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Current state and restoration of sea trout and Atlantic salmon populations in three river systems in the eastern Gulf of Finland

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Description

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Abstract We investigated by electrofishing the state of sea trout population and also the fish assemblage as a whole in two Finnish–Russian cross-border river systems, Mustajoki/Tchornaja/Soskuanjoki/Malinovka and Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, draining into the Gulf of Finland. Based on the fish assemblage, we assessed the ecological status of the rivers. In the third of our target river systems, Gladyshevka/Rotshinka in the Karelian Isthmus, our interest was particularly focused on the Atlantic salmon population. In Mustajoki/Tchornaja/Soskuanjoki/Malinovka, trout dominated in density the upper reaches and small tributaries, their densities decreasing towards the river mouth. Restoration of rapids led to increased trout densities, but benign weather conditions may partly explain the trend. The trout population in this river system was found to be genetically unique and diverse. In Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, only a few trout were found – from the Russian side. The absence of trout, especially from the upper reaches, is due to migration obstacles but also probably to poorer water quality compared to Mustajoki/Tchornaja/Soskuanjoki/Malinovka. This was also reflected in the poorer ecological status. In Gladyshevka/Rotshinka, both salmon and trout were caught from the River Gladyshevka, but neither of these from the River Rotshinka. The densities of salmon in the River Gladyshevka partly reflect the releases of hatchery fish. We established a broodstock of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout to enhance restoration of this native sea trout population still found on both the Finnish and Russian sides of the cross-border rivers draining into the Gulf of Finland. We also transferred wild-caught trout to the River Soskuanjoki on the Finnish side and upper reaches of the River Malinovka on the Russian side to promote the existence of the population in the whole river system in the wild. Later observations of trout from the Finnish side suggested that trout accepted the area. We also analysed in which proportions trout from different native or hatchery populations around the Gulf of Finland are represented in the Finnish coastal sea trout catch. Genetic analyses indicated that at least 75% of the catch originated from Finnish hatchery releases, and at least 20% of the catch consisted of wild trout, mostly from Estonia. Trout from the cross-border rivers represented only about 1% of the total catch. Scale analysis of a sample of captured trout indicated that individuals were caught young and often undersized. The salmon releases into the River Gladyshevka started over a decade ago were continued during the project. Salmon were also released into the River Rakkolanjoki. A sample of released salmon was additionally tagged with T-bar anchor tags prior to release to gain information on their migration based on tag recoveries. Seven tags have so far been recovered.			
Keywords Sea trout, Atlantic salmon, cross-border rivers, Gulf of Finland, electrofishing, DNA analysis, ecological status			
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Kuvailulehti

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Meritaimen- ja lohikantojen tila ja elvyttäminen kolmessa itäisen Suomenlahden jokivesistössä			
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Selvitimme sähkökoekalastuksin meritaimenkantojen tilaa sekä kalastoa kahdessa Suomen ja Venäjän rajajokivesistössä, Mustajoki/Tchornaja/Soskuanjoki/Malinovka ja Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, jotka laskevat Viipurinlahteen itäisellä Suomenlahdella. Arvioimme kalastoon perustuen jokivesistöjen ekologisen tilan. Kolmas hankkeen kohdevesistö, jossa mielenkiintomme kohteena oli erityisesti merilohi, oli Karjalan kannaksella sijaitseva Gladyshevka/Rotshinka, joka on tärkeä merilohen palauttamiskohde itäisellä Suomenlahdella Venäjän puolella. Taimenen poikastiheydet ylittivät Mustajoki/Tchornaja/Soskuanjoki/Malinovka -jokivesistössä muiden kalalajien tiheydet erityisesti latvavesissä sekä sivu-uomissa. Taimentiheydet laskivat jokisuulle mentäessä. Taimenen poikastiheydet kasvoivat tutkimuksen aikana kunnostetuilla koskilla. Osittain kasvu voi selittyä taimenen lisääntymiselle ja poikasille suotuisilla sääolosuhteilla. Mustajoki/Tchornaja/Soskuanjoki/Malinovka -jokivesistön taimenkanta osoittautui perinnöllisesti ainutlaatuiseksi ja monimuotoiseksi. Hounijoki/Buslovka/Rakkolanjoki/Seleznevka -jokivesistöstä löytyi vai jokunen taimen Venäjän puolelta. Taimenen puuttuminen erityisesti jokivesistön yläosista selittyy nousuesteillä, mutta osittain myös veden Mustajoki/Tchornaja/Soskuanjoki/Malinovka -jokivesistöä heikommalla laadulla. Tätä heijasti myös havaittu huonompi ekologinen tila. Gladyshevka/Rotshinka -jokivesistöstä saatiin sekä lohta että taimenta Gladyshevka-joesta, mutta Rotshinka-joesta ei lajeista kumpaakaan. Glahyshevka-joessa havaitut lohitiheydet selittyvät osittain jokeen tehdyillä lohi-istutuksilla. Mustajoki/Tchornaja/Soskuanjoki/Malinovka -jokivesistön taimenesta perustettiin viljelyyn emokalasto tämän ainoan Suomen ja Venäjän puolelta Viipurinlahteen laskevista rajajoista tavatun alkuperäisen meritaimenkannan säilyttämiseksi ja suojelemiseksi. Villejä taimenia siirrettiin myös Soskuanjokeen ja Malinovka-joen yläosiin taimenkannan olemassaolon turvaamiseksi koko jokivesistön alueella. Soskuanjoesta myöhemmin tehtyjen havaintojen perusteella taimenet hyväksyivät siirtoalueen. Selvitimme myös, miten luonnontaimenkannat ja laitoskannat ovat edustettuina Suomen rannikon taimensaaliissa. Geneettiset analyysit osoittivat, että vähintään 75 % saaliista on peräisin laitoskannoista. Ainakin viidennes saaliista oli peräisin luonnonkannoista, enimmäkseen Viron puolelta. Rajajokiemme taimenten todettiin muodostavan taimenen kokonaissaaliista vain n. 1 %. Suomuanalyysit osoittivat taimenten jäävän saaliiksi nuorina ja usein alamittaisina. Yli vuosikymmen sitten aloitettua istutuksin toteutettua merilohen elvytysprojektia Gladyshevka-joella jatkettiin tässä hankkeessa. Merilohta istutettiin myös Rakkolanjokeen. Istukkaita myös merkittiin t-ankkurimerkein ennen vapautusta vaellustietojen kartuttamiseksi. Palautustiedot on saatu tähän mennessä seitsemästä merkistä.			
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Contents

Kuvailulehti **4**

1. Introduction **6**

2. Characteristics of the target rivers **8**

3. Fish populations in the target rivers **9**

3.1. Material and methods 9

3.2. Results and discussion 13

3.2.1. Trout and the fish assemblage in the target rivers 13

3.2.2. Ecological status of the cross-border rivers 20

3.2.3. The effect of restoration on trout densities 22

3.2.4. Size and age distribution of trout 23

3.2.5. Growth and migration of tagged 1+ and older trout 24

3.2.6. Genetic structure of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout population 25

4. Conservation of River Mustajoki trout **28**

4.1. Broodstock establishment 28

4.2. Introducing trout into the River Soskuanjoki/upper reaches of the River Malinovka 29

Composition of the Finnish sea trout catch in the eastern Gulf of Finland **30**

4.3. Material and methods 30

4.4. Results and discussion 33

5. Scale analysis and tagging of trout in the Gulf of Finland **35**

6. Stocking of Atlantic salmon in the River Gladyshevka and River Rakkolanjoki **39**

6.1. Material and methods 39

6.2. Results and discussion 39

Conclusions **40**

Acknowledgements **41**

References **43**

1. Introduction

Salmonid populations around the world, including Finland and Russia, have suffered from overexploitation and human-caused environmental degradation. It is typical for salmonid fish that they form genetically distinctive populations adapted to the local environmental conditions in the wild (MacCrimmon & Marshall 2011). Unfortunately, many of the locally adapted salmonid populations already disappeared before sufficient protective measures to prevent population extirpation were applied.

According to ICES (2013), there are 47 native, wild sea trout (*Salmo trutta*) populations left and not a single native, exclusively wild population of Atlantic salmon (*Salmo salar*) in rivers or brooks draining into the Gulf of Finland from either Finland or Russia. Most of the naturally reproducing sea trout populations are on the Russian side (Saulamo *et al.* 2007, Koljonen *et al.* 2013, Figure 15). On the Finnish side of the Gulf of Finland, there are according to current knowledge eight sea trout populations left that can be regarded as native (Koljonen *et al.* 2013, http://www.rktl.fi/kala/kalavarat/itameren_lohi_taimen/meritaimen/).

Generally, the status of the still existing sea trout populations is considered poor in both Finland and Russia (ICES 2013). In the Finnish Red Data Book from 2010 (Rassi *et al.* 2010), sea trout in the Gulf of Finland were rated as Critically Endangered. The state of the sea trout populations in Finland in general is the poorest among the countries around the Baltic Sea (ICES 2013, Romakkaniemi *et al.* 2014). The status of sea trout has also been rated as vulnerable in the Red Data Book of Nature of the Leningrad Region (Kudersky 2002). According to the Nature Conservation Act in Russia, all the species mentioned in the Red Data Book are completely protected and the use of the species for any economic purpose is prohibited. Poaching, however, is a problem (ICES 2013).

For salmon, releases of hatchery-reared individuals of the Neva stock have been carried out since 1980 in the Rivers Vantaanjoki and Kymijoki, and lately also regularly in the Rivers Mustionjoki and Koskenkylänjoki on the Finnish side of the Gulf of Finland. In the Rivers Kymijoki and Vantaanjoki, natural reproduction of salmon nowadays occurs, supported by releases of hatchery-reared fish (ICES 2013). In Russia, hatchery-reared fish are also regularly released into the Rivers Gladyshevka and Luga to support natural reproduction, but according to ICES (2013) the status of the populations is very uncertain. In the River Neva, there has been no indication of wild reproduction since 2003 and the salmon population is expected to be of hatchery origin (ICES 2013).

A common means of salmonid management has, indeed, been the stocking of hatchery-reared fish into the wild with the aim of maintaining or reintroducing populations, or releasing fish for harvest to compensate for catch losses owing to water construction. Various fishing regulations, differing from region to region, have also been applied to protect wild populations and to secure catches. For example, the size of captured fish and gill net mesh sizes have been regulated.

Lately, the importance of the restoration of natural habitats for population viability and long-term existence has increasingly gained ground. In Finland, the "National Strategy for Fish Passages" (Kansallinen kalatiestrategia, Valtioneuvoston periaatepäätös 8.3.2012) has been established to enhance the viability of endangered migrating fish populations. The main emphasis is on supporting different measures that enable migrating fish species to fulfil their whole life cycle in the wild. In addition, in the Background Studies for the National Salmon Strategy for the Baltic Sea Region (Romakkaniemi *et al.* 2014), measures necessary for strengthening the salmon and sea trout populations in the wild have been put forward. An important aim of the National Fisheries Act of

Finland, of which an update is underway, is also the recovery of the naturally reproducing populations of migrating fish species.

Finland and Russia share sea trout populations in the cross-border rivers. In addition, populations from these rivers are a target of the mixed-stock fishery during their feeding migration in the region of the Gulf of Finland, before returning to their native river to spawn. Mixed stock fisheries that simultaneously harvest individuals of different origin are generally a problem for the conservation and management of native wild salmonid populations, because the populations differ in the fishing pressure that they are able to tolerate (Romakkaniemi *et al.* 2014). Therefore, it is of great importance that common actions to follow the state of shared populations and measures to enhance population survival in the wild are executed.

Recently, in the final report of the ISKALT II project (Saulamo *et al.* 2007), the potential decline of the trout populations in the cross-border rivers draining into the Bay of Vyborg in the Gulf of Finland was recognised. Several recommendations were made for reversing the negative trend. This was regarded as especially important, because the populations were found to be original and to belong to a genetically distinctive unit differing from the two other genetic units of sea trout found in Russia in the Gulf of Finland region (Saulamo *et al.* 2007). This genetic structure has recently been confirmed by further genetic analyses by Koljonen *et al.* (2013). Saulamo *et al.* (2007) suggested that the breeding possibilities and environment need to be secured by river restoration, by the removal of migration obstacles and by ensuring good water quality in the rivers. It was also suggested that a broodstock of the native trout population in the Mustajoki/Tchornaja/Soskuanjoki/ Malinovka River system (River Mustajoki population in Saulamo *et al.* 2014) should be established for conservation purposes, because it is the only native trout population still existing on both the Finnish and Russian sides of the southeastern cross-border rivers draining into the Gulf of Finland (Saulamo *et al.* 2007, Koljonen *et al.* 2013). Offspring of this hatchery stock should be used in releases into the sea-run rivers in Southeast Finland, where native trout populations no longer exist. The initiation of common Finnish–Russian research concerning the cross-border rivers and the state and characteristics of their valuable fish populations was also called for. It was additionally recognised as important to strengthen fishing regulations to improve the viability of the wild populations.

The abovementioned recommendations were put into practice in the Finnish–Russian project “Rivers and fish - our common interest” (RIFCI) funded by the Southeast Finland – Russia ENPI CBC 2007–2013 Programme. In this report, we present research that was carried out as part of the RIFCI project in 2011–2014 on the state of fish populations, especially salmonids, in the target river systems of the RIFCI project, namely the Mustajoki/Tchornaja/Soskuanjoki/Malinovka and the Hounijoki/Buslovka/Rakkonlanjoki/Seleznevka River systems, crossing the Finnish–Russian border and draining into the Bay of Vyborg in the Gulf of Finland. The Gladyshevka/Rotshinka River system in the Karelian Isthmus was also included in the study (see Figure 1 for a map indicating the location of the target river systems) because of its importance for salmon reintroduction on the Russian side of the Southeast Finland – Russia ENPI CBC 2007–2013 Programme area. Here, we also describe the work that was carried out to enhance the population restoration of sea trout and salmon in the project’s target river systems.

Figure 1. Map of the project's main target area. The location of cross-border river systems, (1a) Mustajoki/Tchornaja/Soskuanjoki/Malinovka and (1b) Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, and (2) the Gladyshevka/Rotshinka River system in the Karelian Isthmus, is indicated. Part of the work was also carried out in the sea area of the Gulf of Finland.

More specifically, the main aims of the work presented in this report were to:

- Investigate the state of the valuable salmonid populations, specifically sea trout in the cross-border river systems, Mustajoki/Tchornaja/Soskuanjoki/Malinovka and Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, and salmon in the Gladyshevka/Rotshinka River system in the Karelian Isthmus;
- Study the structure of the fish assemblage in the target rivers and assess the ecological status of the cross-border rivers;
- Aid the conservation of the River Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout population by broodstock establishment and by extending the range of occurrence of the native trout population in the wild;
- Study the origin of sea trout in the catch in the Eastern Gulf of Finland;
- Start introducing Atlantic salmon to the River Rakkolanjoki and continue strengthening the salmon population in the River Gladyshevka by releases of hatchery fish.

2. Characteristics of the target rivers

The Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system belongs to the Juustilanjoki watershed, which is comprised of typical moorland, the water draining into the river through peatlands and forests. The watershed covers an area of 269 km^2, of which ca. 60% is on the Finnish side, the remaining 40% existing on the Russian side. Lakes make up about 3.6% of the area (Ekholm 1993). The river drains into the Gulf of Vyborg as the River Malinovka, just by the mouth of the Saimaa canal (Figure 1). The mean flow in the main river channel is ca. 2 m^3/s (Pursiainen & Ruokonen 2006). A native sea trout population exists in the river system (Saulamo *et al.* 2007, Koljonen *et al.* 2013).

The River Hounijoki watershed, which the Hounijoki/Buslovka/Rakkolanjoki/Seleznevka River system belongs to, is characterised by clay soil, the water draining into the river mainly through agricultural lands. Compared to Mustajoki/Tchornaja/Soskuanjoki/Malinovka, the external load to this river system is much greater, because the treated waste waters of the City of Lappeenranta are led to the upper reaches of the River Rakkolanjoki and also because agriculture is more extensively practiced in this region. The area of the watershed is 621 km^2, of which ca. 60% is on the Finnish side, the rest being on the Russian side, and 2.9% of the area consists of lakes (Ekholm 1993). The mean flow of the main river channel is ca. 4 m^3/s (Pursiainen & Ruokonen 2006). The river drains as the River Seleznevka into the Gulf of Vyborg, a few kilometres northwest of the City of Vyborg (Figure 1). There are old dam structures on the Russian side of this river system that prevent fish migration upstream. According to Hurme (1962), sea trout existed in the river system at the time the whole of it was part of Finland. Trout and salmon juveniles have since occasionally been observed in the River Seleznevka (Saulamo *et al.* 2007, pers. obs.).

The Gladyshevka/Rotshinka River system begins from Lake Gladyshevskoe. The mean flow of the main channel is ca. 4 m^3/s. After the merging of the Rivers Gladyshevka and Rotshinka, the river continues as the River Tchornaja, draining into the Gulf of Finland near Serovo village, west of Zelenogorsk village (Figure 1). The area of the whole watershed is 293 km^2, of which lakes make up about 9%. The River Gladyshevka used to be an important salmon river in the Gulf of Finland. However, the native salmon has become extinct and salmon of the Neva stock have been released into the river since 2001.

3. Fish populations in the target rivers

Our goal was to monitor the native trout population in the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system in order to gain knowledge of its current state and structure, and also of possible effects on the population of the restoration carried out in the RIFCI project. We additionally monitored the trout population found to exist, although in low numbers, in the River Seleznevka (Saulamo *et al.* 2007, pers. obs.) on the Russian side of Hounijoki/Buslovka/Rakkolanjoki/Seleznevka. Given that one goal of RIFCI was to enable fish migration by modifying the dam structures in this river system, we considered it important to gain knowledge on the current state of the trout population and whether there appears to be potential for it to recolonize upstream habitats. In Gladyshevka/Rotshinka, the main emphasis was on studying the current state of the Atlantic salmon population that has been restocked into the river for conservation purposes.

In addition to studying salmonids, we investigated the structure of the whole fish assemblage in the target river systems, because it can be regarded as reflecting environmental quality in the rivers. Given that fish communities can be used to measure relative ecosystem health (Fausch *et al.* 1990), we assessed the ecological status of the cross-border river systems by making use of the observed fish assemblages. For Gladyshevka/Rotshinka, the ecological status was not assessed, because the practiced salmon restocking presumably would have led to biased estimates.

3.1. Material and methods

Electrofishing was used as a method to sample trout and other fish species in the rapids of the target rivers. The rapids for electrofishing were selected based on field screening and on information gained from local water owners. In the smallest tributaries, sampling sites were established in stream reaches having a gravel and stone bottom, and thus likely to be suitable for spawning and the young of salmonids.

Electrofishing was conducted in late August and September of 2011, 2012 and 2013. The total number of established electrofishing sites was 57. In Mustajoki/Tchornaja/Soskuanjoki/Malinovka, there were altogether 35 sites, while the corresponding figure for Hounijoki/Buslovka/Rakkolanjoki/Seleznevka was 17. In Gladyshevka/Rotshinka, the number of sampling sites was five (see Figure 2 for the location of sampling sites, and the Appendix for more details of the sites). Our aim was to carry out electrofishing annually at each site. However, in 2011 and 2012 the target area was hit by heavy floods and electrofishing was rather inefficient, or could not be conducted at all, especially in the lower reaches of the cross-border rivers on the Russian side. At the majority of the sites on the Finnish side, the rapids were possible to electrofish each year, even though 2013 was in turn exceptionally dry. In total, 111 electrofishing occasions were conducted during the three sampling years. The electrofishing data from the cross-border river systems are saved in the Finnish Fish Sampling Data Register (https://portaali.ymparisto.fi/Koekalastus_sahko/default.aspx), which has open access for researchers and authorities, provided that they have a user name and a password that can be received on request.

Electrofishing in the River Soskuanjoki.

