Annex 7.9

Pre-restoration study of freshwater pearl mussel glochidia larvae on salmon and trout in rivers within ReBorN-LIFE (LIFE15 NAT/SE/000892)

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Länsstyrelsen Norrbotten

Contents

Summary

During the weeks 22-24 of 2017 electrofishing was done at 35 sites in 13 different rivers within the ReBorN-project. The study was conducted to examine the gills of brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*) to see if, and to what extent, they were infected with freshwater pearl mussel (*Margaritifera margaritifera*) glochidia larvae. This pre-study indicates that the salmon act as the host fish for freshwater pearl mussel (FPM) in the main stem of Rivers Råneälven, Åbyälven, Lögdeälven and that the brown trout is the host fish in the tributaries. This is new knowledge and one of the first observations in Sweden that salmon may act as host fish for the freshwater pearl mussel.

In all the studied rivers where infection was registered, the overall infestation rate was above 20 %, except one river (10%). The number of glochidia larvae on each fish was in general very low. 74 % of all infected fishes in the study had between 1-10 larvae and only 4 % of the fishes had more than 50 larvae attached to their gills.

Background

The freshwater pearl mussel (*Margaritifera margaritifera),* one of the longest living species in our Nordic fauna, can attain an age of at least 150 years. According to some studies, the oldest mussels are more than 200 years old, the record being 280 years (Oulasvirta et al., 2015). The life cycle of the FPM (Fig. 1) is complex and includes critical stages at which mortality is very high. It is estimated that only one in a hundred million mussel larvae reaches the adult stage. The great loss in larvae and juvenile stages is compensated for by the long-life span and huge life time larvae production. An indispensable part of the life cycle is associated with Atlantic salmon or brown trout, which are the host species for the FPM larvae in Scandinavia.

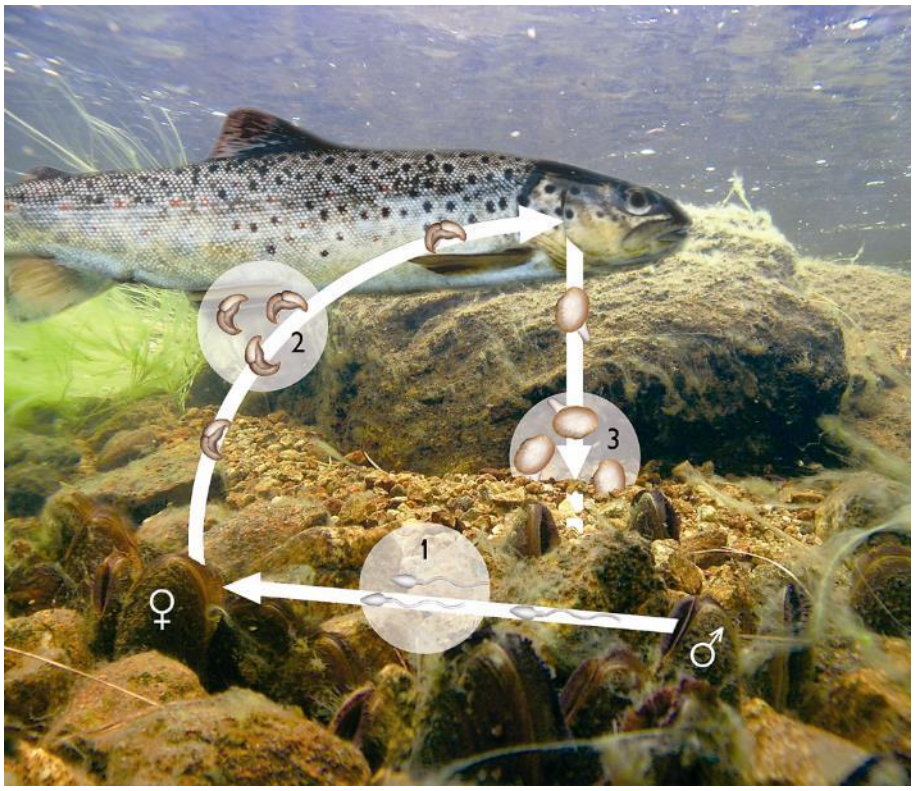

Figure 1. Life cycle of the freshwater pearl mussel. 1. Male mussels release their sperm into the water. The sperm enters female gills with the current and fertilizes the egg cells. 2. Glochidia larvae are released in the autumn. Small percentage of the larvae manage to attach themselves to the gills of a host fish, where they live as parasites over the winter. During the parasitic stage the larvae metamorphose into juvenile mussels. 3. After dropping off the host fish, the juveniles dig into the bottom substrate, where they live submerged for 1-7 years. They eventually become visible at a length of 7-9 mm. Photos and graphics Alleco Ltd.

