personal communication 2011.
[5] N. Riekstiņš and J. Birzaks, Fishery Department, Ministry of Agriculture. Personal communication.
[6] M. Strazds, zoologist, Riga, Latvia. Personal communication 2010.
[7] K. Aronsuu, Centre for Economic Development, Transport and the Environment in Northern Ostrobothnia, Finland. Personal communication 2011.
[8] N. Riekstiņš and J. Birzaks, Fishery Department, Ministry of Agriculture. Personal communication.

REFERENCES

Aronsuu, K. (2011a). "River lamprey fishing and rehabilitation of lamprey stocks," Centre for Economic Development, Transport and the Environment in Northern Ostrobothnia. Unpublished data.

— (2011b). "Overview of research, monitoring and supplementation efforts in Finland," in *First International Forum on the Recovery and Propagation of Lamprey. Workshop Report. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for the Columbia River Inter-Tribal Fish Commission, Portland, Oregon*, eds. L. Greig & A. Hall; http://host119.yakama.com/Hydro/ILF/ILF.html; access date 31 October 2011.

— (2011c). "State of lamprey in Finland," in *First International Forum on the Recovery and Propagation of Lamprey. Workshop Report. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for the Columbia River Inter-Tribal Fish Commission, Portland, Oregon*, eds. L. Greig & A. Hall; http://host119.yakama.com/Hydro/ILF/ILF.html; access date 31 October 2011.

— & Tuohino, J. (2011). "Monitoring and research in the natural environment in Finland," in *First International Forum on the Recovery and Propagation of Lamprey. Workshop Report. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for the Columbia River Inter-Tribal Fish Commission, Portland, Oregon*, eds. L. Greig & A. Hall http://host119.yakama.com/Hydro/ILF/ILF.html; access date 31 October 2011.

Asplund, C. & Södergren, S. (1975). "Flodnejonögats (*Lampetra fluviatilis* L.) lekvandring i Rickleån" ['The spawning migration of the river lamprey in the River Rickleån'], *Zoologisk revy*, 36, pp. 111–119.

Bartel, R., Bradauskas, B., Ikonen, E., Mitans, A., Borowski, W., Garbacik-Wesołowska, A., Witkowski, A., Błachuta, J., Morzuch, J., Bernaś, R. & Kapusta, A. (2010). "Patterns of river lamprey size and sex ratio in the Baltic Sea basin," *Archives of Polish Fisheries*, 18, pp. 247–255.

Berg, S. E. (1960). "Nättingfisket i Klabböle" ['The river lamprey fishing at Klabböle'], *Svensk Fiskeri Tidskrift*, 69, pp. 29–30.

Edén, P., Weppling, K. & Jokela, S. (1999). "Natural and land-use induced load of acidity, metals, humus and suspended matter in Lestijoki, a river in western Finland," *Boreal Environment Research*, 4, pp. 31–43.

Eglite, R. (1958a). "Die Biologie des Flussneunauges in der Lettischen SSR," *Gidrobiologicheskie issledovaniya*, Tallin, 1, pp. 261–269.

— (1958b). "Feeding habits of *Lampetra fluviatilis* L. in the sea," *Zoologichesky zhurnal*, 37, pp. 1509–1514.

Ehn, W. (1970). "Nejonögonfiske i Älvkarleby" ['River lamprey fishing at Älvkarleby'], *Svenska landsmål och svenskt folkliv*, 93, pp 9–25.

— (1986). "Nejonögonfiske i Sverige. Kort om fiske, fångstmetoder och användning" (Yhteenveto: Nahkiaispyynti Ruotsissa. Pyyntitavat, valmistus ja käyttö) ['River lamprey fishing i Sweden. Short about fishing, catching methods and use'], in *Riista—ja kalatalouden tutkimuslaitos, Kalantutkimusosasto Monistettuja julkaisuja* N. 46, eds. T. Järvenpää & L. Westman, pp. 44–59.

Eklund, J., Niemi, A. & Ojutkangas, E. (1984). **"The river lamprey in two regulated Finn**ish rivers," in *Regulated Rivers*, vol. 2, eds. A. Lillehammer & S. J. Saltveit, Oslo: Universitetsforlaget AS, pp. 417–426.