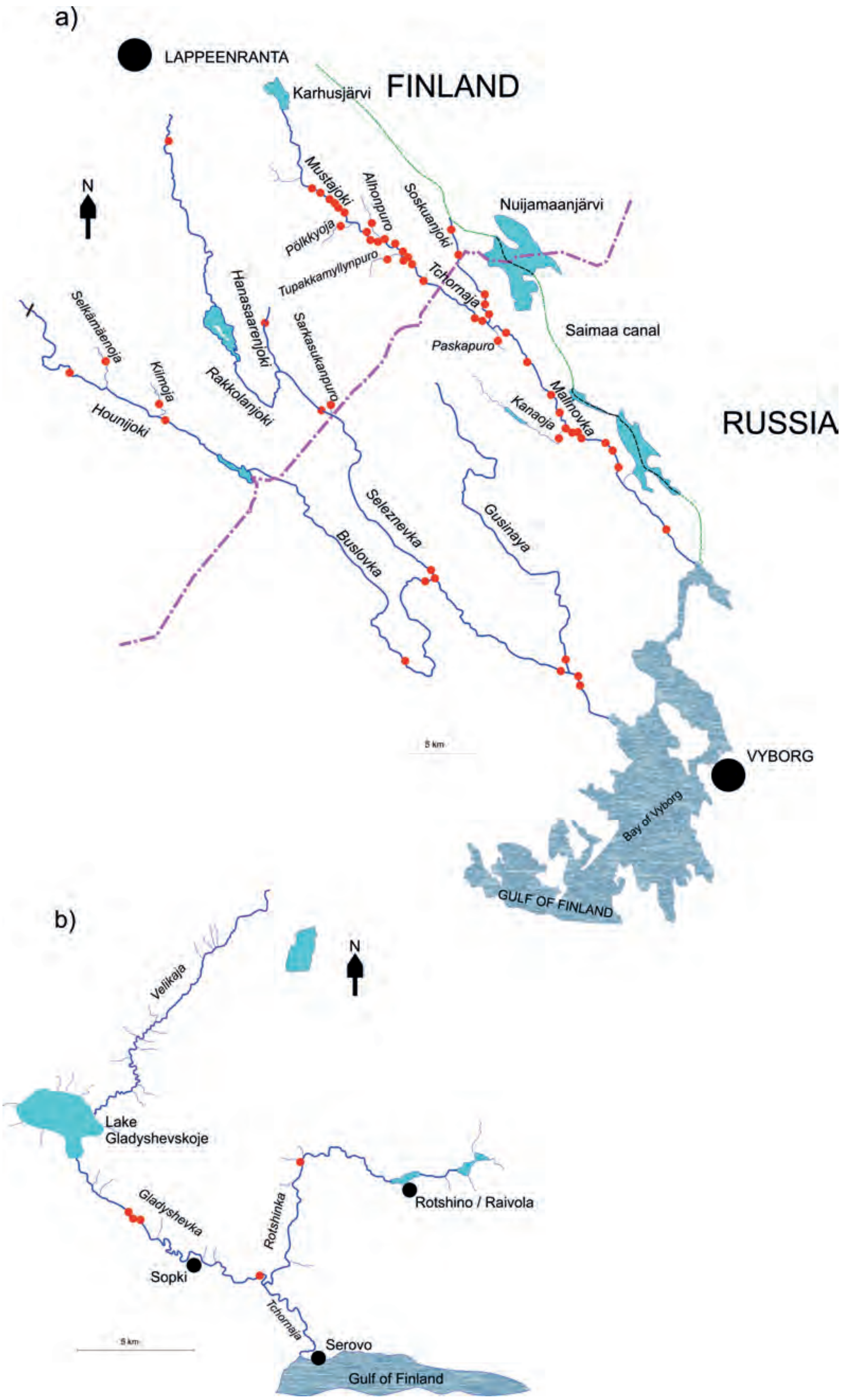

Figure 2. Map of the electrofishing sites (red dots) in a) cross-border river systems, Mustajoki/Tchornaja/Soskuanjoki/Malinovka and Hounijoki/Buslovka/Rakkonlanjoki/Seleznevka, and b) the Gladyshevka/Rotshinka River system in the Karelian Isthmus.

Sampling was conducted with one or two successive removals and it proceeded upstream. At least 15 min elapsed between the two removals. The fish were hoop netted by two or three persons. The electrofished area was measured for each site and electrofishing occasion. The area of the electrofishing sites ranged from approx. 25 m^2 in the smallest tributaries to 320 m^2 in the main river channel. All caught fish were anaesthetized with buffered MS 222 or benzocaine before measurements. The fish were identified to species. The captured trout and salmon were individually measured to the nearest millimetre (total length). For trout, we also determined the age distribution. Trout of ages 0+ and 1+ can easily be identified based on their length. For larger trout (n = 25), scales were obtained in order to assess the age of the fish. For the other fish species, the number of individuals per species was recorded. Trout aged 1+ or older were tagged with individual T-bar anchor tags (n = 258; 222 tagged trout on the Finnish side, 36 tagged trout on the Russian side of the cross-border rivers) in order to follow their growth and migratory behaviour. All captured fish were released back into the river.

The number of different fish species and individuals per species caught from the electrofished sites were counted for each electrofishing pass. The estimated density of the fish was calculated in the Finnish Fish Sampling Data Register following the method by Seber & Le Cren (1967). The ecological status of the rapids in the cross-border river systems was assessed with a standardised fish-based method as obliged by the EU Water Framework Directive, WFD. In line with Vehanen *et al.* (2010), we followed the premise of rapids being the key habitats that characterise the condition of the entire river. Five metrics sensitive to human disturbance were used to calculate the index: the number of fish species, proportion of sensitive species, proportion of tolerant species, observed density of cyprinid individuals and the observed density of 0+ salmonids during the first electrofishing pass (Vehanen *et al.* 2006, 2010, Table 1). The density of cyprinids and proportion of tolerant species increase as a function of human disturbance, whereas human disturbance reduces the value of the other metrics, except for the number of species, for which human disturbance first increases the value and then reduces it (Vehanen *et al.* 2006, 2010).

Table 1. The limits of different ecological statuses (Vehanen *et al.* 2006, 2010) in Mustajoki/Tchornaja/Soskuanjoki/Malinovka and Hounijoki/Buslovka/Rakkolanjoki/Seleznevka River systems based on the type of catchment area.

River system	bad/poor	poor/moder.	moder./good	good/high
Mustajoki/Tchornaja/Soskuanjoki/Malinovka	0.18	0.35	0.53	0.71
Hounijoki/Buslovka/Rakkolanjoki/Seleznevka	0.18	0.37	0.56	0.76

The genetic characteristics of the trout population in Mustajoki/Tchornaja/Soskuanjoki/Malinovka were also analysed. For the analysis, a tissue sample (a 1 mm^2 clip of a fin) was taken from 0+ individuals. The samples were preserved in 95% ethanol. DNA sampling was mainly focused on the small tributaries, because a number of samples from the main stream were already available from previous projects, ISKALT (Rahikainen & Vähänäkki 2006) and ISKALT II (Saulamo *et al.* 2007). Some samples had also been collected from the mainstream for the HEALFISH project (Koljonen *et al.* 2013). Total genomic DNA was extracted from the tissue samples using the DNeasy Blood & Tissue Kit method (Qiagen). Variation was determined at 15 microsatellite loci, which were the same as in Koljonen *et al.* (2013). The locus SSa289 (McConnell *et al.* 1995) was omitted, as it was not included in the Estonian data used here later for population composition analysis of sea catches (see Chapter 5).

For each sample, two multiplex PCR reactions were performed using the Qiagen Type-it Microsatellite kit in a 10 µl reaction volume with 3 µl of extracted DNA, 5 µl of kit master mix and primers with concentrations and dyes the same as in Koljonen *et al.* (2013). PCR reactions were carried out with PTC200 Thermal Cyclers (MJ Research), and the temperature profile of the PCR program was suggested in the Type-it Microsatellite kit manual. The annealing temperature was 56 °C. Microsatellite genotypes were detected with an Applied Biosystems ABI 3130 automated DNA sequencer and analysed with GENEMAPPER Analysis Software version 4.0, with the size standard of Applied Biosystems GeneScan 500LIZ. Automatic outputs were manually checked.

The diversity measures, i.e. the number of alleles, allelic richness and mean diversities, were calculated with FSTAT version 2.9.3.2. (Feb. 2002) (Goudet 1995, 2001) (http://www2.unil.ch/popgen/softwares/fstat.htm). Analysis of the differences between samples was based on genotype frequency differences, and was carried out with FSTAT, which includes Bonferroni correction for multiple tests. Comparison with other rivers was based on results from Koljonen *et al.* (2013). Genetic distances between the samples from the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system were calculated using Nei's DA distances (Nei *et al.* 1983). Phylogenetic trees were constructed using a neighbour-joining (NJ) algorithm (Saitou & Nei 1987, Takezaki 1998) with Populations 1.2.32 software (Langella 1999, http://bioinformatics.org/~tryphon/populations/). Bootstrapping with 1 000 replicates was used to test the statistical strength of the branches. The phylogenetic tree of subpopulations was drawn with TreeView version 1.6.1 (Page 1996, http://taxonomy.zoology.gla.ac.uk/rod/treeview.html).

3.2. Results and discussion

3.2.1. Trout and the fish assemblage in the target rivers

In the cross-border rivers, 509 age 0+ and 441 age 1+ or older trout were caught during 2011–2013 (see Appendix for a more detailed description of the data). The majority (0+: n = 440; 1+ or older: n = 330) of the trout were caught from Mustajoki/Tchornaja/Soskuanjoki/Malinovka, from the River Mustajoki and its small tributaries on the Finnish side, where the density of the trout was also estimated to be at its highest level (Figure 3). Trout numbers and densities decreased in the lower reaches of the main river channel, on the Russian side, with the exception of small tributaries still containing high densities of young trout (Figure 3). No trout were found from the River Soskuanjoki on the Finnish side or from the upper reaches of the River Malinovka on the Russian side. In Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, a few trout were caught from the Lanakoski rapids in the River Seleznevka (0+: n = 10; 1+: n = 2) and from its tributary, the River Gusinaya (0+: n = 1; 1+: n = 3), but not from elsewhere (Appendix).

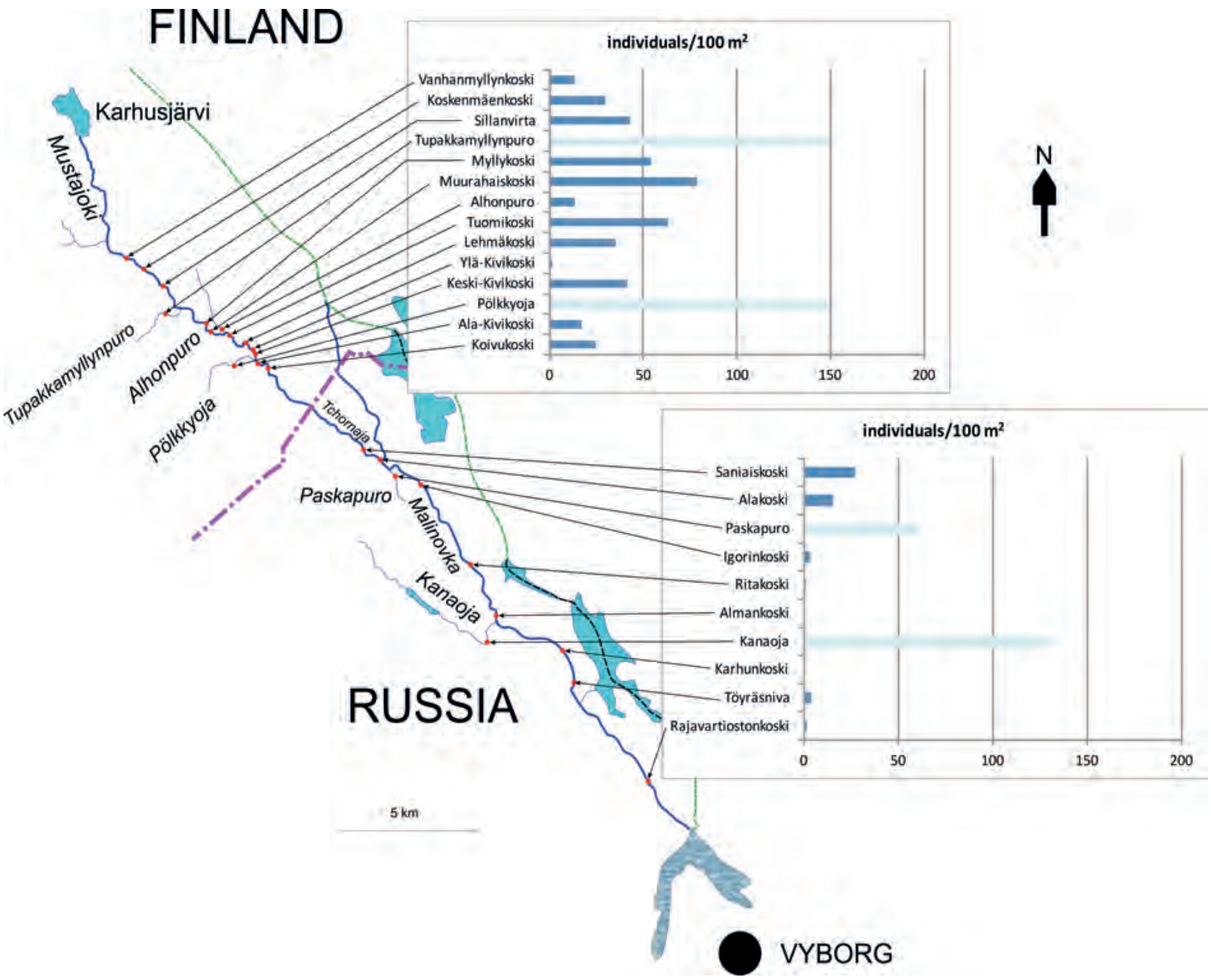

Figure 3. Estimated trout densities (individuals/100 m^2) in the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system. The dark bars indicate the main channel and the light bars indicate small tributaries. Data are presented for 2013 only, when the most comprehensive data set could be obtained from the field survey on both the Finnish and the Russian side (see Appendix for more detailed data).

The total number of different fish species that were found from cross-border rivers was 13. The species were perch (*Perca fluviatilis*), stone loach (*Noemacheilus barbatulus*), bullhead (*Cottus gobio*), roach (*Rutilus rutilus*), bleak (*Alburnus alburnus*), chub (*Leuciscus cephalus*), rudd (*Scardinius erythropthalmus*), tench (*Tinca tinca*), pike (*Esox lucius*), burbot (*Lota lota*), trout (*Salmo trutta*), Atlantic salmon (*Salmo salar*) and brook lamprey (*Lampetra laneri*). In addition to young trout and salmon, bullhead, stone loach, young burbot and brook lamprey are typical species of the fluvial environment. The other captured species can be regarded as more or less common freshwater species.

In Mustajoki/Tchornaja/Soskuanjoki/Malinovka, the densities of the non-salmonid species were much lower than those of trout in the River Mustajoki on the Finnish side. However, in the lower reaches, on the Russian side of the river system, trout no longer predominated in the fish community in terms of density (Figure 4). Considering the occurrence of the different species in the electrofishing catch in Mustajoki/Tchornaja/Soskuanjoki/Malinovka, trout were also most often found in the catch, especially on the Finnish side in the River Mustajoki (upper and middle reaches Finland in Table 2). The trout thus appeared to be the most common fish species in these parts of the river system. Perch and stone loach followed trout, being the two most typical non-salmonid species in this river system, followed by burbot, bullhead and pike. Cyprinids were most often caught in the middle and lower reaches of the river system on the Russian side (Table 2), where their densities were also as high as or even higher than those of trout (Figure 4).

Table 2. The occurrence of fish species in the catch from the different parts of Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system.

	Upper reaches Finland	Middle reaches Finland	Middle reaches Russia	Lower reaches Russia	sum	%
Trout	39	31	9	6	**85**	**49.1**
Perch	6	4	2	4	**16**	**9.2**
Stone loach	5	6	3	2	**16**	**9.2**
Burbot	8	5		1	**14**	**8.1**
Bullhead		6	3	4	**13**	**7.5**
Pike	7	1	2	1	**11**	**6.4**
Roach	1		1	5	**7**	**4.0**
Bleak			2	3	**5**	**2.9**
River Lamprey	5				**5**	**2.9**
Salmon			1		**1**	**0.6**
					173	**100**

A bullhead caught from the River Mustajoki.

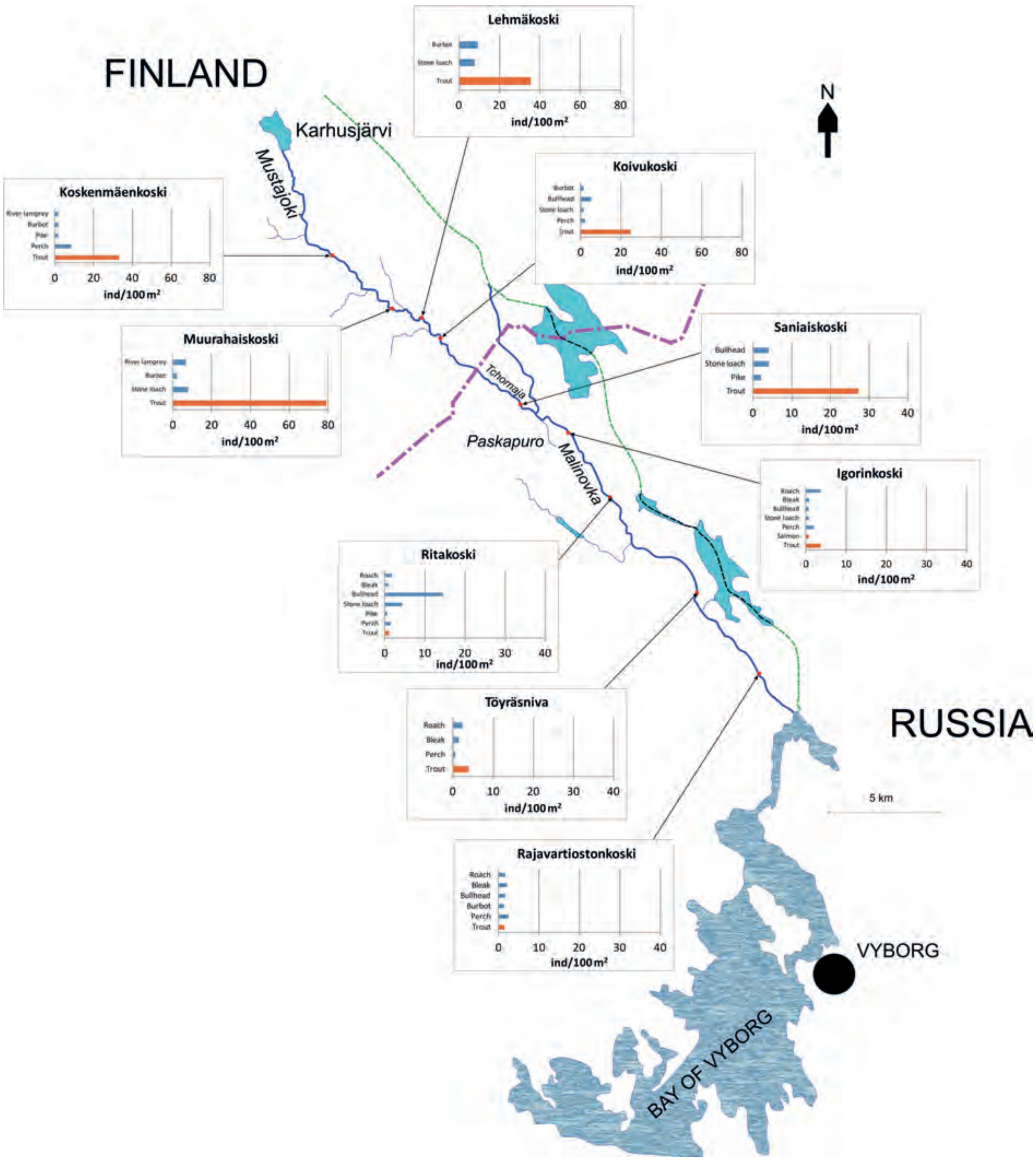

Figure 4. Fish species composition in rapids representing upper, middle and lower reaches of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system. Please note the different scale of the diagrams on the Finnish and Russian sides. Due to flooding, the electrofishing results from the first two study years from the Russian side are only suggestive, so data are presented here only for 2013. More detailed data are provided in the Appendix.

The trout is typically territorial in the river, and in areas where it thrives the other species do not have such a dominant position in the fish community. Generally, in such areas, the water quality is good and the bottom fauna is diverse. The physical structure of the bottom is usually dominated by stones and gravel. Such areas are typically located in the upper parts of the main river. They also exist in small tributaries where groundwater emerges from wells and keeps the water temperature in the river suitable for trout throughout the year. Our finding of trout mainly dominating in density in the upper reaches of the River Mustajoki and in small tributaries of the whole river system (Figure 4) is in line with this notion.

The exceptionally low density of trout in the uppermost rapids area in River Mustajoki, Vanhanmyllynkoski (Appendix), might result from the sedimentation of organic solids due to ditching of the peatlands nearby. Surface runoff of organic soils, such as peat, affects water transparency, nutrients and dissolved solids. Sedimentation of solids may be an important factor in worsening the environmental conditions for salmonids (Laine *et al.* 2001). Water quality sampling carried out in RIFCI during 2011–2013, however, did not indicate such high levels of organic solids in the water in Vanhanmyllynkoski that would be harmful for young trout. The pH of the water was also interpreted as being suitable for salmonids (Lindgren 2014a). The water quality sampling, however, only indicates the conditions at the time of sampling and does not reflect the conditions in the river throughout the year.

For the River Soskuanjoki/upper reaches of the River Malinovka, where no trout were found, no data on water quality are available. However, the uppermost reaches are probably not very suitable for the reproduction of trout due to the observed local external loading (Manu Vihtonen pers. comm.). Water discharging from the Saimaa canal to the lower reaches of River Soskuanjoki increases the water volume in the river, thereby diluting the water and presumably also dampening the temperature fluctuation. This possibly makes the lower rapids more suitable for salmonids. The appearance of young salmon in a restored rapids area near the border in the River Soskuanjoki in 2012 and 2013 lends support to this view (see 3.2.3).

Compared to Mustajoki/Tchornaja/Soskuanjoki/Malinovka, cyprinids were more evenly spread over the whole of Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, being found from the upper reaches to the lowermost rapids near the river mouth (Figure 5, Table 3, Appendix). Otherwise, the species composition was rather similar to that found in Mustajoki/Tchornaja/Soskuanjoki/Malinovka, except for the absence of trout from all but one of the rapids near the river mouth of the River Seleznevka (Figure 5). The estimated forage base for salmonids (i.e. the abundance of benthic and drifting invertebrates) would, however, allow for a viable trout population in this river system (Zuyev & Mitskevitch 2014). The water quality measurements revealed that the main channel of the River Rakkolanjoki/Seleznevka was hypertrophic, but the current buffering capacity and pH were favourable for salmonids (Lindgren 2014a). Interestingly, stone loach were found in just one electrofishing removal and from the same site where trout were caught (Table 3). The stone loach is known to be slow in recovering from strong habitat disturbance (Nilsson 1996). It is very local with no particular predisposition to migratory behaviour. Once lost from a habitat, its rate of recolonization is slow. It is thus possible that there has been an incidental heavy discharge to the river system that has caused the species to disappear.

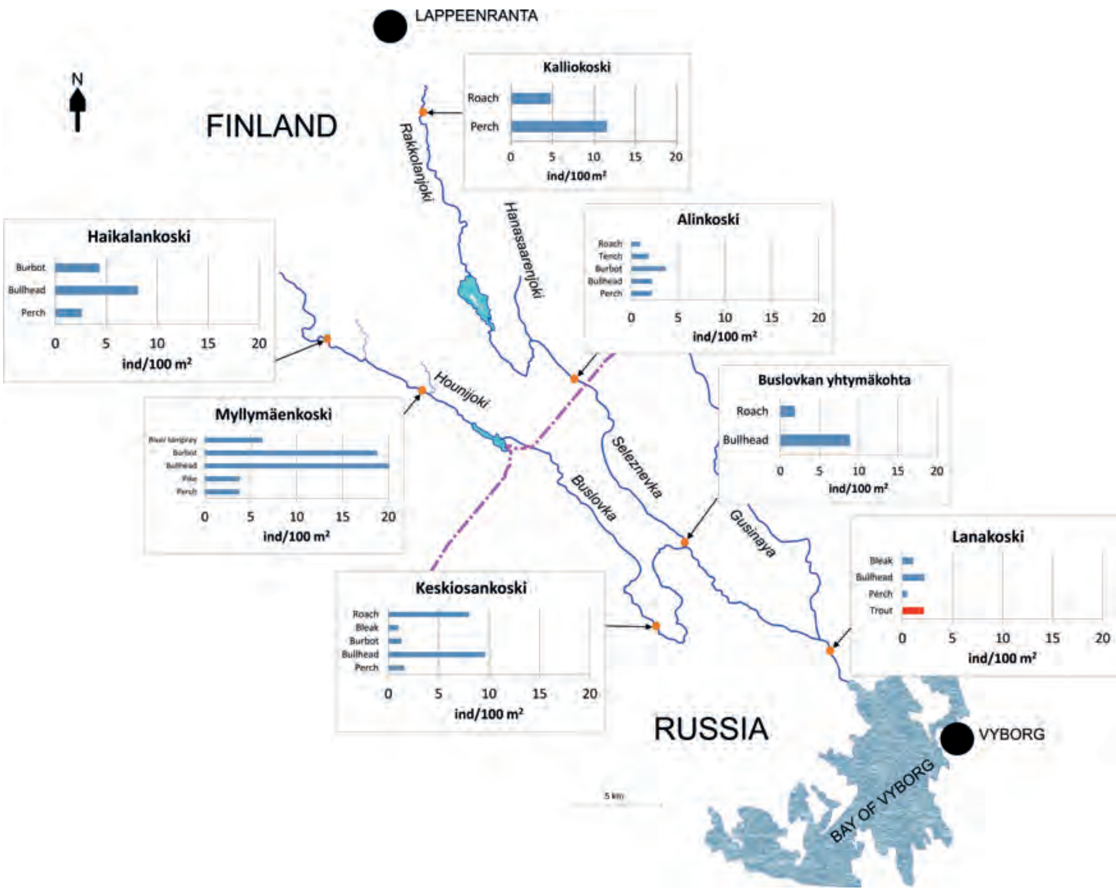

Figure 5. Fish species composition in different parts of the Hounijoki/Buslovka/Rakkolanjoki/Seleznevka River system in 2013. For Haikalankoski and Myllymäenkoski rapids, the data are from 2012 because, due to the drought in 2013, these rapids were too dry to make any inferences regarding the prevailing species composition.

Table 3. The number of electrofishing removals in which individual fish species were recorded in the electrofishing catch shown for the different parts of the Hounijoki/Buslovka/Rakkolanjoki/Seleznevka River system and pooled (sum) for each species. The percentage of electrofishing removals in which the species were found in the catch is also shown.

	Hounijoki	Buslovka	Rakkolanjoki	Seleznevka	sum	%
Bullhead	4	2	2	4	**12**	**21.4**
Perch	3	1	4	2	**10**	**17.9**
Roach	1	1	4	4	**10**	**17.9**
Burbot	4	1	3	1	**9**	**16.1**
Bleak	2	1		2	**5**	**8.9**
Trout				4	**4**	**7.1**
Pike	1		1	1	**3**	**5.4**
Stone loach				1	**1**	**1.8**
Rudd	1				**1**	**1.8**
Tench			1		**1**	**1.8**
					56	**100**

The lack of trout in the upper reaches of Hounijoki/Buslovka/Rakkolanjoki/Seleznevka can partly be explained by old dam structures acting as migration obstacles for the fish. However, no resident trout spending their whole life in the river were caught, either. Nevertheless, the existence of such individuals is rather typical for trout populations. This suggests the role of other factors as well, presumably the external load from the waste waters of the city of Lappeenranta and from the surrounding agricultural areas, in influencing the distribution and abundance of trout in this river system, specifically in the River Rakkolanjoki/Seleznevka. The observed hypertrophic water (Lindgren 2014a) is likely to impair the breeding conditions for trout, e.g., by the deposited organic matter reducing gravel permeability and the rate of dissolved oxygen supply, which is important for the developing eggs and hatched alevins. If the external load was reduced, the river system might prove more suitable for salmonids. Based on the neutral pH level of the water (Lindgren 2014a), this is probable. In the River Hounijoki/Buslovka, the clayey nature of the water might impair the conditions for trout. When there are large amounts of clay in the water, the permeability of the spawning gravel may decrease. In the River Buslovka, in addition, almost the entire biomass of benthos was found to be formed by only one species (Zuyev & Mitskevich 2014). This may negatively affect the feeding conditions of trout. A more diverse forage base in terms of species richness would presumably provide more sufficient feed for salmonids, with food items of various sizes and a temporally more even distribution (Zuyev & Mitskevich 2014). Nevertheless, the observed pH level of the water should enable salmonid breeding (Lindgren 2014a).

In the River Gusinaya, a migration obstacle exists near the river mouth, so the captured trout were presumably of local origin. The low number of trout, only four in total during 2011–2013, may partly be explained by weakening of the living conditions in the river. Water quality analysis in RIFCI (Lindgren 2014a) indicated that the buffering capacity of the water has recently weakened and the pH level has decreased in the River Gusinaya. The underlying reason for this, however, is unknown.

In the Karelian Isthmus, in the rapids of the Gladyshevka/Rotshinka River system, representatives of ten fish species were found. These were salmon, trout, perch, bullhead, roach, bleak, European minnow (*Phoxinus phoxinus*), gudgeon (*Gobio gobio*), stone loach and lamprey (*Lampetra sp.*) (Figure 6). Both trout and salmon were present at the two electrofishing sites in the River Gladyshevka (Figure 6). This is in line with the finding of Zuyev & Mitskevich (2014) of the diversity and biomass of the benthos being sufficient to provide a high level of forage base for salmonids. In the River Rotshinka, neither trout nor salmon were caught, and European minnow and gudgeon were found exclusively from one electrofishing site in the River Gladyshevka (Figure 6). The latter two species were not observed in Hounijoki/Buslovka/Rakkolanjoki/Seleznevka or Mustajoki/Tchornaja/Soskuanjoki/Malinovka at all. The number of fish species was higher at the uppermost electrofishing site, Kirjavalankoski, whereas the observed densities of fish were higher at the lower site, Talissalankoski, mainly due to the release of a large number of hatchery-reared salmon in this rapids area. However, wild-born 0+ salmon were also caught, indicating natural reproduction. It is also generally typical for the sea-run rivers on the coast that the headwaters contain a smaller number of fish species than the parts of the river nearer to the river mouth. Both the number of species and their densities in the River Rotshinka were significantly lower than in the main River Gladyshevka. There is no clear explanation for this pattern.

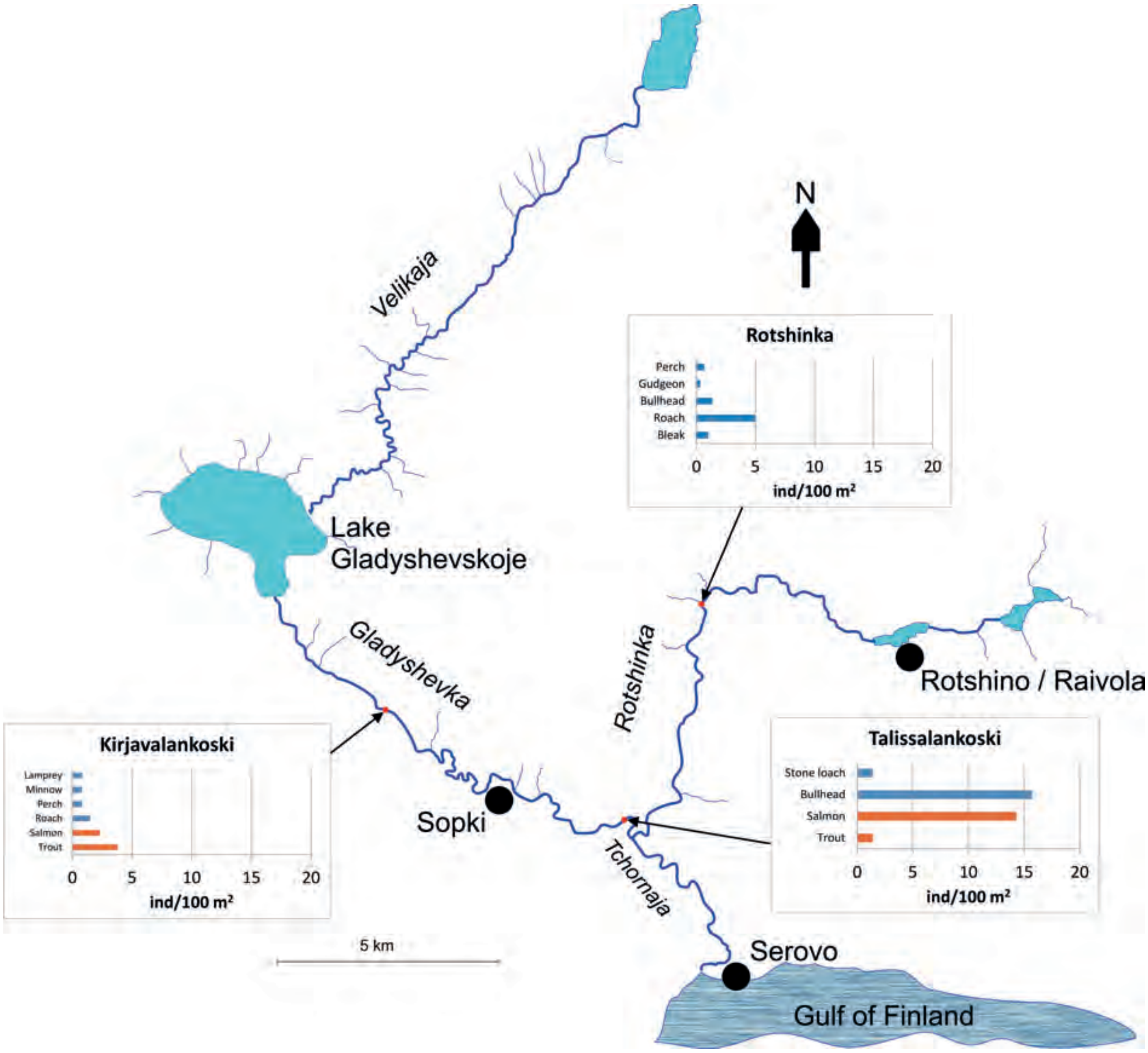

Figure 6. The fish species composition and observed densities of the different fish species in the Gladyshevka/Rotshinka River system in 2013.

3.2.2. Ecological status of the cross-border rivers

Of the species caught from the cross-border rivers, perch, roach and bleak were regarded as species tolerant of anthropogenic pressure, whereas bullhead, trout, salmon and brook lamprey were included in the group of intolerant fish species (Vehanen *et al.* 2010).

As already suggested by the species assemblage and the high observed density of trout, the ecological status in the River Mustajoki was assessed in general as good or high, and high in the tributaries of the whole Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system (Figure 7). In the lower parts, i.e., the Rivers Tchornaja and Malinovka on the Russian side, the ecological status, by contrast, was mainly moderate (Figure 7). This primarily results from the fact that cyprinids were more abundant and the observed density of 0+ trout lower here than in the upper reaches. Trout appeared to select the headwaters for spawning, presumably due to the favourable conditions for reproduction and feeding of their young.

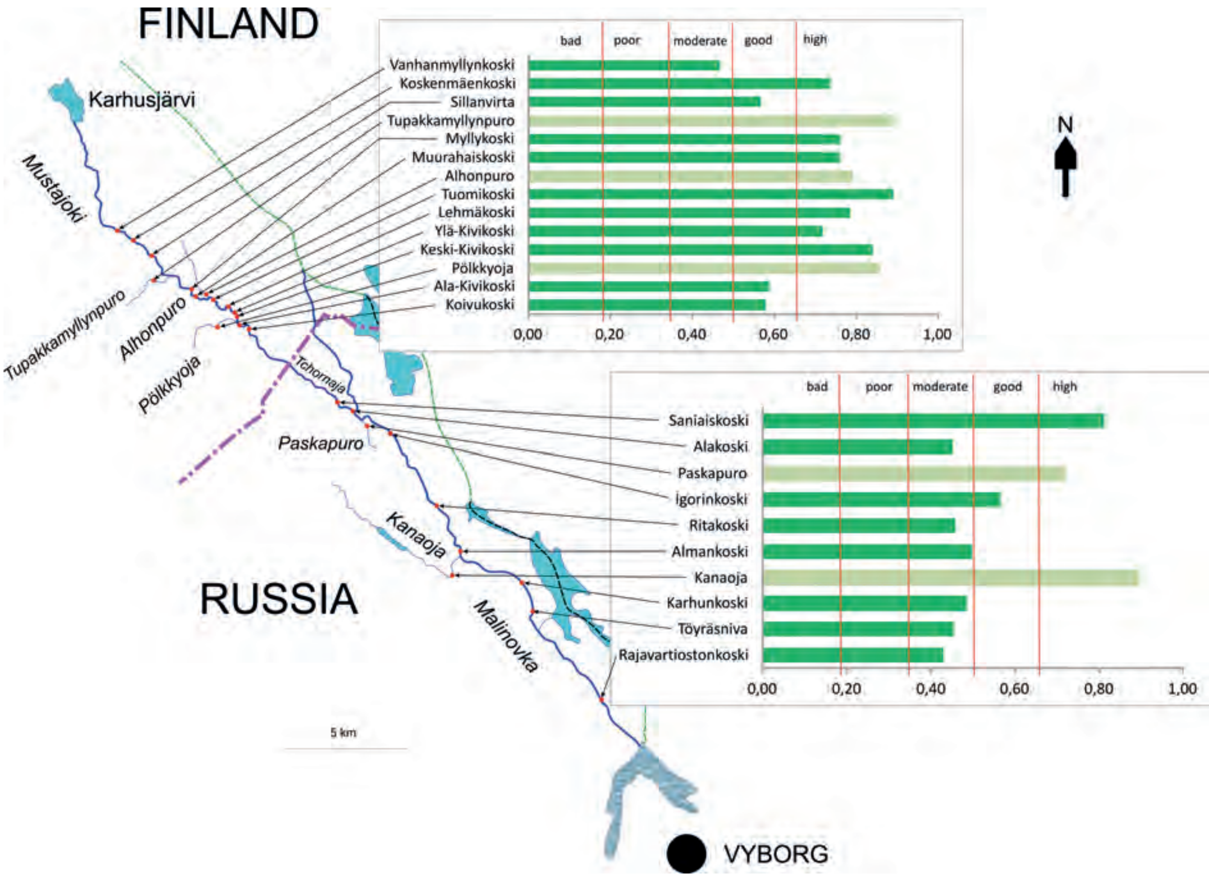

Figure 7. The ecological status of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system in 2013. The dark green bars indicate the main river channel and the light green bars the small tributaries.

The ecological status in Hounijoki/Buslovka/Rakkolanjoki/Seleznevka was mainly moderate. In one rapids, Buslovka alin, the ecological status was rated as high, which resulted from the fact that the intolerant species, bullhead, was the only species in the electrofishing catch (Figure 8, Appendix). Some mayflies and caddisfly larvae of species that are indicators of clean water were also observed in this rapids area (Zuyev & Mitskevich 2014). The tributary, Gusinaya, was also classified as high in its ecological status, because only trout were caught from there, although low in numbers and density (Figure 5, Appendix).