Fogelin, P. (1972). "Studier över drift av larver och nymetamorfoserade ungar av flodnejonöga (*Lampetra fluviatilis* L.) i Indalsälven och Rickleån" ['Studies of newly metamorphosed larvae of river lamprey (*Lampetra fluviatilis* L.) in the rivers Indalsälven and Rickleån'], Report No. 20 from Rickleå Field Station, Umeå University.

Freyhof, J. & Kottelat, M. (2008). "*Lampetra fluviatilis*," in IUCN 2019. IUCN Red List of Threatened Species. Version 2010.4.; www.iucnredlist.org; access date13 November 2010.

Gärdenfors, U. (ed.) (2005). *Rödlistade arter i Sverige 2005* ['The 2005 red list of Swedish species'], Uppsala: ArtDatabanken, SLU, i samarbete med Naturvårdsverket.

— (ed.). (2010). *Rödlistade arter i Sverige 2010* ['The 2010 red list of Swedish species'], Uppsala: ArtDatabanken, SLU, i samarbete med Naturvårdsverket.

Gaygalas, K. S. & Matskevichyus, A. P. (1968). "Fishing for the river lamprey [*Lampetra fluviatilis* (L.)] in the Basin of the Nyamunas River. Some features and potentialities," *Problems of Ichthyology*, 8, pp. 169–176.

Hardisty, M. W. (1986a). "General introduction to lampreys," in *The Freshwater Fishes of Europe.* Vol. 1, Part I. *Petromyzontiformes*, ed. J. Holcík, Wiesbaden: Aula-Verlag, pp. 19–84.

— (1986b). "*Lampetra fluviatilis* (Linnaeus, 1759)," in *The Freshwater Fishes of Europe.* Vol. 1, Part I. *Petromyzontiformes*, ed. J. Holcík, Wiesbaden: Aula-Verlag, pp. 249–278.

— (2006). *Lampreys. Life without Jaws*, Cardigan, UK: Forrest Text.

— & Potter, I. C. (eds.) (1971). *The biology of Lampreys*. Vol. 1, London: Academic Press.

HELCOM (2007). *HELCOM Red List of Threatened and Declining Species of Lampreys and Fish of the Baltic Sea* (Baltic Sea Environmental Proceedings 109), the Baltic Marine Environment Protection Commission, Helsinki Commission.

Hurme, S. (1966). "Nahkiaisjoet Suomen rannikolla" ['Finnish river lamprey rivers'], *Suomen Kalastuslehti*, 5, pp. 135–139.

Igoe, F., Quigley, D. T. G., Marnell, F., Meskell, E., O'Connor, W. & Byrne, C. (2004). "The sea lamprey *Petromyzon marinus* (L.), river lamprey *Lampetra fluviatilis* (L.) and brook lamprey *Lampetra planeri* (Bloch) in Ireland. General biology, ecology, distribution and status with recommendations for conservation," *Biology and Environment. Proceedings of the Royal Irish Academy*, 104B (3), pp. 43–56.

Imam, A. K. E. S., Lühmann, M. & Mann, H. (1958). "Über Neunaugen und Neunaugenfisherei in der Elbe," *Der Fischwirt*, 8, pp. 249–261.

Juvelius, E. (1772). "Om Nejonögons Fisket i Österbotten" ['About river lamprey fishing in Ostrobothnia'], *Tidningar utgifne af et sällskap i Åbo*, 20 & 21, pp. 158–160; 161–165.

Kainua, K. & Valtonen, T. (1980). "Distribution and abundance of European river lamprey (*Lampetra fluviatilis*) larvae in three rivers running into Bothnian Bay, Finland," *Canadian Journal of Fisheries and Aquatic Sciences*, 37, pp. 1960–1966.

Kangur, M., Viilmann, M.-L. & Talvik, Ü. (2005). "Lampern in the rivers of Pärnu and Häädemeeste" (in Estonian with Engl. Summary), in *Fishes and fisheries of the Gulf*

of Riga, eds. T. Saat & H. Ojaveer, Tartu: University of Tartu, Estonian Marine Institute, pp. 129–142.

Kaski, O. & Oikarinen, J. (2011). "Nykytilaselvitys 2011. Nahkiainen. Perämeri Tornio-Kokkola alue" ['Investigation of present state. The lamprey. The Bay of Bothnia, Tornio-Kokkola area'], Nahkiainen ennen, nyt ja tulevaisuudessa – hanke, 27 pages.

Katajisto, J. (2001). *Markkinatutkimus nahkiaiskaupasta/Marknadsundersökning om nejonögonhandeln* ['Lamprey consumers and buying behaviour'] (Regional Environment Publications 212:IV), Vasa: West Finland Regional Environment Centre, 108 pages.

Kelly, F. L. & King, J. J. (2001). "A review of the ecology and distribution of three lamprey species, *Lampetra fluviatilis*, (L.), *Lampetra planeri* (Bloch) and *Petromyzon marinus* (L.). A context for conservation and biodiversity consideration in Ireland," *Biology and Environment. Proceedings of the Royal Irish Academy* 101B, pp. 165–185.

Kesminas, V & Švagždys, A. (2010). "Length and weight distribution of the river lamprey, *Lampetra fluviatilis* (L.), sampled in the Nemunas River Estuary," *Archives of Polish Fisheries*, 18, pp. 257–260.

Kullander, S. O. (2011). "*Lampetra fluviatilis* Flodnejonöga" ['*Lampetra fluviatilis* River lamprey'], in *Nationalnyckeln till Sveriges flora och fauna. Lansettfiskar-broskfiskar. Branchiostomatidae-Chondrichtyes*, Uppsala: ArtDatabanken och Sveriges lantbruksuniversitet, pp. 199–200.

Laine, A., Kamula, R. & Hooli, J. (1998). "Fish and lamprey passage in a combined Denil and vertical slot fishway," *Fisheries Management and Ecology*, 5, pp. 31–44.

Lanzing, W. J. R. (1959). "Studies on the river lamprey, *Lampetra fluviatilis*, during its anadromous migration," diss., Uitgeversmaatschappij, Neerlandia, Utrecht.

Larinier, M. (2008). "Fish passage experience at small-scale hydro-electric power plants in France," *Hydrobiologia*, 609, pp. 97–108.

Lehtonen, H. (2006). "Actions taken to protect and restore the river lamprey in Finland," in *ICES Migratory fish. How land managers and fishing associations contribute to the protection of their habitats*, Baltic Area Conference 22 June 2006, Copenhagen; www.fdd-fsd.eu/eufish/baltic_conference.php; access date 21 December 2011.

Linnæus, C. (2003) [1732]. *Iter Lapponicum. Lappländska resan 1732. Dagboken* ['The journey to Lapland 1732. The diary'], eds. A. Hellbom, S. Fries & R. Jacobsson, Umeå: Kungl. Skytteanska Samfundet.

Ljunggren, N. (2006). "Lampreys in Swedish waters. The situation for sea and river lamprey," in *ICES Migratory fish. How land managers and fishing associations contribute to the protection of their habitats*, Baltic Area Conference 22 June 2006, Copenhagen; www.fdd-fsd.eu/eufish/baltic_conference.php; access date 21 December 2011.

Lucas, M. C., Bubb, D. H., Jang, M.-H., Ha, K & Masters, J. E. G. (2009). "Availability of and access to critical habitats in regulated rivers. Effects of low-head barriers on threatened lampreys," *Freshwater Biology*, 54, pp. 621–634.

Mäenpää, E., Myllynen, K., Pakkala, J. & Aronsuu, K. (2000). *Talvehtimisaikaisen veden laadun vaikutus sukukypsien nahkiaisten* (Lampetra fluviatilis) *fysiologiseen tilaan ja mädin hedelmöittymiseen* ['The effect of winter time water quality on the physiology of mature lampreys (*Lampetra fluviatilis*) and on the fertilization of roe'], Länsi-Suomen ympäristökeskus.

Maitland, P. S. (1980). "Review of the ecology of Lampreys in northern Europe," *Canadian Journal of Fisheries and Aquatic Sciences*, 37, pp. 1944–1952.

— (2003). *Ecology of the River, Brook and Sea Lamprey* (Conserving Natura 2000 Rivers Ecology Series 5), Petersborough: English Nature.