The lack of trout from most rapids in this river system (Figure 5) can clearly be seen in the generally lower values of the ecological status estimates compared to Mustajoki/Tchornaja/Soskuanjoki/Malinovka. As already discussed above, the lack of trout may partly relate to the observed hypertrophic nature of the water in the River Rakkolanjoki/Seleznevka (Lindgren 2014) as a consequence of the external load to this river channel. It should be noted here that, in general, the number of species caught from Hounijoki/Buslovka/Rakkolanjoki/Seleznevka was so low (Figure 5, Appendix) that the observed fish densities and values of ecological status are not precise and can thus be regarded as only suggestive. However, the general impression of Mustajoki/Tchornaja/Soskuanjoki/Malinovka holding a better ecological status than Hounijoki/Buslovka/Rakkolanjoki/Seleznevka most likely reflects the true situation.

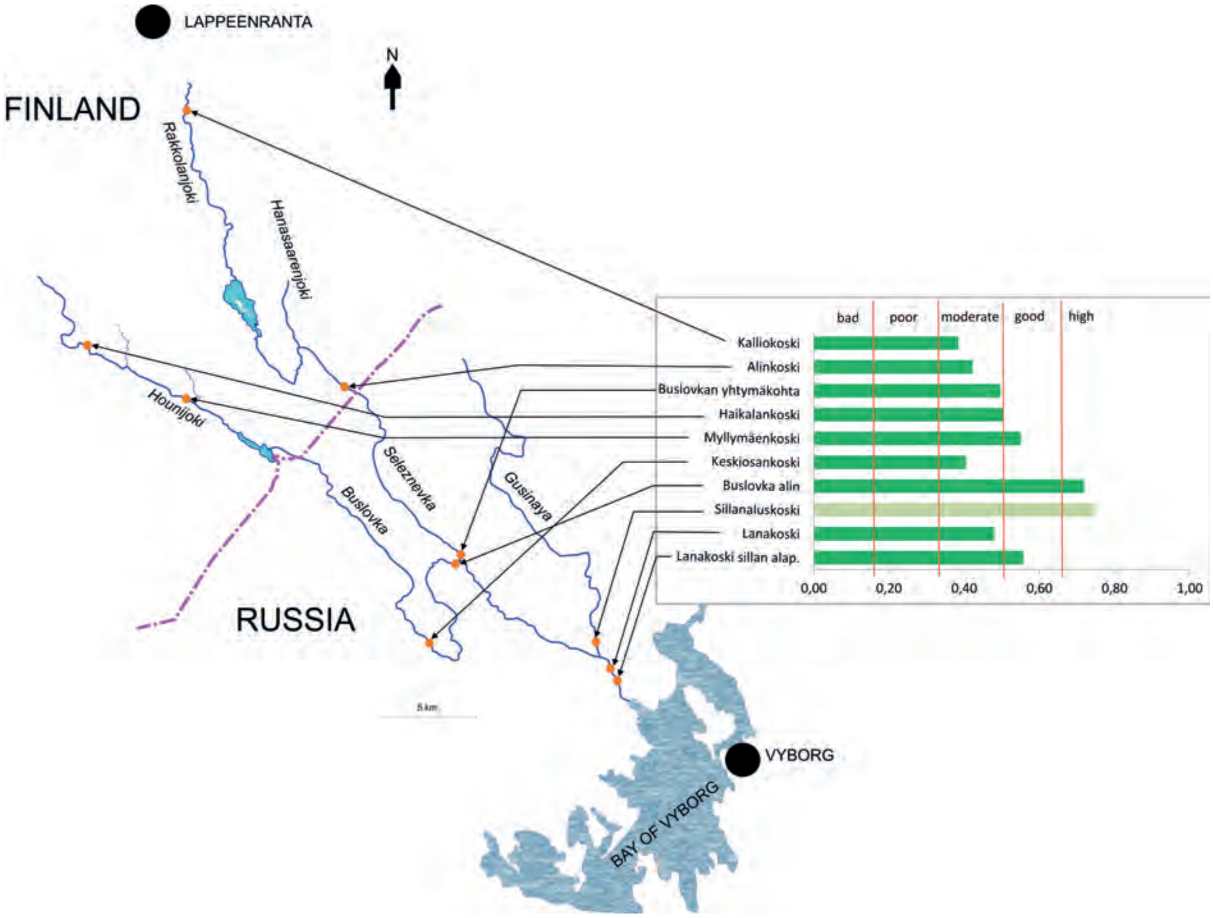

Figure 8. The ecological status of the Hounijoki/Buslovka/Rakkolanjoki/Seleznevka River system in 2013. For Haikalankoski and Myllymäenkoski rapids, the data are from 2012 (see Figure 5 caption for explanation). The dark green bars indicate the Rivers Rakkolanjoki/Seleznevka and Hounijoki/Buslovka, and the light green bar indicates the tributary Gusinaya.

3.2.3. The effect of restoration on trout densities

River restoration in RIFCI was conducted in nine rapids of the main channel of the River Mustajoki and in five rapids in the River Soskuanjoki (Lindgren 2014b). Five of the restored rapids in the River Mustajoki were electrofished yearly, and possible changes in trout densities could thus be monitored at these sites. The estimated trout densities in the restored rapids clearly increased during the project (Figure 10). However, some increase in trout densities was also observed in the other rapids (Appendix).

Restored spawning ground for the sea trout.

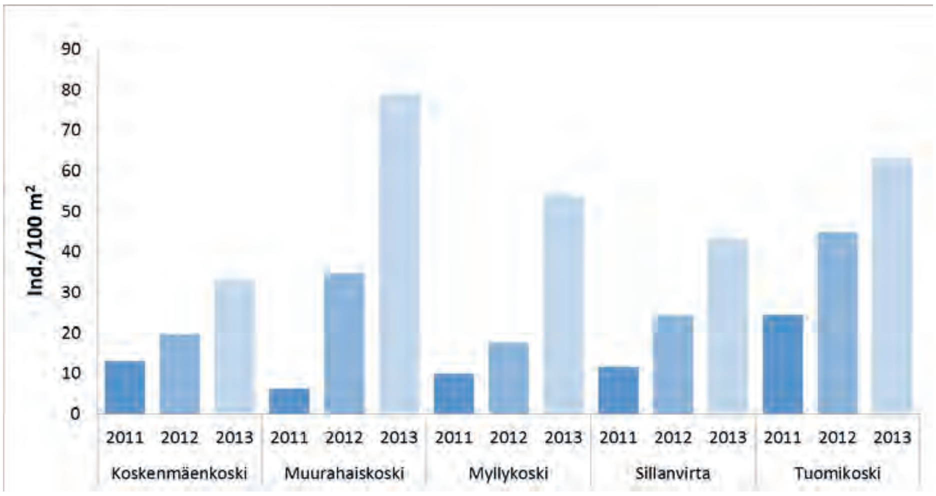

Figure 9. Estimated trout densities in five restored rapids of the River Mustajoki in three successive years.

The heavy rains and the resulting high water level in 2011 and 2012 improved the breeding conditions for trout in general. Therefore, in addition to restorations as such, benign environmental conditions also presumably increased the numbers of young trout. Although these two factors cannot be distinguished from each other with the current data, our finding of 0+ (n = 3) and 0+ and 1+ (n = 6 and 5) salmon in 2012 and 2013, respectively, from the electrofishing sites in a restored rapids area, Rajalinjankoski (Appendix), in the River Soskuanjoki suggests a positive influence of restoration on the overall living conditions of salmonids. Salmon appeared to accept the restored rapids as their breeding habitat. To the best of our knowledge, salmon have not occurred in this river system earlier. No trout were found from the restored rapids in the River Soskuanjoki. The fact that only salmon were found this restored area may be a mere coincidence. Trout are typically relatively flexible in finding new reproduction areas, although admittedly in rivers where they have already been reproducing (Elliot 1994). Future monitoring of the fish populations in the restored rapids will reveal whether the anticipated positive effect of restoration will hold true.

3.2.4. Size and age distribution of trout

The length and age structure of trout caught from Mustajoki/Tchornaja/Mustajoki/Malinovka (Figure 10) was characterized by a profusion of the youngest year classes (0+, 1+), with the older year classes being represented by only a small number of individuals (n = 25). The age of the older trout ranged from 2+ to 5+ years, with trout of age groups 2+ and 3+ making up the majority (12 and 10 individuals, respectively). Only two 4+ and one 5+ trout were caught. The size of these older fish ranged from 176 mm to 400 mm in length, and 52 g to 650 g in weight. The observed age structure is typical for a wild sea trout parr population from which the older fish have migrated to the sea (Saura 1999). The presence of a few larger and older fish suggests that there are also resident trout in the population, which is typical for trout.

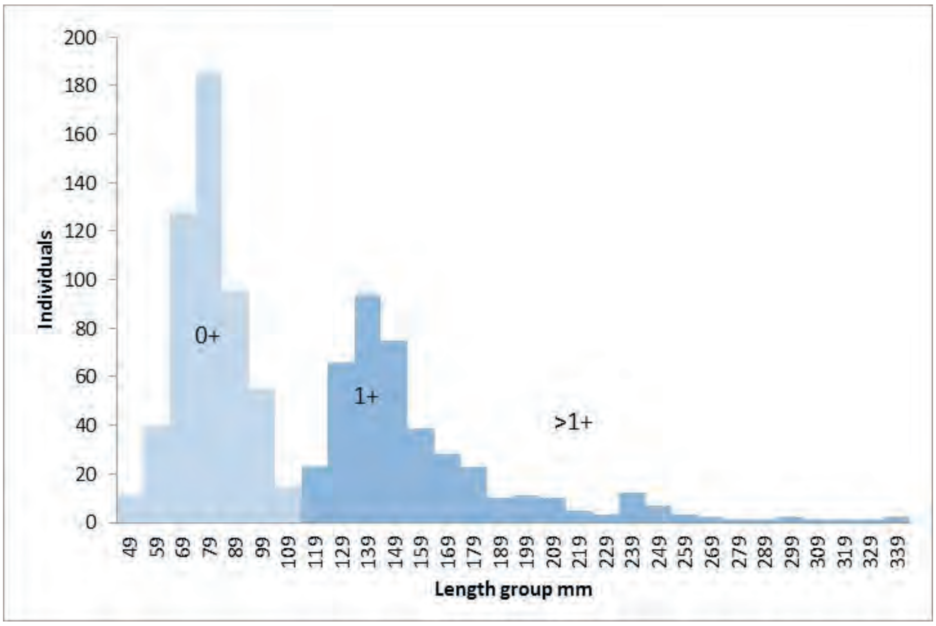

Figure 10. Length and age structure of trout in the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system (n = 955 individuals) in 2011–2013.

3.2.5. Growth and migration of tagged 1+ and older trout

Eight of the 258 tagged 1+ or older trout from Mustajoki/Tchornaja/Soskuanjoki/Malinovka have been recaptured thus far. All the recaptures were carried out in the year following tagging. Five individuals had stayed at the tagging site, two fish had moved upstream and one fish downstream (Figure 13). All the recaptured fish had grown a few centimetres during the year, the fastest grower attaining an increase of 8.4 cm in length (Table 4).

Given that the recaptured fish either remained at the site of tagging or did not move very far from there, they appeared to belong to the resident portion of the population. The fish that were not caught again probably belonged to the migrating, anadromous part of the population. However, no tags have thus far been recovered from the sea, so this suggestion cannot yet be verified by the data. However, the size distribution of the trout population during electrofishing (Figure 10) and the observation of bright, large spawning fish from the river slightly later in the autumn (pers. obs.) strongly suggests that the population is anadromous, or at least partly.

A T-bar anchor tagged trout from the River Mustajoki.

Table 4. The year and site of tagging, and tagging size of the recaptured trout from Mustajoki/Tchornaja/Soskuanjoki/Malinovka. The recapture year and site, and the individual size at recapture are also given. The distance that the fish moved from the tagging site between tagging and recapture is indicated in the last column.

Tagging year	Tagging site	Tagging size, mm	Recapture year	Recapture site	Recapture size, mm	Movement, m
2011	Sillanvirta	207	2012	Vanhanmyllynkoski	282	1670, upstream
2011	Sillanvirta	124	2012	Koskenmäenkoski	180	872, upstream
2011	Koskenmäenkoski	128	2012	Koskenmäenkoski	219	0
2011	Sillanvirta	148	2012	Sillanvirta	248	0
2011	Sillanvirta	205	2012	Sillanvirta	289	0
2012	Koivukoski	242	2013	Koivukoski	277	0
2012	Koivukoski	149	2013	Koivukoski	190	0
2012	Paskapuro	215	2013	Igorinkoski	235	1700, downstream

Figure 11. Tagging sites (red dots) and movement (black arrows) of the three tagged fish from the site.

3.2.6. Genetic structure of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout population

All cross-border river populations grouped together with short genetic distances when analysed together with all the sea trout populations of the Gulf of Finland. They formed a distinct Bay of Vyborg population group. The overall diversity of the trout of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka population was rather high (0.63) when compared to the other Bay of Vyborg populations (50-64) (see Koljonen *et al.* 2013). The Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout population was found to be very unique, with Fst values over 0.1 when compared to other rivers of the area. It only had some similarity with the trout from the rivers Urpalanjoki (Fst = 0.06) and Santajoki (Fst = 0.07) (Koljonen *et al.* 2013), which are also cross-border rivers in the Bay of Vyborg area.

In all, 605 trout individuals and 11 samples were analysed from the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system itself, and one sample of 40 individuals from those was a broodstock sample from the Laukaa fish hatchery collected from the River Mustajoki, on the Finnish side (Table 5). The samples from the main channel were divided into five sections, and five tributaries were also sampled. Sampling sites are indicated in Figure 12.

Table 5. Number of fish (N) sampled from different sites of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system, diversity values (DIV), number of observed alleles in each sample (N all), the sum of the allelic richness over 15 loci (Sum A rich) and the mean allelic richness (Mean A rich) are given over 15 loci and for 17 individuals, which was the smallest number of analysed individuals in any locus.

	Sample	Location/name	N	DIV	N all	Sum A rich	Mean A rich
1	Main stream 1	Russia	62	0.62	80	68.4	4.6
2	Main stream 2	Russia	31	0.60	73	68.7	4.6
3	Main stream 3	Finland	45	0.60	75	67.9	4.5
4	Main stream 4	Finland	103	0.62	85	69.4	4.6
5	Main stream 5	Finland	116	0.60	86	67.6	4.5
6	Tributary 1	Kananoja, Russia	59	0.58	77	65.3	4.4
7	Tributary 2	Paskapuro, Russia	19	0.57	55	54.4	3.6
8	Tributary 3	Tupakkamyllynpuro, Finland	66	0.60	90	72.0	4.8
9	Tributary 4	Alhonpuro, Finland	27	0.58	71	66.0	4.4
10	Tributary 5	Pölkkyoja, Finland	37	0.58	70	62.0	4.1
11	Hatchery	Laukaa, Finland	40	0.61	86	73.2	4.9
All			605		115	73.5	4.9

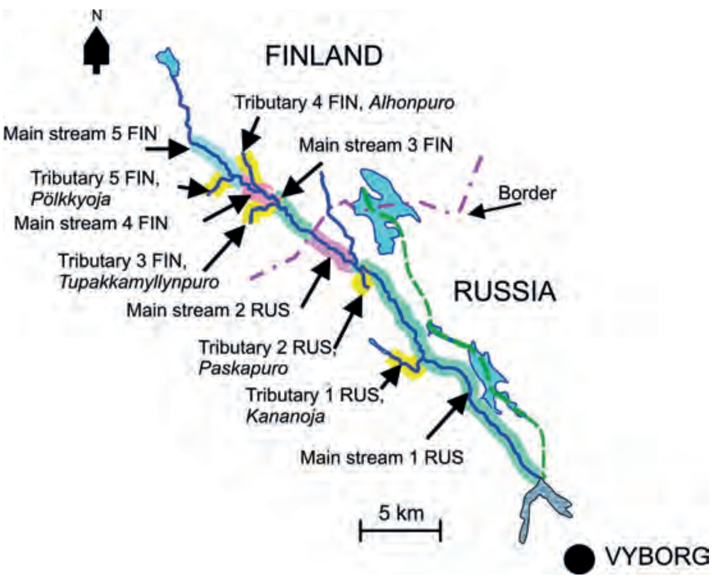

Figure 12. Sampling sites and numbering of river sections for DNA-microsatellite analysis of trout samples in Mustajoki/Tchornaja/Soskuanjoki/Malinovka.

The genetic distances between different samples were small, the average Fst among samples being only 0.04. The diversity level of all samples was high and varied from 0.57 to 0.62 (Table 5). The total number of alleles in trout from Mustajoki/Tchornaja/Soskuanjoki/Malinovka was 115, and as many as 86 of these were also observed in the broodstock sample. The allelic richness of the hatchery sample was also high. The mean allelic richness among samples from the wild varied from 3.6 for Paskapuro to 4.8 for Tupakkamyllynpuro. The overall allelic richness was 4.9, the same as in the hatchery sample. In comparison with other rivers, the Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout had the highest allelic richness (4.7) among the cross-border river populations (3.3 - 4.4), when the partly hatchery-influenced Urpalanjoki (6.2) was excluded. On the Russian side, however, a higher allelic richness has been observed in several trout populations (4.5 - 5.7) (Koljonen *et al.* 2013)

A statistically significant difference was observed between samples from the mainstream sections 2 and 3 on both sides of the border (Figure 12). Although the distances were small, some grouping could be seen and the samples formed three main groups: the lower reaches on the Russian side and the middle and upper reaches in Finland (Figure 13). The lower reaches, river sections 1 and 2, and two lowest tributaries, Kananoja and Paskapuro on the Russian side, grouped together. The middle reaches, river sections 3 and 4, and tributaries 3 and 4, Tupakkamyllynpuro and Alhonpuro, formed a loose group. The third group was the most distant section of the stream and tributary 5, Pölkkyoja.

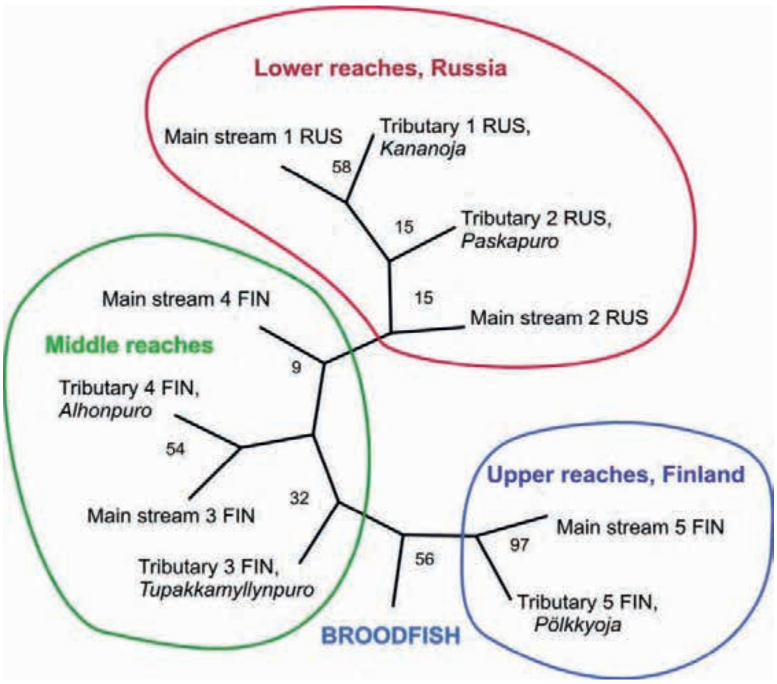

Figure 13. Genetic distances drawn from the Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout samples, based on Nei D_A distances and the NJ tree.

The broodstock sample from Laukaa hatchery grouped closer to the Finnish areas, where broodstock sampling has also occurred (see 4.1). Additional broodstock sampling from the Russian side of the river might increase the diversity of the broodstock, although this is already high.

The mainstream samples and the tributary samples did not group separately, so gene flow (mixing of gene pools of subpopulations) between tributaries and the mainstream appears not to be limited, and no special differentiation has occurred in the tributary populations. If local resident subpopulations exist, they share much of the common gene pool. As already suggested by the ISKALT II project (Saulamo *et al.* 2007), the Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout population seems to be a native and viable population, which has maintained its original although relatively weak structuring.

4. Conservation of River Mustajoki trout

4.1. Broodstock establishment

A representative broodstock (live gene bank) of the River Mustajoki trout was established in order to preserve the genetic biodiversity of the only native sea trout population on both the Finnish and Russian sides in the cross-border rivers draining into the Gulf of Finland. The broodstock was also established for returning by restocking the sea trout to its former distribution area in Finnish rivers draining into the eastern Gulf of Finland. Currently, the hatchery stock of Isojoki trout originating from the western coast of Finland is used for trout releases in the coastal sea-run rivers of Southeast Finland. The ultimate goal is to replace the foreign Isojoki trout with the Mustajoki trout. The hatchery-produced young trout could also be used for releases into the River Mustajoki in case the local wild population is in immediate danger of going extinct, e.g., due to some external disturbance.

Trout were electrofished from the River Mustajoki in three successive autumns from 2011–2013. The collection of fish was spread as far along the river as possible to obtain a representative sample of the wild population. In all, 254 young trout (0+ and 1+ age class) were transferred to the Laukaa aquaculture station of FGFRI (Table 6).

Table 6. The capture site, date and the number of 0+ and 1+ trout caught from the River Mustajoki for broodstock establishment in different years.

Catching site	2011	0+	1+	2012	0+	2013	0+	1+	
Vanhanmyllynkoski				12.9.	12				
Metsänvirta						11.9.	3		
Sillanvirta	20.-21.9.	2	5	12.9.	14				
Koskenmäenkoski	20.-21.9.	5	5	12.9.	6	11.9.	6		
Tuomikoski	20.9.	12	1	12.9.	17	11.-12.9.	6	13	
Alhonpuro, downstream	20.9.	1	4	12.9.	10				
Alhonpuro, upstream	20.9.		2						
Tupakkamyllynpuro, downstream						11.9.	15		
Tupakkamyllynpuro, upstream				12.9.	15	11.9.	27		
Pölkkyoja	20.-21.9.		8			11.9.	10		
Muurahaiskoski	21.9.		2						
Myllykoski	21.9.	3	9	12.9.	15	11.9.	14		
Ylä-Kivikoski	21.9.	1							
Vedenottamo	21.9.		1						
Sum		24	37		99		81	13	**254**

The electrofished trout were stored in a flow-through tank in the river for 24 hours at maximum before their transportation in an aerated tank to the quarantine facilities in the Laukaa aquaculture station, FGFRI.

The trout have been reared in Laukaa aquaculture station since their capture. They were first fed fly pupae *ad libitum* and were gradually habituated to artificial pelleted fish feed. To monitor for any infectious diseases, the water from the rearing tanks was conveyed to adjacent tanks containing sentinel fishes (rainbow trout, Arctic charr) known to be susceptible to infectious diseases. According to the instructions of the Finnish Food Safety Authority Evira, the sentinel fishes were analysed for diseases after rearing the trout in the quarantine tanks for a minimum of 60 days with the water temperature maintained at under +14 °C for at least 30 days. No signs of diseases have been found from the sentinel fishes and all trout have been transferred to normal hatchery conditions to continue rearing. Some mortality occurred during the early phases in the hatchery when the fish needed to acclimatise to the artificial conditions. Currently, there are 156 trout left in the Laukaa aquaculture station. When the fish reach maturity, they will be individually tagged with PIT tags and artificially mated, avoiding parings with close relatives in order to produce as genetically variable a broodstock as possible. The offspring of the broodstock will be used for later releases into the wild. The hatchery stock will be supplemented from the wild in order to maintain its genetic diversity and viability in the long term.

4.2. Introducing trout into the River Soskuanjoki/upper reaches of the River Malinovka

In order to expand the range of occurrence of the native trout population in the whole of the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system, and thereby support population existence in the wild, trout were introduced into the River Soskuanjoki/upper reaches of the River Malinovka (Figure 14).

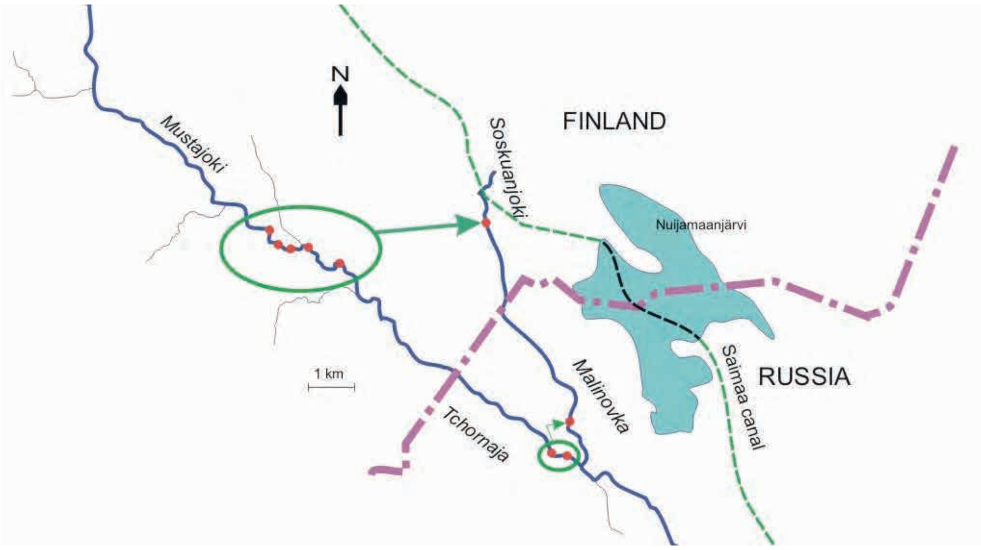

Figure 14. Catch and release sites of trout in the River Mustajoki/Tchornaja and River Soskuanjoki/upper reaches of the River Malinovka, respectively.

In total, 78 trout aged 1+ or older were transferred to the River Soskuanjoki in 2013, to a rapids area, Suikin Myllykoski, that had previously been under restoration in the RIFCI project. The transfer was possible to carry out on the Finnish side during the third field season of the project, when enough 1+ or older trout were present in the river. On the Russian side, 30 trout were transferred from the River Tchornaja to a rapids area, Kasevankoski, in the upper reaches of the River Malinovka in 2012. Trout that were large enough for tagging were individually T-bar anchor tagged (n = 67).

The presence of the trout at the site of introduction was later confirmed by a visual check and electrofishing. Based on the occurrence of trout in the River Soskuanjoki, it appears that they accepted the new habitat and remained there at least during the first autumn after transfer. On the Russian side, no observations of the transferred trout have subsequently been made.

Composition of the Finnish sea trout catch in the eastern Gulf of Finland

It is not known in which proportions trout from different native or hatchery populations around the Gulf of Finland are represented in the coastal sea trout catch. This knowledge is important for sea trout management in the whole of the Gulf of Finland. Therefore, genetic analyses were carried out to investigate the population composition and origin of the trout catch. These analyses also provided some information on the migration pattern of the different trout populations around the Gulf of Finland.

4.3. Material and methods

In all, 59 river systems and 4 224 individuals were utilised in the current work as comparison information, or baseline data, for analysing the origin of the Finnish coastal sea trout catches. The rivers were listed and numbered from west to east along the coast (Figure 15). The samples only included anadromous populations. Sixteen of the rivers were entirely on the Finnish side of the coast. Seven of the rivers crossed the Russian border, with the upper reaches of the rivers located in Finland and the lower parts draining into the sea in Russia (FIN/RUS status). In addition, 23 rivers on the Russian coast and 14 rivers from the Estonian coast were included in the baseline comparison data.

Moreover, one hatchery stock, Isojoki, from Finland was included in the analyses. Given that this stock has been used in hatchery releases in the area, it was assumed to occur in the catches as well. The Russian baseline samples, similarly to some Finnish samples, had already been collected in the previous INTERREG projects ISKALT (Rahikainen & Vähänäkki 2006) and ISKALT II (Saulamo *et al.* 2007). This part of the data set was updated for 15 DNA microsatellite loci from the previous 10-loci data sets. The Finnish and Estonian river samples were mainly collected within the HEALFISH project (Koljonen *et al.* 2013, Gross *et al.* unpublished data). The Finnish population samples were obtained from rivers discharging into either the nearby Archipelago Sea or into the Gulf of Finland.

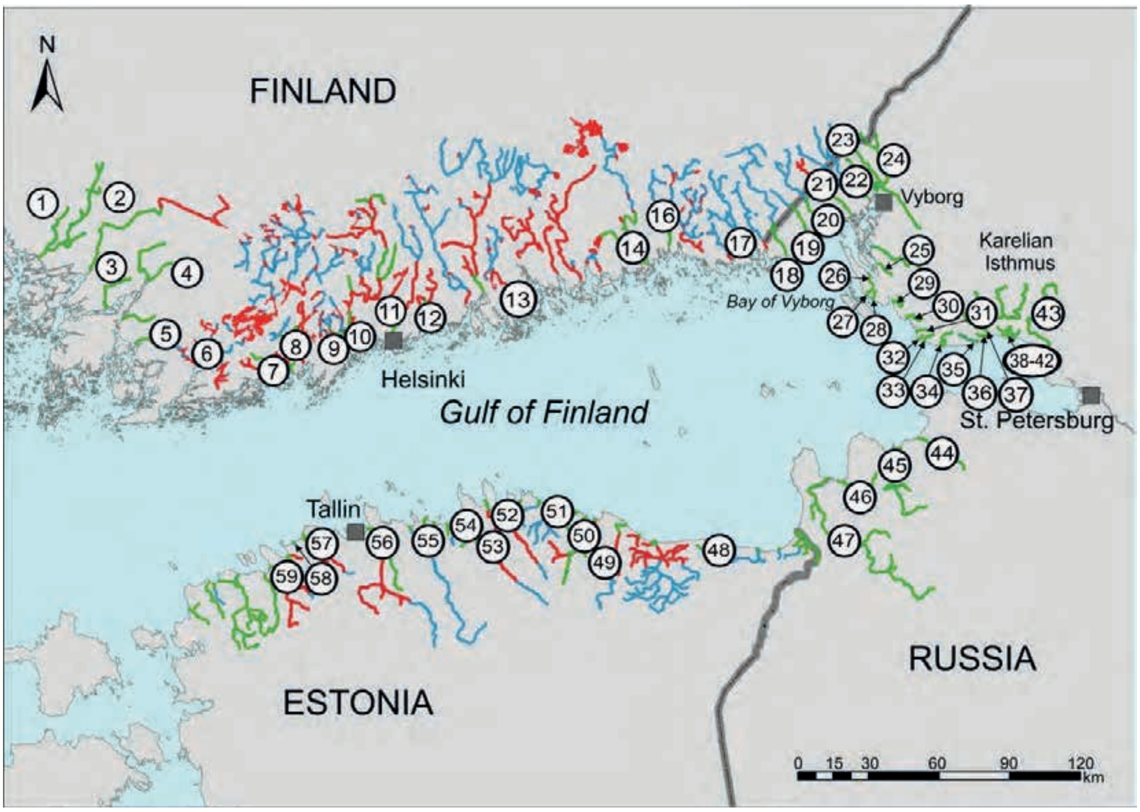

Figure 15. Sea trout populations in Finland, Russia and Estonia that were sampled and genotyped to create a baseline data set for mixed stock analysis. The colour of the river indicates its quality as a spawning site and potential environment for brown trout. Red: river is closed; blue: irregular reproduction occurs; and green: open river with regular natural production of trout populations. The names and numbering of the rivers are as follows: 1) Aurajoki, 2) Paimionjoki, 3) Purilanjoki, 4) Uskelanjoki, 5) Kiskonjoki, 6) Fiskarsinjoki, 7) Ingarskilanjoki, 8) Siuntionjoki, 9) Mankinjoki, 10) Espoonjoki, 11) Vantaanjoki, 12) Sipoonjoki, 13) Koskenkylänjoki, 14) Kymijoki, 15) Isojoki (hatchery stock, not in map), 16) Summanjoki, 17) Virojoki, 18) Urpalanjoki, 19) Santajoki, 20) Vilajoki, 21) Tervajoki, 22) Rakkolanjoki, 23) Mustajoki, 24) Kilpeenjoki, 25) Römpötinpuro, 26) Myllyoja, 27) Koivistonpuro, 28) Penttilänoja, 29) Kello-oja, 30) Lohijoki, 31) Papinoja, 32) Toivolanpuro, 33) Notkopuro, 34) Jukkolanpuro, 35) Inojoki, 36) Pikkuvammeljoki, 37) Vammeljoki, 38) Tyrisevänoja, 39) Hurrinoja, 40) Terijoki, 41) Huumosenoja, 42) Kuokkalanpuro, 43) Rajajoki, 44) Voronka, 45) Sista, 46) Havlonka, 47) Luga, 48) Pühajõgi, 49) Kunda, 50) Toolse, 51) Selja, 52) Loobu, 53) Valgejõgi, 54) Pudisoo, 55) Mustoja, 56) Pirita, 57) Vääna, 58) Keila, 59) Vasalemma.

For the catch analysis, 1 372 trout were caught from the sea from three sectors of the Gulf of Finland, mostly from the eastern part of the Gulf of Finland and relatively close of the Finnish coast (Table 7). The samples were from the years 1996 to 2012, and they do not therefore represent results from any particular year (Table 8), but rather provide an overview of the situation in recent times, when hatchery stock releases have been rather intensive in Finland.

Table 7. Sampling sites and numbers of sampled fish (N) from the Finnish sea trout catch.

Area	Municipality	Location	N
1	Virolahti, Hamina, Kotka	East	656
2	Pyhtää, Ruotsinpyhtää, Loviisa, Pernaja	Middle	492
3	Porvoo, Sipoo, Helsinki, Espoo, Kirkkonummi	West	224
In all			1 372

Table 8. Sampling years and numbers of sampled fish of Finnish sea trout catch samples in the three sampling areas numbered from east to west.

Year	N Area1	N Area2	N Area3	N all areas
1996	1	-	39	40
1997	19	-	10	29
1998	-	3	-	3
2002	2	-	4	6
2003	14	1	1	16
2004	7	-	-	7
2005	13	-	-	13
2006	63	-	-	63
2007	106	-	-	106
2008	70	26	2	98
2009	95	87	2	184
2010	61	104	61	226
2011	67	140	104	311
2012	138	131	1	270
All	656	492	224	1 372

Based on genetic distances, a clear clustering of populations into eight groups could be seen in the baseline data set. These eight groups were used as reporting groups in the catch analysis (Table 9). Four groups were from Finland (1–4), one group was a cross-border river group (5), two groups were from Russia (6, 7) and one from Estonia (8).

DNA-sampling of trout by fin clipping.

Table 9. Sea trout populations included in the reporting groups of the catch analysis.

	Reporting group name	River populations	
1	Aurajoki	Aurajoki, Kiskonjoki, Fiskarsinjoki	FIN
2	Uskelanjoki	Paimionjoki, Purilanjoki, Uskelanjoki, Siuntionjoki	FIN
3	Ingarskilanjoki	Ingarskilanjoki, Mankinjoki, Espoonjoki, Vantaanjoki, Sipoonjoki, Koskenkylänjoki	FIN
4	Isojoki	Kymijoki, Isojoki, Summanjoki	FIN
5	Bay of Vyborg	Virojoki (FIN), Urpalanjoki, Santajoki, Vilajoki, Tervajoki, Rakkolanjoki, Mustajoki, Kilpeenjoki, Römpotinpuro, Myllyoja	FIN/ RUS
6	Karelian Isthmus	Koivistonpuro, Penttilänjoki, Kello-oja, Lohijoki, Papinoja, Toivolanpuro, Notkopuro, Jukkolanpuro, Inojoki, Pikkuvammeljoki, Vammeljoki, Tyrisevänoja, Hurrinoja, Terijoki, Huumosenoja, Kuokkalanpuro, Rajajoki	RUS
7	Russia South coast	Voronka, Sista, Havlonka, Luga	RUS
8	Estonia	Pühajõgi, Pudisoo, Mustoja, Pirita, Kunda, Toolse, Selja, Loobu, Valgejõgi, Vääna, Keila, Vasalemma	EST

The proportion of individual river populations and population groups in sea trout catches in the three areas of the Gulf of Finland was assessed with the maximum likelihood method and ONCOR software (www.montana.edu/kalinowski/Software/ONCOR.htm) (Kalinowski *et al.* 2007, Anderson *et al.* 2008). In all, 59 baseline populations, eight reporting groups and 15 microsatellite loci were used. The DNA methods were the same as in Koljonen *et al.* (2013).

The composition of sea trout catches in the Gulf of Finland was calculated separately for the total catch and the three sea areas, for the individual stocks, and for the defined eight reporting groups. In addition, the probability of each individual fish originating from any of the baseline populations was calculated. Information on individual river populations and individual fish is not given here, but all fishermen received the information on the origin of trout in their own catch.

4.4. Results and discussion

The majority of the catch came from Finnish trout populations (Table 10, Figure 16). The largest group of the catch fish came from Finnish Isojoki hatchery population releases, which alone represented about one half of the catch in the eastern and middle area. The Isojoki hatchery population also comprised a large proportion of the catch (37.8%) in the westernmost area, where the Ingarskilanjoki group also formed a large proportion (38.4%).

In all, at least 75% of the catch originated from Finnish hatchery releases. The Ingarskilanjoki group is not entirely based on hatchery production, and hatchery and wild production of the same population cannot be distinguished in this type of analysis. Therefore, no exact figure for the hatchery production percentage could be given. The trout from the Bay of Vyborg population group mostly occurred in the eastern area, but represented only about 1% of the total catch. About half of these fish appeared to originate from the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system. The Russian groups, 6 and 7, together represented about 6% of the catch and were also more common in the eastern sector. Somewhat surprisingly, the Estonian trout populations, group 8, quite commonly occurred in Finnish catches and especially in the western sector of the gulf. This group represented in all about 14% of the total catch. The populations from the Finnish Archipelago Sea, the Uskelanjoki group, did not occur in the studied catches.

Table 10. Maximum likelihood estimates (ONCOR) of sea trout population group proportions (%) and their 95% confidence intervals (CI) for Finnish sea trout catches in the Gulf of Finland in three sea areas numbered from east to west. Proportions that differ statistically significantly from 0 are shown as shaded.

	Area 1			Area 2			Area 3			All		
Reporting group	Prop. %	*2.5 %*	*97.5 %*	Prop. %	*2.5 %*	*97.5 %*	Prop. %	*2.5 %*	*97.5 %*	Prop %	*2.5 %*	*97.5 %*
1 Aurajoki	2	1	3	3	2	5	4	1	7	2	2	4
2 Uskelanjoki	0	0	0	0	0	0	0	0	1	0	0	0
3 Ingarskilanjoki	24	21	28	21	17	25	38	33	45	25	23	28
4 Isojoki	54	49	58	52	48	57	38	30	44	51	48	53
5 Bay of Vyborg	2	1	4	0	0	1	0	0	2	1	1	2
6 Karelian Isthmus	4	2	5	3	1	4	2	0	5	3	2	4
7 Russia South Coast	3	2	5	5	2	7	1	0	3	3	2	4
8 Estonia	11	9	14	16	13	20	17	12	22	14	12	16

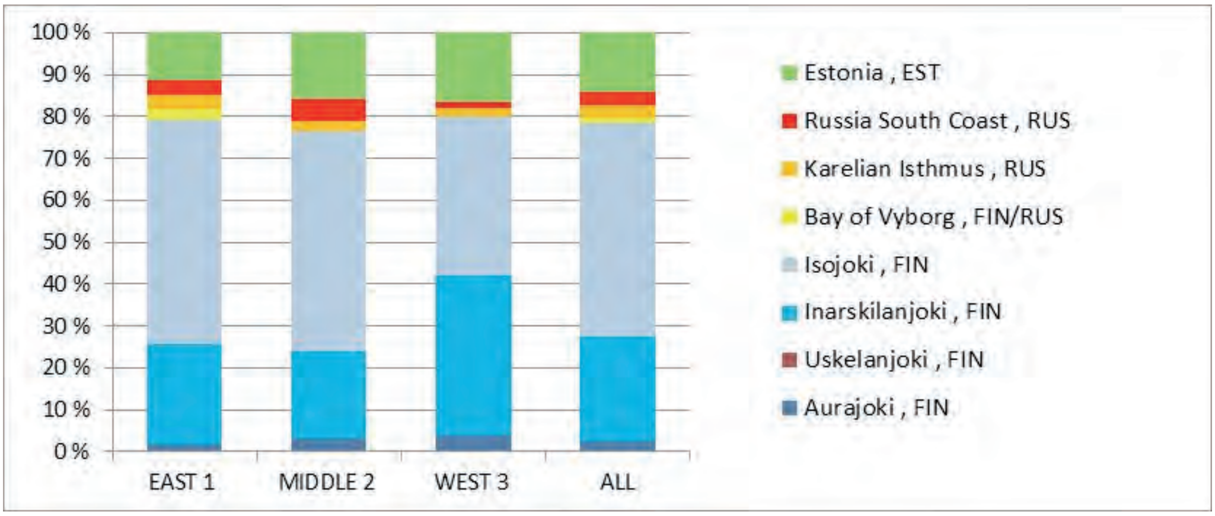

Figure 16. Population group proportions in the Finnish sea trout catches in the Gulf of Finland for the eight reporting groups.