Mäkelä, H. & Kokko, H. (1990). "Nahkiaiskantojen hoito" ['Management of lamprey populations.'], Vesi ja ympäristöhallituksen monistesarja 208. Vesi ja ympäristöhallitus, Helsinki, p. 100.

Masters, J. E. G., Jang, M.-H., Ha, K., Bird, P. D., Frear, P. A. & Lucas, M. C. (2006). "The commercial exploitation of a protected anadromous species, the river lamprey (*Lampetra fluviatilis* (L.)), in the tidal River Ouse, north-east England," *Aquatic Conservation. Marine and Freshwater Ecosystems*, 16, pp. 77–92.

Merivirta, L. (2007). "The food hygienic quality of European river lamprey (*Lampetra fluviatilis* L.)," diss., Faculty of Veterinary Medicine, University of Helsinki.

Myllynen, K., Ojutkangas, E. & Nikinmaa, M. (1997). "River water with high iron concentration and low pH causes mortality of lamprey roe and newly hatched larvae," *Ecotoxicology and Environmental Safety*, 36, pp. 43–48.

Nathanson, J.-E. & Liby, H. (2007). "Flodnejonöga" ['River lamprey'], in *Människan och faunan. Etnobiologi i Sverige* 3, eds. H. Tunón, M. Iwarsson & S. Manktelow, Stockholm: Wahlström & Widstrand.

Niemi, A. & Kauppinen, V. (1986). "Vesistötöiden vaikutuksesta nahkiaiskantaan Kala – ja Pyhäjoella" (Sammandrag: Om vattendragsarbetenas verkan på Kalajoki och Pyhäjoki älvarnas nejonögonbestånd) ['About the effects of construction work in the rivers Kalajoki and Pyhäjoki'], in *Riista—ja kalatalouden tutkimuslaitos*, *Kalantutkimusosasto Monistettuja julkaisuja* N. 46, eds. T. Järvenpää & L. Westman, pp. 28–43.

Nordberg, P. (1977). *Ljungan. Vattenbyggnader i den näringsgeografiska miljön 1550–1940* ['Ljungan. Hydraulic constructions in the industrial geographic environment 1550–1940'] (Kungl. Skytteanska samfundets handlingar 18), Umeå: Skytteanska samfundet.

Öhman, B. (2000). "Lax- och nättingfisket i Umeälven" ['Salmon and river lamprey fishing in the River Umeälven'], *Västerbotten*, 1, pp. 18–25.

Ojutkangas, E., Aronen, K. & Laukkanen, E. (1995). "Distribution and abundance of river lamprey (*Lampetra fluviatilis*) ammocoetes in the regulated river Perhonjoki," *Regulated Rivers. Research & Management*, 10, pp. 239–245.

Oras, K. (ed.) (2007). *Statistical Office of Estonia. Final report of the Grant Agreement No. 71401.2005.001–2005.293. Fish and Fisheries Accounts*.

Renaud, C. B. (1997). "Conservation status of Northern Hemisphere lampreys (Petromyzontidae)," *Journal of Applied Ichthyology*, 13, pp. 143–148

Riekstiņš, N. (1999). "Current status and trends in inland fisheries in Latvia," Country Report presented at the 5th BAFICO seminar, Tallinn, 20–21 May 1999 by Normunds Riekstiņš, National Board of Fisheries, Ministry of Agriculture; http://www.fishing.lv/teorija/countrep.htm; access date 31 October 2011.

—, Joffe, R., Kozlovskis, A., Mitāns, A. & Vītiņš, M. (eds.) (2010). *Latvijas Zivsaimniecības Gadagramāta 2010* ['Latvian Fisheries Yearbook 2010'].

Root, W. (1978). "Lamprey of ancient and moderns," *National Herald Tribune*, 10 January.

Ryapolova, N. I. (1960). "Some data on the catches and population dynamics of lamprey (*Lampetra fluviatilis* L.) in the rivers of the Latvian SSR," *Annales biologiques Copenhague*, 17, 118–119.

Saat, T., Tambets, J. & Kangur, M. (2003). "Lampern, river lamprey, *Lampetra fluviatilis* (L.)," in *Fishes of Estonia*, eds. E. Ojaveer, E. Pihu, & T. Saat, Tallinn: Estonian Academy Publishers, pp. 48–52.