The four groups that represented entirely wild sea trout populations (Estonia Group, Russia South coast Group, Karelian Isthmus Group, Bay of Vyborg Group in Figure 16) contributed slightly more than 20% to the total catch. River Mustajoki/Tchornaja/Soskuanjoki/Malinovka trout (Bay of Vyborg Group) made up only a small fraction of this catch, and trout from the Karelian Isthmus and Russia South coast were the next most abundant, both representing approximately similar proportions of the catch (Figure 16). See Koljonen *et al.* 2014 for a more detailed analysis.

The result of ca. 20% of the trout catch being of wild origin emphasizes the importance of marking the hatchery-born stocked trout to be able to identify them from the catch by visual examination and thus release the unmarked, wild-born fish back into the sea. In Finland, this marking by adipose fin clipping is already a prevailing practice in trout releases in the Gulf of Finland area.

Most of the wild trout originated from Estonian rivers (Table 10, Figure 16), where the wild trout populations still are in a relatively good condition (ICES 2013). The abundance of wild trout from the Estonian rivers in the Finnish coastal catch can at least partly be explained by the direction and circulation of predominant water currents in the Gulf of Finland. The water flows from the Estonian coast towards the eastern Gulf of Finland, and then turns back along the Finnish coast (Figure 17). The trout follow the currents during their feeding migration and end up on the Finnish coast.

The low abundance of the Karelian Isthmus populations in the catch may be explained by the current circulating in another direction in the southeasternmost part of the Gulf of Finland, probably resulting in the feeding migration being directed to the coastal areas of Estonia and Russia in the southeastern part of the Gulf of Finland.

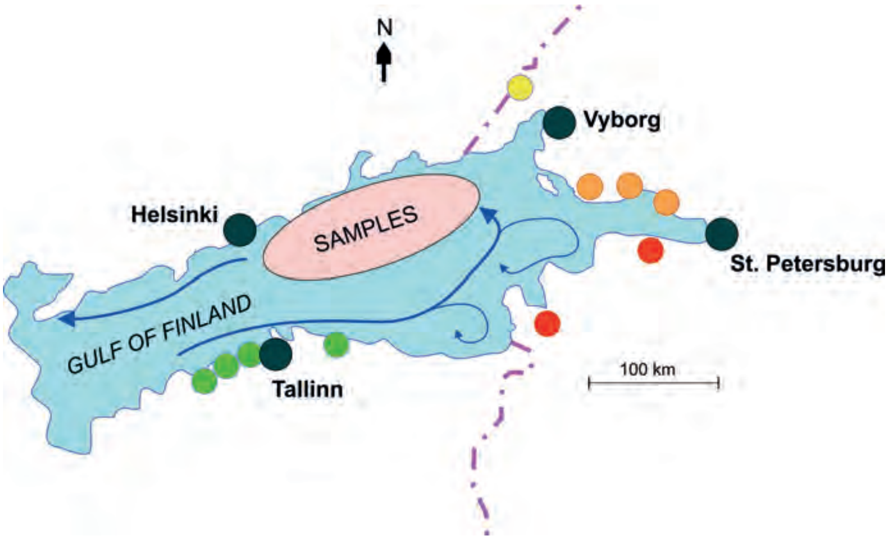

Figure 17. The sea area of the main trout catch (SAMPLES), and the regions from where the cross-border (yellow), Karelian Isthmus (orange), Russian south coast (red) and Estonian (green) wild trout populations in the catch originated. The arrows indicate the prevailing water currents in the Gulf of Finland.

5. Scale analysis and tagging of trout in the Gulf of Finland

Genetic sampling of trout in the sea catch was accompanied by scale sampling for age determination, and the tagging and release of the trout that had been caught alive to obtain information on their migration. Scale samples were taken from 616 trout, and 498 trout were tagged with T-bar anchor tags and released back into the sea during 2011–2013. In addition, we used data on tagged trout (n = 347) in the coastal area of Southeast Finland from 2006–2012 provided by a sea trout tagging project run by the Centre for Economic Development, Transport and the Environment of Southeast Finland.

The age and size were determined for the 616 trout from which scale samples were analysed. The trout were mostly caught during their first years (0 and 1) in the sea (Figure 18).

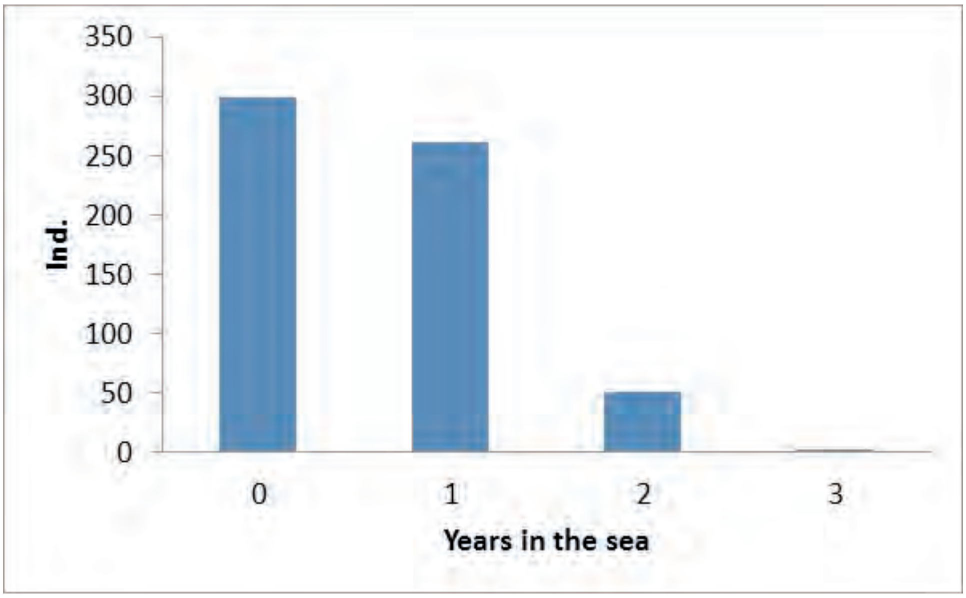

Figure 18. The number of caught trout representing different age groups (the number of years the fish have spent in the sea after smolting). Data are shown for trout from which scales were analysed (n = 616).

Most of the trout were undersized, the regional minimum size limits at the time of capture ranging from 40 to 65 cm (Figure 19). According to legislation from 2014 onwards, the legal minimum size limit for sea trout is 60 cm in Finland, and in the governmentally owned waters in the Gulf of Finland it was already set to 65 cm from the beginning of 2013 by the Centres for Economic Development, Transport and the Environment of Uusimaa and Southeast Finland. Female sea trout generally reach maturity at approx. 60 cm in length, having by then spent on average two or three years in the sea (Figure 20).

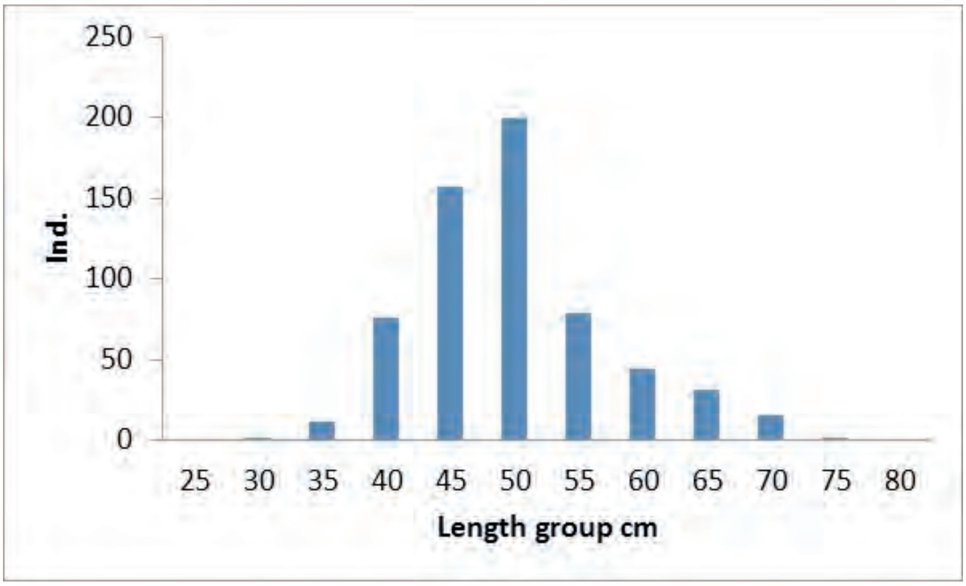

Figure 19. The length distribution of the captured trout from which scale samples were analysed (n = 616).

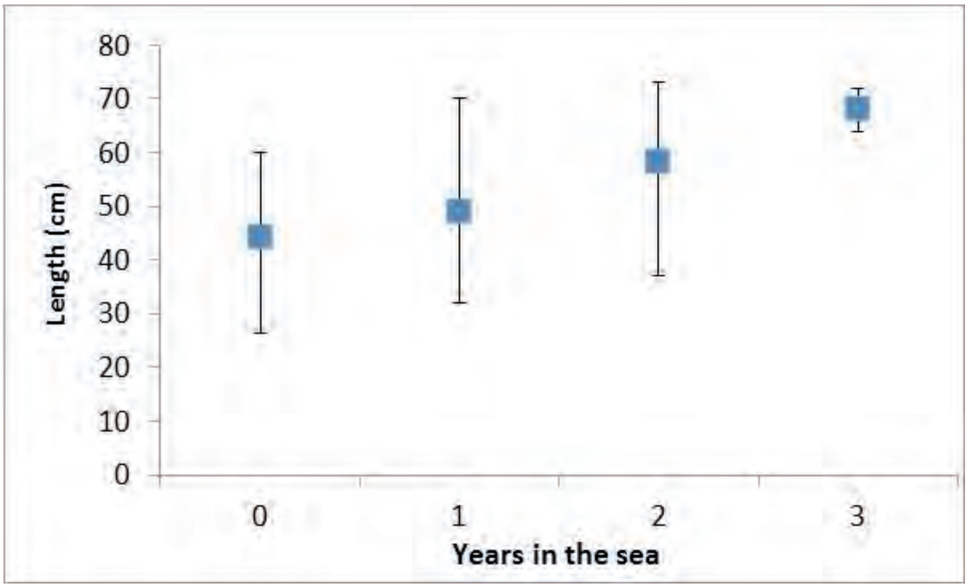

Figure 20. The mean length (the interval between the minimum and maximum length also shown) and age (number of sea years after smolting) of the trout at time of capture (n = 616).

In all, 58 T-bar anchor tags have been recovered thus far (Figure 21). Three of the tagged trout were recaptured from a river, one from the River Vantaanjoki and two from the River Kymijoki, possibly on their way to spawn. Seven tags were recovered from river mouths, from the River Vantaanjoki (n = 2) and Kymijoki (n = 2) in Finland, the River Urpalanjoki (n = 1) in Russia and the River Selja (n = 2) in Estonia. Three tags were recovered from the coastal waters of Estonia and the rest from the coastal waters of Finland (Figure 21). The recovery data suggest that the main migration route of sea trout in the Gulf of Finland is towards the west (Figure 21), which is in accordance with the results of the catch analysis. The result may also partly reflect the possible concentration of fishing activity in these areas. This may also explain the lack of all but one tag recovery from the Russian side, as fishing of trout is prohibited, and no tags can therefore be assumed to be returned from there (Kudersky 2002).

Figure 21. Map of the recapture sites (red dots) of tagged trout (n = 58).

Data on the weight gain of the tagged trout in between release and recapture reveal that most fish gained weight after release and the most intensive growth occurred during the second and third years in the sea (Figures 22 & 23). Nine of the recaptured trout had lost weight. It is possible that these individuals were stressed or developed inflammation due to handling (catching and tagging), and that this, in turn, resulted in weight loss. It is also possible that the weight loss was not related to handling of the trout, but to some other internal or external factor.

Overall, the results imply that it is very useful to release the trout if caught young, because the released individuals survive and will later provide a larger catch, but also, and perhaps even more importantly, they will reach maturity and reproduce. Our results thus support the recent changes in fishing policy that have been made to increase the legal minimum size of sea trout in Finland.

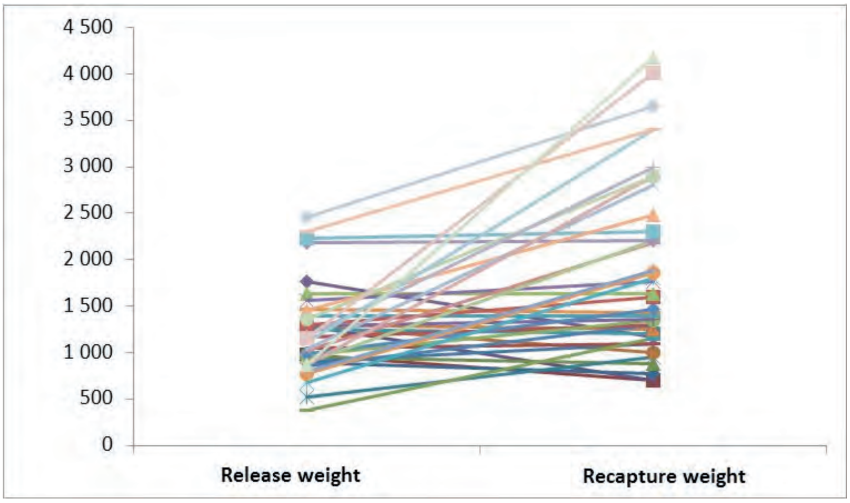

Figure 22. The release and recapture weight (g) of the tagged trout from which both measurements were available (n = 38), pooled for all release and recapture years

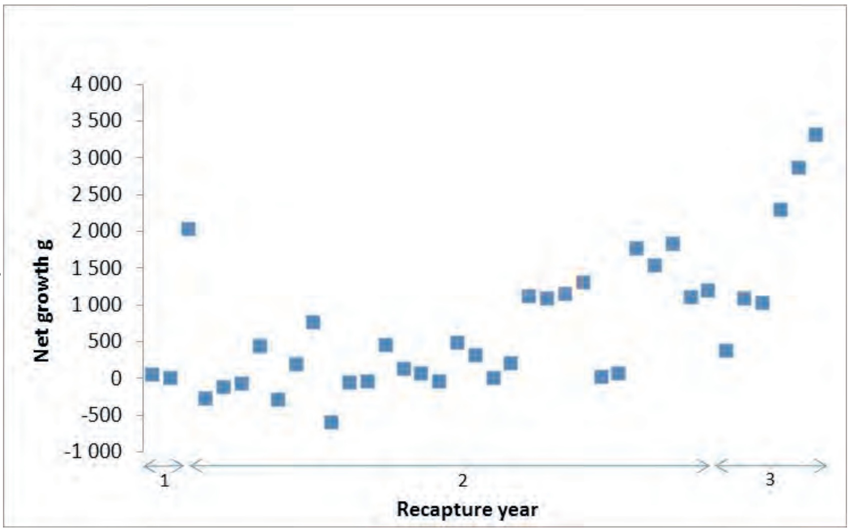

Figure 23. Net growth in grams (recapture weight-release weight) of tagged fish (n = 38) indicated for each individual for the recapture year: 1 = recapture during the tagging and release year, 2 = recapture during the second year after tagging and release, 3 = recapture during the third year after tagging and release.

The tagged trout could be divided into three types according to the fishing gear they were caught with. Most of the trout (69.2%) were caught with bottom gill nets. The rest of the trout had been caught by rod or line (17.3%) or using a fyke net (13.5%). The distribution of the trout catch among the different types of fishing gear in the current study reflects well the trout catch by different gear in the Gulf of Finland in general (Romakkaniemi *et al.* 2014).

6. Stocking of Atlantic salmon in the River Gladyshevka and River Rakkolanjoki

In 1999, the River Gladyshevka was included in the List of Potential Salmon Rivers of the ICES Salmon Action Plan. Salmon stock restoration by restocking was launched in the River Gladyshevka in the last decade, in 2001, and this activity has regularly been practiced since then. More than 150 000 hatchery-reared young salmon smolts have been released into the river. There is now evidence of natural reproduction from 2004 onwards. Restocking of salmon was continued during the current project to strengthen the salmon population in the river given that the status of the population according to ICES (2013) is still very uncertain.

In Hounijoki/Buslovka/Rakkolanjoki/Seleznevka, occasional observations of young salmon have earlier been made in the River Seleznevka during electrofishing, suggesting that the river might provide a suitable habitat for salmon. Salmon were therefore also released into the River Rakkolanjoki. The aim was to enhance salmon spawning migration all the way to the Finnish side after the migration obstacles have been removed from the river as a result of the RIFCI project. A sample of the released salmon was individually tagged in both Russia and Finland to obtain tag-recovery-based information on their migratory behaviour, and also on their possible return to the river to spawn.

6.1. Material and methods

In Russia, ca. 6 000 of the over 80 000 stocked salmon smolts of the hatchery-reared Neva population were T-bar anchor tagged and released into two rapids in the River Gladyshevka, near Old Mill and Sosnovaya Polyana village, during 2011–2013. Of these salmon, 80% were one-year-old fish (mean size 130 mm) and 20% were two-year-old fish (mean size 197 mm) (Figure 25). In Finland, ca. 12 000 two-year-old Atlantic salmon smolts (mean size 205 mm) of the hatchery-reared Neva population were released into the River Rakkolanjoki at Lyijynen village, near the border, in 2011–2013 (Figure 25). Of these salmon, ca. 2 000 individuals annually were T-bar anchor tagged.

6.2. Results and discussion

Seven individuals of the 12 000 tagged salmon were caught from the sea area during this project (Figure 25). Six of the captured fish were from the 2011 tagging and stocking in the River Rakkolanjoki and one fish from the 2012 tagging and stocking in the River Gladyshevka. Four of the salmon stocked in River Rakkolanjoki were caught from the coastal waters on the Finnish side of the Gulf of Finland. Two fish were caught from the Russian side, one individual from the Bay of Vyborg soon after stocking and one individual by the mouth of the Bay of Vyborg later on. The only salmon that has been recovered thus far from the River Gladyshevka stocking was caught from the Neva Bay (Figure 25).

With the exception of the one individual caught soon after stocking, the stocked salmon migrated to the sea and appear to have grown well during their feeding migration, based on the recoveries of seven of the tagged fish. The weight of these fish ranged from 2.2 to 11.2 kg at the time of capture (Figure 25). The size of the largest fish suggests that it was already on its way back to the river to reproduce.

The recovery data unfortunately are currently too scarce to draw any conclusions on the stocking success or migration pattern of the released salmon. Given that salmon spend one to several years in the sea before their spawning migration back to the river, it is likely that more tag recoveries will be obtained in the future. Licenses for technological changes to dams that would enable free migration of fish in the Hounijoki/Buslovka/Rakkolanjoki/Seleznevka River system were, unfortunately, not obtained during the RIFCI project, so tag recoveries from the upper reaches on the Finnish side cannot be expected, at least in the near future.

Figure 24. Stocking sites of salmon (open stars) in the River Rakkolanjoki and the River Gladyshevka, and the recapture sites of the released individuals (red dots). The weight of the fish (kg) at the time of recapture is also indicated.

Conclusions

The current study demonstrated that the only native sea trout population still existing on both Finnish and Russian sides of the cross-border rivers draining into the Bay of Vyborg in the Gulf of Finland is viable and genetically relatively diverse. The existence of this wild sea trout population in the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system and its contribution to the biodiversity in the area also needs to be secured in the future. Given that most other sea trout populations in Southeast Finland have become extinct, it is also very important that the broodstock established from this population is available for returning and maintaining local sea trout in the rivers in this area by releasing juveniles until natural reproduction is sufficient for a self-sustaining population to survive in the wild. The broodstock of the River Ingarskilanjoki sea trout population is nowadays commonly used for the same purpose in the western part of the Gulf of Finland. The broodstock (live gene bank) also makes it possible to enhance the trout population in the Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system in case its existence some reason becomes threatened.

In the River Gladyshevka, restoration of the salmon population by releasing smolts was initiated in the last decade. The actions have proved successful based on the occurrence of young salmon parr in the river, indicating that salmon nowadays also reproduce independently in the wild. Salmon juveniles share rapids habitats with trout and other conventional river fish species. Releasing juvenile fish may thus be an appropriate conservation measure by enhancing the return of a population to the river.

The Mustajoki/Tchornaja/Soskuanjoki/Malinovka River system generally appears to be healthy based on its good ecological state recorded in this study, and also on the water quality measures and available forage base for salmonids. Restoration actions may further improve the conditions for trout and salmon, as inferred from the increase in trout densities and the appearance of salmon in the restored rapids. In the Hounijoki/Buslovka/Rakkolanjoki/Seleznevka River system, the ecological state is not so good. A reduction in the external load to the river system as well as removal of the obstacles hindering free migration of the fish upstream would presumably improve the current situation for migrating fish, including salmonids.

Wild populations of sea trout from rivers draining into the Gulf of Finland made up approximately one-fifth of the trout catch in the Finnish coastal area. This underlines the importance of marking all the hatchery released trout, thereby enabling fishermen to distinguish them in the catch and thus release the unmarked wild-born trout back into the sea. Marking of released fish with adipose fin clipping has already been taken into practice in Finland in the Gulf of Finland region. In addition, the release of marked individuals in governmentally owned water areas in the Gulf of Finland has been obliged by the Centres for Economic Development, Transport and the Environment of Uusimaa and Southeast Finland from the beginning of 2013 onwards. Some local water owners have also voluntarily made such a decision in their own fishing areas. Trout often appear to be caught undersized. Even if the current legislation in Finland obliges all undersized fish to be released, all possible additional measures to enhance the survival of undersized trout, such as gill net mesh size regulations, are in great need in order to conserve the endangered wild trout populations and ensure their existence in the future. Such measures would also enable larger catches of stocked trout and also of wild trout after the wild populations have recovered in the long term.

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Appendix. The name of the electrofishing site (name of the river in parentheses) in alphabetic order for the cross-border river systems shown separately for the Finnish and Russian sides. The date of electrofishing, area of the electrofishing site, number of electrofishing removals per electrofishing occasion and species caught are also indicated. For trout, the age group is also shown. Ind.1. and Ind.2. indicate the number of individuals caught during first and second electrofishing removal, respectively. Ind./E indicates the number of individuals caught during the whole electrofishing occasion, Ind./100m^2 the observed number of individuals caught per 100m^2 (observed density), and N/100m^2 the estimated number of individuals per 100m^2 (estimated density).

Finnish side

Name of the electrofishing site	Date	Area m^2	Number of removals	Species	Age	Ind.1.	Ind.2.	Ind./E	Ind./100m2	N/100m2
Ala-Kivikoski (Mustajoki)	19.9.2011	88	1	Perch	-	1		1	1.14	2.02
Ala-Kivikoski (Mustajoki)	19.9.2011	88	1	Trout	>0+	2		2	2.29	2.95
Ala-Kivikoski (Mustajoki)	10.9.2012	88	2	Stone loach	-	2		2	2.29	9.16
Ala-Kivikoski (Mustajoki)	10.9.2012	88	2	Bullhead	-	1	1	2	2.29	9.16
Ala-Kivikoski (Mustajoki)	10.9.2012	88	2	Burbot	-		1	1	1.14	3.80
Ala-Kivikoski (Mustajoki)	10.9.2012	88	2	Trout	0+	1	1	2	2.29	4.77
Ala-Kivikoski (Mustajoki)	10.9.2012	88	2	Trout	>0+		1	1	1.14	1.48
Ala-Kivikoski (Mustajoki)	9.9.2013	88	2	Perch	-	8	2	10	11.43	12.19
Ala-Kivikoski (Mustajoki)	9.9.2013	88	2	Bullhead	-	1		1	1.14	4.56
Ala-Kivikoski (Mustajoki)	9.9.2013	88	2	Trout	0+	1		1	1.14	5.70
Ala-Kivikoski (Mustajoki)	9.9.2013	88	2	Trout	1+	2		2	2.29	11.45
Alhonpuro (Mustajoki)	19.9.2011	61	2	Trout	0+	2		2	3.27	8.18
Alhonpuro (Mustajoki)	19.9.2011	61	2	Trout	>0+	1	1	2	3.27	5.45
Alinkoski (Rakkolanjoki)	21.9.2011	182	2	Perch	-	1	1	2	1.10	2.20
Alinkoski (Rakkolanjoki)	21.9.2011	182	2	Bullhead	-	1		1	0.55	2.20
Alinkoski (Rakkolanjoki)	21.9.2011	182	2	Burbot	-		2	2	1.10	3.67
Alinkoski (Rakkolanjoki)	21.9.2011	182	2	Tench	-	1	1	2	1.10	1.83
Alinkoski (Rakkolanjoki)	21.9.2011	182	2	Roach	-	1		1	0.55	0.92
Alinkoski (Rakkolanjoki)	11.9.2012	182	2	Bullhead	-	1		1	0.55	2.20
Alinkoski (Rakkolanjoki)	11.9.2012	182	2	Burbot	-	2		2	1.10	3.67
Alinkoski (Rakkolanjoki)	11.9.2012	182	2	Roach	-	3		3	1.65	2.75

Alinkoski (Rakkolanjoki)	10.9.2013	182	1	Pike	-	1		1	0.55	1.10
Alinkoski (Rakkolanjoki)	10.9.2013	182	1	Burbot	-	1		1	0.55	1.84
Alinkoski (Rakkolanjoki)	10.9.2013	182	1	Perch	-	4		4	2.20	4.41
Haikalankoski (Hounijoki)	22.9.2011	77	2	Bullhead	-	5	1	6	7.79	8.12
Haikalankoski (Hounijoki)	22.9.2011	77	2	Roach	-	6	2	8	10.39	11.69
Haikalankoski (Hounijoki)	22.9.2011	77	2	Perch	-	1		1	1.30	2.60
Haikalankoski (Hounijoki)	22.9.2011	77	2	Bleak	-	4		4	5.19	12.98
Haikalankoski (Hounijoki)	22.9.2011	77	2	Rudd	-	1		1	1.30	2.60
Haikalankoski (Hounijoki)	11.9.2012	77	2	Bullhead	-	5	1	6	7.79	8.12
Haikalankoski (Hounijoki)	11.9.2012	77	2	Perch	-	1		1	1.30	2.60
Haikalankoski (Hounijoki)	11.9.2012	77	2	Burbot	-	1		1	1.30	4.33
Haikalankoski (Hounijoki)	10.9.2013	77	1	Burbot	-	4		4	5.19	17.32
Kalliokoski (Rakkolanjoki)	11.9.2012	69	1	Roach	-	2		2	2.90	4.83
Kalliokoski (Rakkolanjoki)	11.9.2012	69	1	Perch	-	4		4	5.80	11.59
Kalliokoski (Rakkolanjoki)	12.9.2013	69	1	Roach	-	2		2	2.90	4.83
Kalliokoski (Rakkolanjoki)	12.9.2013	69	1	Perch	-	4		4	5.80	11.59
Keski-Kivikoski (Mustajoki)	19.9.2011	70	1	Trout	>1+	1		1	1.43	2.38
Keski-Kivikoski (Mustajoki)	19.9.2011	70	1	Stone loach	-	10		10	14.29	57.14
Keski-Kivikoski (Mustajoki)	10.9.2012	70	2	Bullhead	-	10	5	15	21.43	28.57
Keski-Kivikoski (Mustajoki)	10.9.2012	70	2	Trout	0+	1	1	2	2.86	5.96
Keski-Kivikoski (Mustajoki)	10.9.2012	70	2	Trout	>0+	1		1	1.43	1.86
Keski-Kivikoski (Mustajoki)	10.9.2012	70	2	Trout	>1+	1		1	1.43	2.38
Keski-Kivikoski (Mustajoki)	9.9.2013	95	2	Trout	0+	11	4	15	15.79	18.20
Keski-Kivikoski (Mustajoki)	9.9.2013	95	2	Burbot	-	1	1	2	2.11	7.03
Keski-Kivikoski (Mustajoki)	9.9.2013	95	2	Trout	1+	4		4	4.21	21.05
Keski-Kivikoski (Mustajoki)	9.9.2013	95	2	Trout	>1+		1	1	1.05	2.02
Koivukoski (Mustajoki)	19.9.2011	79	2	Bullhead	-	7	2	9	11.36	12.37
Koivukoski (Mustajoki)	19.9.2011	79	2	Pike	-	1		1	1.26	2.52
Koivukoski (Mustajoki)	19.9.2011	79	2	Trout	0+	3		3	3.79	7.90
Koivukoski (Mustajoki)	9.9.2013	231	2	Perch	-	3		3	1.30	2.28
Koivukoski (Mustajoki)	9.9.2013	231	2	Stone loach	-	1		1	0.43	1.72

Koivukoski (Mustajoki)	9.9.2013	231	2	Bullhead	-	3		3	1.30	5.20
Koivukoski (Mustajoki)	9.9.2013	231	2	Burbot	-	1		1	0.43	1.43
Koivukoski (Mustajoki)	9.9.2013	231	2	Trout	-		2	2	0.87	1.45
Koivukoski (Mustajoki)	9.9.2013	231	2	Trout	0+	4		4	1.73	8.65
Koivukoski (Mustajoki)	9.9.2013	231	2	Trout	1+	6		6	2.60	13.00
Koivukoski (Mustajoki)	9.9.2013	231	2	Trout	>1+	2		2	0.87	1.64
Koskenmäenkoski (Mustajoki)	19.9.2011	265	2	Trout	>0+	11	1	12	4.53	4.57
Koskenmäenkoski (Mustajoki)	19.9.2011	265	2	Perch	-		1	1	0.38	0.67
Koskenmäenkoski (Mustajoki)	19.9.2011	265	2	Pike	-	2		2	0.75	1.50
Koskenmäenkoski (Mustajoki)	19.9.2011	265	2	Trout	0+	5	6	11	4.15	8.65
Koskenmäenkoski (Mustajoki)	10.9.2012	204	2	Trout	>0+	7	1	8	3.92	4.00
Koskenmäenkoski (Mustajoki)	10.9.2012	204	2	Trout	0+	15	8	23	11.27	15.76
Koskenmäenkoski (Mustajoki)	10.9.2012	204	2	Pike	-	1		1	0.49	0.98
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	Trout	>1+	13	2	15	7.35	7.53
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	Trout	1+	14	4	18	8.82	9.61
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	Trout	0+	20	7	27	13.24	15.08
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	Perch	-	10		10	4.90	8.60
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	Pike	-	2		2	0.98	1.96
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	Burbot	-	1		1	0.49	1.63
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	River lamprey	-	1		1	0.49	1.63
Koskenmäenkoski (Mustajoki)	9.9.2013	204	2	Trout	3+	1		1	0.49	0.82
Koskenmäenkoski 2 (Mustajoki)	27.8.2013	620	1	Burbot	-	1		1	0.16	0.54
Koskenmäenkoski 2 (Mustajoki)	27.8.2013	620	1	Pike	-	2		2	0.32	0.65
Koskenmäenkoski 2 (Mustajoki)	27.8.2013	620	1	Trout	>1+	4		4	0.65	1.22
Koskenmäenkoski 2 (Mustajoki)	27.8.2013	620	1	Perch	-	13		13	2.10	3.71
Koskenmäenkoski 2 (Mustajoki)	27.8.2013	620	1	Trout	0+	6		6	0.97	4.84
Koskenmäenkoski 2 (Mustajoki)	27.8.2013	620	1	Trout	1+	13		13	2.10	10.48
Lehmäkoski (Mustajoki)	19.9.2011	72	1	Trout	0+	1		1	1.39	2.87
Lehmäkoski (Mustajoki)	10.9.2012	72	2	Bullhead	-	4	1	5	6.94	7.41
Lehmäkoski (Mustajoki)	10.9.2012	72	2	Stone loach	-	1	2	3	4.17	16.68
Lehmäkoski (Mustajoki)	10.9.2012	72	2	Burbot	-	1		1	1.39	4.63

Lehmäkoski (Mustajoki)	10.9.2013	72	2	Stone loach	-	2	1	3	4.17	5.56
Lehmäkoski (Mustajoki)	10.9.2013	72	2	Trout	0+	4	1	5	6.94	7.41
Lehmäkoski (Mustajoki)	10.9.2013	72	2	Burbot	-	1	1	2	2.78	9.27
Lehmäkoski (Mustajoki)	10.9.2013	72	2	Trout	1+	4		4	5.56	27.80
Metsävirta (Mustajoki)	29.8.2012	83	1	Trout	>0+	1		1	1.21	1.56
Metsävirta (Mustajoki)	29.8.2012	83	1	Trout	0+	17		17	20.61	42.61
Muurahaiskoski (Mustajoki)	19.9.2011	160	2	Trout	>0+	7	1	8	5.00	5.10
Muurahaiskoski (Mustajoki)	19.9.2011	160	2	Trout	0+		1	1	0.63	1.31
Muurahaiskoski (Mustajoki)	10.9.2012	152	2	Trout	0+	14	10	24	15.79	32.24
Muurahaiskoski (Mustajoki)	10.9.2012	152	2	Burbot	-		1	1	0.66	2.20
Muurahaiskoski (Mustajoki)	10.9.2012	152	2	Trout	>0+	3		3	1.97	2.56
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	Stone loach	-	3		3	1.97	7.88
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	Burbot	-	1		1	0.66	2.20
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	River lamprey	-		1	1	0.66	1.65
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	River lamprey	-	2		2	1.32	5.28
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	Trout	-		3	3	1.97	3.28
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	Trout	0+	7		7	4.61	23.05
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	Trout	1+	11		11	7.24	36.20
Muurahaiskoski (Mustajoki)	10.9.2013	152	2	Trout	>1+	15		15	9.87	16.45
Myllykoski (Mustajoki)	19.9.2011	171	2	Pike	-	1		1	0.58	1.16
Myllykoski (Mustajoki)	19.9.2011	171	2	Stone loach	-	1	1	2	1.17	4.68
Myllykoski (Mustajoki)	19.9.2011	171	2	Trout	0+	2		2	1.17	2.44
Myllykoski (Mustajoki)	19.9.2011	171	2	Trout	>0+	5	5	10	5.85	7.60
Myllykoski (Mustajoki)	10.9.2012	171	2	Trout	0+	22	6	28	16.37	17.69
Myllykoski (Mustajoki)	10.9.2012	171	2	Stone loach	-	2		2	1.17	4.68
Myllykoski (Mustajoki)	10.9.2013	171	2	Burbot	-	2	1	3	1.75	2.34
Myllykoski (Mustajoki)	10.9.2013	171	2	Stone loach	-	3	1	4	2.34	2.63
Myllykoski (Mustajoki)	10.9.2013	171	2	Trout	1+	31	4	35	20.47	20.81
Myllykoski (Mustajoki)	10.9.2013	171	2	Trout	0+	7	6	13	7.60	28.65
Myllykoski (Mustajoki)	10.9.2013	171	2	Trout	>1+	4		4	2.34	4.42
Myllymäenkoski (Hounijoki)	22.9.2011	53	2	Bullhead	-	11	6	17	31.95	45.49

Myllymäenkoski (Hounijoki)	11.9.2012	53	2	Perch	-		1	1	1.88	3.76
Myllymäenkoski (Hounijoki)	11.9.2012	53	2	Pike	-		1	1	1.88	3.76
Myllymäenkoski (Hounijoki)	11.9.2012	53	2	Bullhead	-	10	1	11	20.75	23.06
Myllymäenkoski (Hounijoki)	11.9.2012	53	2	Burbot	-	3		3	5.64	18.80
Myllymäenkoski (Hounijoki)	11.9.2012	53	2	River lamprey	-		1	1	1.88	6.27
Myllymäenkoski (Hounijoki)	10.9.2013	53	1	Burbot	-	1		1	1.88	6.27
Myllymäenkoski (Hounijoki)	10.9.2013	53	1	Bleak	-	3		3	5.64	14.10
Pitkäkoski (Rakkolanjoki)	11.9.2012	118	1	Burbot	-	5		5	4.26	14.18
Pölkkyoja (Mustajoki)	19.9.2011	170	1	Trout	>0+	4		4	2.35	3.92
Pölkkyoja (Mustajoki)	10.9.2012	170	2	Trout	0+	2	5	7	4.12	10.30
Pölkkyoja (Mustajoki)	10.9.2013	170	2	Trout	0+	10	6	16	9.41	14.71
Pölkkyoja (Mustajoki)	10.9.2013	25	1	Trout	-	20		20	80.00	133.33
Rajalinjankoski 0 (Soskuanjoki)	28.8.2013	136	1	Salmon	0+	2		2	1.47	7.35
Rajalinjankoski 0 (Soskuanjoki)	28.8.2013	136	1	Stone loach	-	3		3	2.21	8.82
Rajalinjankoski 0 (Soskuanjoki)	28.8.2013	136	1	Perch	-	3		3	2.21	11.03
Rajalinjankoski 1 (Soskuanjoki)	30.8.2011	140	2	Stone loach	-	7	3	10	7.14	8.75
Rajalinjankoski 1 (Soskuanjoki)	30.8.2011	140	2	Perch	-	1		1	0.71	1.42
Rajalinjankoski 1 (Soskuanjoki)	30.8.2011	140	2	Pike	-	1		1	0.71	1.42
Rajalinjankoski 1 (Soskuanjoki)	30.8.2011	140	2	Bullhead	-	1	3	4	2.86	11.44
Rajalinjankoski 1 (Soskuanjoki)	30.8.2011	140	2	Roach	-		1	1	0.71	1.18
Rajalinjankoski 1 (Soskuanjoki)	30.8.2011	140	2	Chub	-	1		1	0.71	1.18
Rajalinjankoski 1 (Soskuanjoki)	28.8.2012	135	2	Bullhead	-	2	1	3	2.22	2.96
Rajalinjankoski 1 (Soskuanjoki)	28.8.2012	135	2	Stone loach	-	4	2	6	4.44	5.93
Rajalinjankoski 1 (Soskuanjoki)	28.8.2012	135	2	Perch	-	3		3	2.22	4.44
Rajalinjankoski 1 (Soskuanjoki)	28.8.2012	135	2	Salmon	0+	3		3	2.22	5.55
Rajalinjankoski 1 (Soskuanjoki)	28.8.2012	135	2	Roach	-		1	1	0.74	1.23
Rajalinjankoski 1 (Soskuanjoki)	28.8.2013	105	1	Roach	-	1		1	0.95	1.59
Rajalinjankoski 1 (Soskuanjoki)	28.8.2013	105	1	Salmon	1+	2		2	1.90	3.17
Rajalinjankoski 1 (Soskuanjoki)	28.8.2013	105	1	Perch	-	2		2	1.90	9.52
Rajalinjankoski 1 (Soskuanjoki)	28.8.2013	105	1	Salmon	0+	2		2	1.90	9.52
Rajalinjankoski 1 (Soskuanjoki)	28.8.2013	105	1	Bullhead	-	3		3	2.86	11.43