Seppälä, T. & Sarell, J. (2002). *Nahkiaisen pyynti, saalis ja nahkiais kannan koko Lapväärtin ja Himangan välisellä alueella vuosina 1999 ja 2000* ['Lamprey fishing, catch and

size of lamprey stock in the area between Lapväärtti and Himanko in the years 1999 and 2000'] (Regional Environment Publications 270), Kokkola: West Finland Regional Environment Centre.

Sjöberg, K. (1980). "Ecology of the European river lamprey (*Lampetra fluviatilis*) in northern Sweden," *Canadian Journal of Fisheries and Aquatic Sciences*, 37, pp. 1974–1980.

— (1982). "Exploitation of Lampreys in Europe," *Ethnologia Scandinavica*, 1982, pp. 94–108.

Soler, T. & Nathanson, J. E. (2006). "Fiske och fångster av flodnejonöga. Undersökning 2002–2003" ['Fishery and catches of river lamprey. Investigation 2002–2003'], Sötvattenslaboratoriet, Fiskeriverket.

Sterba, G. (1962). "Die Neunaugen (Petromyzonidae)," in *Handbuch der Binnenfischerei Mittelleuropas*. Band III, eds. R. Demoll, H. N. Maier & H. H. Wundsch, Stuttgart, pp. 263–352.

Storå, N. (1978). "Lamprey fishing in the rivers of the Gulf of Bothnia," *Ethnologia Scandinavica*, 1978, pp. 67–98.

— (1986). "Etnologiska perspektiv på nejonögonfisket i Österbotten" ['Ethnological perspective on river lamprey fishing in Ostrobothnia'], in *Riista- ja kalatalouden tutkimuslaitos*, *Kalantutkimusosasto Monistettuja julkaisuja* N. 46, eds. T. Järvenpää & L. Westman, pp. 60–73.

— (2008). *Nättingar. Nejonögonfisket i Nykarleby älv* ['River lampreys. The river lamprey fishing in the River Nykarleby'], Nykarleby: Labyrinth Books AB.

Thiel, R., Winkler, H. M., Riel, P., Neumann, R., Gröhsler, T., Böttcher, U., Spratte, S. & Hartmann, U. (2009). "Endangered anadromous lampreys in the southern Baltic Sea. Spatial distribution, long-term trend, population status," *Endangered Species Research*, 8, pp. 233–247.

Tjernberg, M. & Svensson, M. (eds.) (2007). *Artfakta. Rödlistade ryggradsdjur i Sverige* ['Swedish red data book of vertebrates'], Uppsala: ArtDatabanken och Sveriges lantbruksuniversitet.

Tuikkala, A. (1986). "Nahkiaisen pyynnistä Pyhäjoella ja Simojoella," (Sammandrag: Nejonögonfisket i Pyhäjoki och Simojoki) ['The river lamprey fishing in the rivers Pyhäjoki and Simojoki'], in *Riista- ja kalatalouden tutkimuslaitos*, *Kalantutkimusosasto Monistettuja julkaisuja* N. 46, eds. T. Järvenpää & L. Westman, pp. 89–97.

Tuohino, Joffe, R. (2011a). "Research on juvenile rearing and health and outplanting. Experiences from west and north Finland with river lamprey (*Lampetra fluviatilis*)," in *First International Forum on the Recovery and Propagation of Lamprey. Workshop Report. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for the Columbia River Inter-Tribal Fish Commission, Portland, Oregon*, eds. L. Greig & A. Hall; http://host119.yakama.com/Hydro/ILF/ILF.html; access date 31 October 2011.

— (2011b). "Research in spawning, fertilization and incubation. Experiences from west and north Finland with river lamprey (*Lampetra fluviatilis*)," in *First International Forum on the Recovery and Propagation of Lamprey. Workshop Report. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for the Columbia River Inter-Tribal Fish Commission, Portland, Oregon*, eds. L. Greig & A. Hall; http://host119.yakama.com/Hydro/ILF/ILF.html; access date 31 October 2011.

Tuomi-Nikula, O. (1977). "Nahkiaisen käyttötapoja Suomessa" ['Ways of using lampreys in Finland'], *Kotiseutu*, 1–2, pp. 26–32.

— (1986). "Kala- ja Lestijoen muuttuva nahkiaisenpyynti" (Sammandrag: Det föränderliga nejonögonfisket i Kala- och Lestijoki) ['The changable river lamprey fishing in the

rivers Kalajoki and Lestijoki'], in *Riista- ja kalatalouden tutkimuslaitos, Kalantutkimusosasto Monistettuja julkaisuja* N. 46, eds. T. Järvenpää & L. Westman, pp. 74–88.

Tuunainen, P., Ikonen, E. & Auvinen, H. (1980). "Lampreys and lamprey fisheries in Finland," *Canadian Journal of Fisheries and Aquatic Sciences*, 37, pp. 1953–1959.

— (1986). "Nahkiainen ja nahkiaisen pyynti Suomessa" (Sammandrag: Nejonöga och nejonögonfiske i Finland) ['River lamprey and river lamprey fishing in Finland'], in *Riista- ja kalatalouden tutkimuslaitos, Kalantutkimusosasto Monistettuja julkaisuja* N. 46, eds. T. Järvenpää & L. Westman, pp. 3–14.

Urho, L., Pennanen, J. T. & Koljonen, M.-L. (2010). "Kalat, Fish, *Pisces*," *Suomen Lajien Uhanalaisuus*, Punainen Kirja, pp. 336–343.

Valtonen, T. (1980). "European River Lamprey (*Lampetra fluviatilis*) fishing and lamprey populations in some river running into Bothnian Bay, Finland," *Canadian Journal of Fisheries and Aquatic Sciences*, 37, pp. 1967–1973.

— (1986). "Nahkiaisen elämänvaiheet" (Sammandrag: Nejonögats levnadsöden) ['The fates of the river lamprey'], in *Riista- ja kalatalouden tutkimuslaitos, Kalantutkimusosasto Monistettuja julkaisuja* N. 46, eds. T. Järvenpää & L. Westman, pp. 15–27.

— & Niemi, A. (1978). "The present state of fishing in Lestijoki, a small river in Finland," *Verhandlungen des Internationalen Verein Limnologie*, 20, pp. 2085–2091.

Vikström, R. (2002). *Nahkiaisenviljelyä ja viljelykokemuksia/Nejonögonodling och uppfödningserfarenheter* ['Lamprey breeding and breeding experiences'] (Regional Environment Publications 252), Vasa: West Finland Regional Environment Centre.

— (2011a). "Perhonjoen keskiosan järviryhmän säännöstely. Ylisiirrettyjen nahkiaisten ja istutettujen nahkiaisen toukkien tuloksellisuuden seuranta vuonna 2010" ['The regulated middle part of the River Perhonjoki. Follow-up effectiveness of transported lampreys and stocked larval lampreys in 2010'], *Report/Etelä. Pohjanmaan ely-keskus 2011*.

— (2011b). "Perhonjoen keskiosan järviryhmän säännöstely. Perhonjokeen nouseva nahkiaiskanta vuonna 2010" ['The regulated middle part of the River Perhonjoki. The number of migrating lampreys entering the River Perhonjoki in 2010'], *Report/Etelä. Pohjanmaan ely-keskus 2011*.

Witkowski, A. (1992). "Threats and protection of freshwater fishes in Poland," *Netherlands Journal of Zoology*, 42, pp. 243–259.

— (2010). "Anadromous lampreys in Poland. Sea lamprey, *Petromyzon marinus* L. and European river lamprey, *Lampetra fluviatilis* (L.). The present state and threats," *Chnońmy Przyrodę Ojczystą*, 66:2, pp. 89–96.

— & Jęsior, M. (2000). "Fecundity of river lamprey *Lampetra fluviatilis* (L.) in Drwęca River (Vistula Basin, Northern Poland)," *Archives of Polish Fisheries*, 8:2, pp. 224–232.

Witkowski, A. & Kuszewski, J. (1995). "Characteristics of the population of *Lampetra fluviatilis* (L.) entering the Drwęca and Grabowa Rivers (North Poland)," *Acta Ichthyologica et Piscastoria*, 25, pp. 49–56.