Rajalinjankoski 2 (Soskuanjoki)	30.8.2011	200	2	Perch	-	2	1	3	1.50	2.00
Rajalinjankoski 2 (Soskuanjoki)	30.8.2011	200	2	Stone loach	-	3	3	6	3.00	12.00
Rajalinjankoski 2 (Soskuanjoki)	30.8.2011	200	2	Roach	-	2		2	1.00	1.67
Rajalinjankoski 2 (Soskuanjoki)	30.8.2011	200	2	Chub	-		1	1	0.50	0.83
Rajalinjankoski 2 (Soskuanjoki)	28.8.2013	117	1	Salmon	1+	3		3	2.56	4.27
Rajalinjankoski 2 (Soskuanjoki)	28.8.2013	117	1	Stone loach	-	2		2	1.71	6.84
Rajalinjankoski 2 (Soskuanjoki)	28.8.2013	117	1	Roach	-	5		5	4.27	7.12
Rajalinjankoski 2 (Soskuanjoki)	28.8.2013	117	1	Salmon	0+	2		2	1.71	8.55
Rajalinjankoski 3 (Soskuanjoki)	29.8.2013	198	1	Salmon	1+	1		1	0.51	0.84
Rajalinjankoski 3 (Soskuanjoki)	29.8.2013	198	1	Salmon	0+	1		1	0.51	2.53
Rajalinjankoski 3 (Soskuanjoki)	29.8.2013	198	1	Roach	-	4		4	2.02	3.37
Rajalinjankoski 3 (Soskuanjoki)	29.8.2013	198	1	Perch	-	4		4	2.02	10.10
Sarkasukankoski (Rakkolanjoki)	21.9.2011	222	1	Burbot	-	2		2	0.90	3.00
Sarkasukankoski (Rakkolanjoki)	11.9.2012	222	1	Burbot	-	1		1	0.45	1.50
Sarkasukankoski (Rakkolanjoki)	12.9.2013	222	1	Burbot	-	1		1	0.45	1.50
Selkämäenoja (Hounijoki)	11.9.2012	150	1	Burbot	-	2		2	1.33	4.44
Sillanvirta (Mustajoki)	19.9.2011	165	2	Trout	0+	3	2	5	3.03	5.45
Sillanvirta (Mustajoki)	19.9.2011	165	2	Pike	-	1		1	0.61	1.22
Sillanvirta (Mustajoki)	19.9.2011	165	2	River lamprey	-		1	1	0.61	2.03
Sillanvirta (Mustajoki)	19.9.2011	165	2	Trout	>0+	8		8	4.85	6.30
Sillanvirta (Mustajoki)	10.9.2012	224	2	Trout	>0+	8	2	10	4.46	4.76
Sillanvirta (Mustajoki)	10.9.2012	224	2	Trout	0+	23	11	34	15.18	19.68
Sillanvirta (Mustajoki)	10.9.2012	224	2	Burbot	-	1		1	0.45	1.50
Sillanvirta (Mustajoki)	10.9.2013	224	2	Perch	-	2		2	0.89	1.56
Sillanvirta (Mustajoki)	10.9.2013	224	2	Pike	-	1		1	0.45	0.90
Sillanvirta (Mustajoki)	10.9.2013	224	2	Stone loach	-	1		1	0.45	1.80
Sillanvirta (Mustajoki)	10.9.2013	224	2	Burbot	-	1	1	2	0.89	2.97
Sillanvirta (Mustajoki)	10.9.2013	224	2	River lamprey	-		1	1	0.45	1.13
Sillanvirta (Mustajoki)	10.9.2013	224	2	Trout	0+	6	6	12	5.36	26.80
Sillanvirta (Mustajoki)	10.9.2013	224	2	Trout	1+	5		5	2.23	11.15
Sillanvirta (Mustajoki)	10.9.2013	224	2	Trout	>1+	7		7	3.13	5.22

Suikin Myllykoski (Soskuanjoki)	31.8.2011	220	2	Burbot	-	3	1	4	1.82	2.05
Suikin Myllykoski (Soskuanjoki)	31.8.2011	220	2	Stone loach	-	11	5	16	7.27	9.17
Suikin Myllykoski (Soskuanjoki)	31.8.2011	220	2	Perch	-	1		1	0.45	0.90
Suikin Myllykoski (Soskuanjoki)	31.8.2011	220	2	Bleak	-	2		2	0.91	2.28
Suikin Myllykoski (Soskuanjoki)	31.8.2011	220	2	Roach	-	5		5	2.27	3.78
Suikin Myllykoski (Soskuanjoki)	29.8.2012	175	2	Burbot	-	2	1	3	1.71	2.29
Suikin Myllykoski (Soskuanjoki)	29.8.2012	175	2	Perch	-	10	3	13	7.43	8.16
Suikin Myllykoski (Soskuanjoki)	29.8.2012	175	2	Stone loach	-	1	4	5	2.86	11.44
Suikin Myllykoski (Soskuanjoki)	29.8.2013	175	1	Stone loach	-	3		3	1.71	6.86
Suikin Myllykoski (Soskuanjoki)	29.8.2013	175	1	Perch	-	15		15	8.57	42.86
Suikin Myllykoski (Soskuanjoki)	24.10.2013	320	1	Burbot	-	3		3	0.94	3.13
Suikin Myllykoski (Soskuanjoki)	24.10.2013	320	1	Trout	1+	7		7	2.19	3.65
Tunnelikoski (Soskuanjoki)	29.8.2013	126	1	Stone loach	-	1		1	0.79	3.17
Tunnelikoski (Soskuanjoki)	29.8.2013	126	1	Roach	-	4		4	3.17	5.29
Tunnelikoski (Soskuanjoki)	29.8.2013	126	1	Perch	-	2		2	1.59	7.94
Tuomikoski (Mustajoki)	19.9.2011	90	2	Trout	0+	10	3	13	14.44	15.87
Tuomikoski (Mustajoki)	19.9.2011	90	2	Trout	>0+	3	3	6	6.67	8.66
Tuomikoski (Mustajoki)	10.9.2012	90	2	Trout	>0+	9	1	10	11.11	11.25
Tuomikoski (Mustajoki)	10.9.2012	90	2	Trout	0+	11	7	18	20.00	33.61
Tuomikoski (Mustajoki)	28.8.2013	78	1	Trout	>1+	1		1	1.28	2.42
Tuomikoski (Mustajoki)	28.8.2013	78	1	Trout	0+	6		6	7.69	38.46
Tuomikoski (Mustajoki)	28.8.2013	78	1	Trout	1+	10		10	12.82	64.10
Tuomikoski (Mustajoki)	10.9.2013	90	2	Trout	>1+	4	1	5	5.56	5.93
Tuomikoski (Mustajoki)	10.9.2013	90	2	Trout	0+	13	3	16	17.78	18.78
Tuomikoski (Mustajoki)	10.9.2013	90	2	Trout	1+	22	8	30	33.33	38.41
Tuomikoski (Mustajoki)	10.9.2013	90	2	Perch	-	1	1	2	2.22	3.89
Tuomikoski (Mustajoki)	10.9.2013	90	2	Stone loach	-	1		1	1.11	4.44
Tupakkamyllynpuro (Mustajoki)	11.9.2012	75	2	Trout	0+	25	5	30	40.00	41.67
Tupakkamyllynpuro (Mustajoki)	10.9.2013	55	2	Trout	0+	56	17	73	132.73	146.20
Tupakkamyllynpuro (Mustajoki)	10.9.2013	55	2	Trout	1+	1		1	1.82	3.03
Vanhanmyllynkoski (Mustajoki)	19.9.2011	234	1	Trout	>0+	1		1	0.43	0.55

Vanhanmyllynkoski (Mustajoki)	19.9.2011	234	1	Trout	>1+	1		1	0.43	0.71
Vanhanmyllynkoski (Mustajoki)	19.9.2011	234	1	Perch	-	4		4	1.71	3.02
Vanhanmyllynkoski (Mustajoki)	10.9.2012	231	2	Trout	>0+	5	1	6	2.60	2.71
Vanhanmyllynkoski (Mustajoki)	10.9.2012	231	2	Trout	0+	11	6	17	7.36	10.48
Vanhanmyllynkoski (Mustajoki)	9.9.2013	231	1	Roach	-	1		1	0.43	0.72
Vanhanmyllynkoski (Mustajoki)	9.9.2013	231	1	Trout	>1+	1		1	0.43	0.82
Vanhanmyllynkoski (Mustajoki)	9.9.2013	231	1	Burbot	-	1		1	0.43	1.44
Vanhanmyllynkoski (Mustajoki)	9.9.2013	231	1	Trout	0+	1		1	0.43	2.16
Vanhanmyllynkoski (Mustajoki)	9.9.2013	231	1	Trout	1+	5		5	2.16	10.82
Vanhanmyllynkoski (Mustajoki)	9.9.2013	231	1	Perch	-	29		29	12.55	22.19
Ylä-Kivikoski (Mustajoki)	21.9.2011	100	1	Trout	>1+	1		1	1.00	1.67

Russian side

Name of the electrofishing site	Date	Area m^2	Number of removals	Species	Age	Ind.1.	Ind.2.	Ind./E	Ind./100m2	N/100m2
Alakoski (Malinovka)	17.9.2013	120	1	Perch	-	7		7	5.83	11.67
Alakoski (Malinovka)	17.9.2013	120	1	Pike	-	1		1	0.83	1.67
Alakoski (Malinovka)	17.9.2013	120	1	Stone loach	-	5		5	4.17	16.67
Alakoski (Malinovka)	17.9.2013	120	1	Bullhead	-	4		4	3.33	13.33
Alakoski (Malinovka)	17.9.2013	120	1	Bleak	-	4		4	3.33	8.33
Alakoski (Malinovka)	17.9.2013	120	1	Trout	0+	6		6	5.00	12.50
Alakoski (Malinovka)	17.9.2013	120	1	Trout	1+	1		1	0.83	1.39
Alakoski (Malinovka)	17.9.2013	120	1	Trout	>1+	1		1	0.83	1.39
Almankoski (Malinovka)	18.9.2013	312	1	Bullhead	-	36		36	11.54	46.15
Almankoski (Malinovka)	18.9.2013	312	1	Roach	-	3		3	0.96	1.60
Buslovkan yhtymäkohta (Seleznevka)	18.9.2013	180	1	Bullhead	-	4		4	2.22	8.89
Buslovkan yhtymäkohta (Seleznevka)	18.9.2013	180	1	Roach	-	2		2	1.11	1.85
Gazprominkoski (Soskuanjoki)	18.9.2013	329	1	Perch	-	3		3	0.91	1.82
Gazprominkoski (Soskuanjoki)	18.9.2013	329	1	Stone loach	-	3		3	0.91	3.65
Gazprominkoski (Soskuanjoki)	18.9.2013	329	1	Bullhead	-	4		4	1.22	4.86
Gazprominkoski (Soskuanjoki)	18.9.2013	329	1	Salmon	1+	1		1	0.30	0.51
Gazprominkoski (Soskuanjoki)	18.9.2013	329	1	Roach	-	8		8	2.43	4.05
Igorinkoski (Malinovka)	17.9.2013	640	1	Perch	-	6		6	0.94	1.88
Igorinkoski (Malinovka)	17.9.2013	640	1	Stone loach	-	1		1	0.16	0.63
Igorinkoski (Malinovka)	17.9.2013	640	1	Bullhead	-	1		1	0.16	0.63
Igorinkoski (Malinovka)	17.9.2013	640	1	Salmon	1+	2		2	0.31	0.52
Igorinkoski (Malinovka)	17.9.2013	640	1	Bleak	-	2		2	0.31	0.78
Igorinkoski (Malinovka)	17.9.2013	640	1	Roach	-	14		14	2.19	3.65
Igorinkoski (Malinovka)	17.9.2013	640	1	Trout	0+	1		1	0.16	0.39
Igorinkoski (Malinovka)	17.9.2013	640	1	Trout	1+	7		7	1.09	1.82
Igorinkoski (Malinovka)	17.9.2013	640	1	Trout	>1+	5		5	0.78	1.30
Kanaoja (Malinovka)	17.9.2013	40	1	Trout	0+	13		13	32.50	81.25

Kanaoja (Malinovka)	17.9.2013	40	1	Trout	1+	12		12	30.00	50.00
Karhunkoski (Malinovka)	19.9.2013	480	1	Perch	-	4		4	0.83	1.67
Karhunkoski (Malinovka)	19.9.2013	480	1	Stone loach	-	4		4	0.83	3.33
Karhunkoski (Malinovka)	19.9.2013	480	1	Bullhead	-	4		4	0.83	3.33
Karhunkoski (Malinovka)	19.9.2013	480	1	Roach	-	2		2	0.42	0.69
Karhunkoski (Malinovka)	19.9.2013	480	1	Trout	1+	1		1	0.21	0.35
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Perch	-	3		3	0.68	1.36
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Stone loach	-	2		2	0.45	1.81
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Bullhead	-	8		8	1.81	7.26
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Salmon	0+	1		1	0.23	0.57
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Salmon	1+	1		1	0.23	0.38
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Roach	-	5		5	1.13	1.89
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Trout	1+	3		3	0.68	1.13
Kasevankoski (Soskuanjoki)	17.9.2013	441	1	Chub	-	1		1	0.23	0.38
Keskiosankoski (Buslovka)	18.9.2013	250	1	Perch	-	2		2	0.80	1.60
Keskiosankoski (Buslovka)	18.9.2013	250	1	Bullhead	-	6		6	2.40	9.60
Keskiosankoski (Buslovka)	18.9.2013	250	1	Burbot	-	1		1	0.40	1.33
Keskiosankoski (Buslovka)	18.9.2013	250	1	Bleak	-	1		1	0.40	1.00
Keskiosankoski (Buslovka)	18.9.2013	250	1	Roach	-	12		12	4.80	8.00
Lanakoski (Seleznevka)	18.9.2013	900	1	Perch	-	2		2	0.22	0.44
Lanakoski (Seleznevka)	18.9.2013	900	1	Bullhead	-	5		5	0.56	2.22
Lanakoski (Seleznevka)	18.9.2013	900	1	Bleak	-	4		4	0.44	1.11
Lanakoski (Seleznevka)	18.9.2013	900	1	Roach	-	8		8	0.89	1.48
Lanakoski (Seleznevka)	18.9.2013	900	1	Trout	0+	7		7	0.78	1.94
Lanakoski (Seleznevka)	18.9.2013	900	1	Trout	1+	1		1	0.11	0.19
Lanakoski sillan alapuoli (Seleznevka)	18.9.2013	120	1	Perch	-	5		5	4.17	8.33
Lanakoski sillan alapuoli (Seleznevka)	18.9.2013	120	1	Stone loach	-	1		1	0.83	3.33
Lanakoski sillan alapuoli (Seleznevka)	18.9.2013	120	1	Bullhead	-	4		4	3.33	13.33
Lanakoski sillan alapuoli (Seleznevka)	18.9.2013	120	1	Burbot	-	2		2	1.67	5.56
Lanakoski sillan alapuoli (Seleznevka)	18.9.2013	120	1	Roach	-	2		2	1.67	2.78
Lanakoski sillan alapuoli (Seleznevka)	18.9.2013	120	1	Trout	1+	1		1	0.83	1.39

Lanakoski sillan yläpuoli (Seleznevka)	18.9.2013	90	1	Pike	-	3		3	3.33	6.67
Lanakoski sillan yläpuoli (Seleznevka)	18.9.2013	90	1	Bullhead	-	11		11	12.22	48.89
Lanakoski sillan yläpuoli (Seleznevka)	18.9.2013	90	1	Bleak	-	1		1	1.11	2.78
Lanakoski sillan yläpuoli (Seleznevka)	18.9.2013	90	1	Roach	-	15		15	16.67	27.78
Lanakoski sillan yläpuoli (Seleznevka)	18.9.2013	90	1	Trout	0+	3		3	3.33	8.33
Paskapuro (Malinovka)	17.9.2013	55	1	Trout	1+	15		15	27.27	45.45
Paskapuro (Malinovka)	17.9.2013	55	1	Trout	>1+	5		5	9.09	15.15
Rajavartiostonkoski (Malinovka)	19.9.2013	480	1	Perch	-	6		6	1.25	2.50
Rajavartiostonkoski (Malinovka)	19.9.2013	480	1	Bullhead	-	2		2	0.42	1.67
Rajavartiostonkoski (Malinovka)	19.9.2013	480	1	Burbot	-	2		2	0.42	1.39
Rajavartiostonkoski (Malinovka)	19.9.2013	480	1	Bleak	-	4		4	0.83	2.08
Rajavartiostonkoski (Malinovka)	19.9.2013	480	1	Roach	-	5		5	1.04	1.74
Rajavartiostonkoski (Malinovka)	19.9.2013	480	1	Trout	-	1		1	0.21	0.35
Rajavartiostonkoski (Malinovka)	19.9.2013	480	1	Trout	1+	3		3	0.63	1.04
Ritakoski (Malinovka)	18.9.2013	276	1	Perch	-	2		2	0.72	1.45
Ritakoski (Malinovka)	18.9.2013	276	1	Pike	-	1		1	0.36	0.72
Ritakoski (Malinovka)	18.9.2013	276	1	Stone loach	-	3		3	1.09	4.35
Ritakoski (Malinovka)	18.9.2013	276	1	Bullhead	-	10		10	3.62	14.49
Ritakoski (Malinovka)	18.9.2013	276	1	Bleak	-	1		1	0.36	0.91
Ritakoski (Malinovka)	18.9.2013	276	1	Roach	-	3		3	1.09	1.81
Ritakoski (Malinovka)	18.9.2013	276	1	Trout	0+	1		1	0.36	0.91
Saniaiskoski (Tchornaja)	7.9.2013	200	1	Pike	-	2		2	1.00	2.00
Saniaiskoski (Tchornaja)	7.9.2013	200	1	Stone loach	-	2		2	1.00	4.00
Saniaiskoski (Tchornaja)	7.9.2013	200	1	Bullhead	-	2		2	1.00	4.00
Saniaiskoski (Tchornaja)	7.9.2013	200	1	Trout	0+	11		11	5.50	13.75
Saniaiskoski (Tchornaja)	7.9.2013	200	1	Trout	1+	14		14	7.00	11.67
Saniaiskoski (Tchornaja)	7.9.2013	200	1	Trout	>1+	2		2	1.00	1.67
Buslovka alin (Buslovka)	18.9.2013	100	1	Bullhead	-	3		3	3.00	12.00
Sillanaluskoski (Gusinaya)	18.9.2013	60	1	Bullhead	-	5		5	8.33	33.33
Sillanaluskoski (Gusinaya)	18.9.2013	60	1	Burbot	-	1		1	1.67	5.56
Sillanaluskoski (Gusinaya)	18.9.2013	60	1	Trout	0+	1		1	1.67	4.17

Sillanaluskoski (Gusinaya)	18.9.2013	60	1	Trout	>1+	2		2	3.33	5.56
Töyräsniva (Malinovka)	19.9.2013	360	1	Perch	-	1		1	0.28	0.56
Töyräsniva (Malinovka)	19.9.2013	360	1	Bleak	-	2		2	0.56	1.39
Töyräsniva (Malinovka)	19.9.2013	360	1	Roach	-	5		5	1.39	2.31
Töyräsniva (Malinovka)	19.9.2013	360	1	Trout	1+	3		3	0.83	1.39
Töyräsniva (Malinovka)	19.9.2013	360	1	Trout	>1+	5		5	1.39	2.31