The purpose of the study is to collect data from the parasitic stage in the life cycle of the FPM in the rivers that are subject for restoration within the ReBorN-project. Another purpose was to collect important pre-restoration data to be able to compare results before and after restoration, e.g. to see if the number of infected fish and total number of glochidia larvae on each host fish increases or decreases.

A more detailed compilation of the salmon and trout status within the target rivers have been done earlier (Larsson 2017) and will also be followed up after the restoration work have been done.

FPM status of the rivers

Project area River Åbyälven

In River Åbyälven only a few larger (old) individuals have been found from the border to the County of Västerbotten and approximately 24 km upstream. 2,5 km downstream the County border is Hednäs hydropower plant situated. It has an installed fish passage but its functionality is not optimal and not all fishes are able to pass. FPM have also been found downstream the hydropower plant in the County of Västerbotten. The population is made up of single or smaller groups of older FPM. No young FPM have been found in River Åbyälven and the population is considered being at risk for extinction.

Project area River Byskeälven

In River Långträskälven we had information that one FPM earlier has been found in the river outlet. During snorkeling investigations of the restoration stretches in 2017, no FPM was found. This river is now considered to not have a FPM population.

Project area River Piteälven

In River Vitbäcken only a few larger (old) individuals have been found on an approximately 15 km long stretch in the middle part of the river. The population is considered being at risk for extinction.

Project area River Råneälven

In River Råneälven the FPM is known to occur on an approximately 100 km long stretch in the middle and upper part of the river. Individual FPM below 50 mm in length (young) have been found at different places so recruitment of the population seems to occur. Complete knowledge of the total number of individuals and the age structure of the population is lacking.

In River Abramsån a few larger (old) individuals have been found on an approximately 1,7 km stretch in the upper part of the river. Two small individuals (< 50 mm) were found in 2013. The population is considered being at risk for extinction.

In River Forsträskån only a few larger (old) individuals have been found. The population is considered being at risk for extinction.

Project area River Lögdeälven

In River Lögdeälven the FPM is known to occur from the coast an approximately 50 km further up the river. Individual FPM below 50 mm in length have not been found so recruitment of the population is low. Full knowledge of the status of the FPM population in River Lögdeälven is lacking but at least a several thousand FPM occur in the river.

In tributary Bladtjärnbäcken two larger individuals have been found 2 km up in the creek. The population is considered being at risk for extinction.

In tributary Mjösjöån no FPM have been found.

In tributary Karlsbäcken no FPM have been found.

In tributary Blåtjärnbäcken a population of approximately 1 200 individuals exist on a 3,3 km long stretch. 34 individuals below 50 mm in length have been found in 2008. The population is considered to have low ecological status due to low recruitment rate.

In tributary Blåbergsjöbäcken a population of approximately 6 500 individuals exist from the creeks outlet and 1 km further up. FPM below 50 mm in length have been found latest in 2014, but the recruitment of new individuals was low.

In tributary Holmsjöbäcken no FPM have been found.

Method

Electrofishing was used to catch salmon and brown trout at 35 different locations (sites) in 13 different rivers (Fig. 3-11) between 29th of May to 16th of June 2017 based on the Swedish electrofishing method (Havs- och Vattenmyndigheten 2017). The fish was measured, sedated and then the number of glochidia larvae on each gill arch was counted using a stereo loupe (Sagitta 63117) (Fig. 2) before releasing the fish back to the river. Other species, and young-of-the-year salmon and trout, that were caught were immediately released. Young-of-the-year salmon and trout are born in spring and will not carry any glochidia until the first autumn when the FPM releases their larvae.

Figure 2. *Counting of glochidia larvae on sedated fish using a stereo loupe. Photo: Patrik Olofsson, County Administrative Board of Norrbotten*

Figure 3. *Location of the four different electro fishing sites in River Råneälven. © Lantmäteriet.*

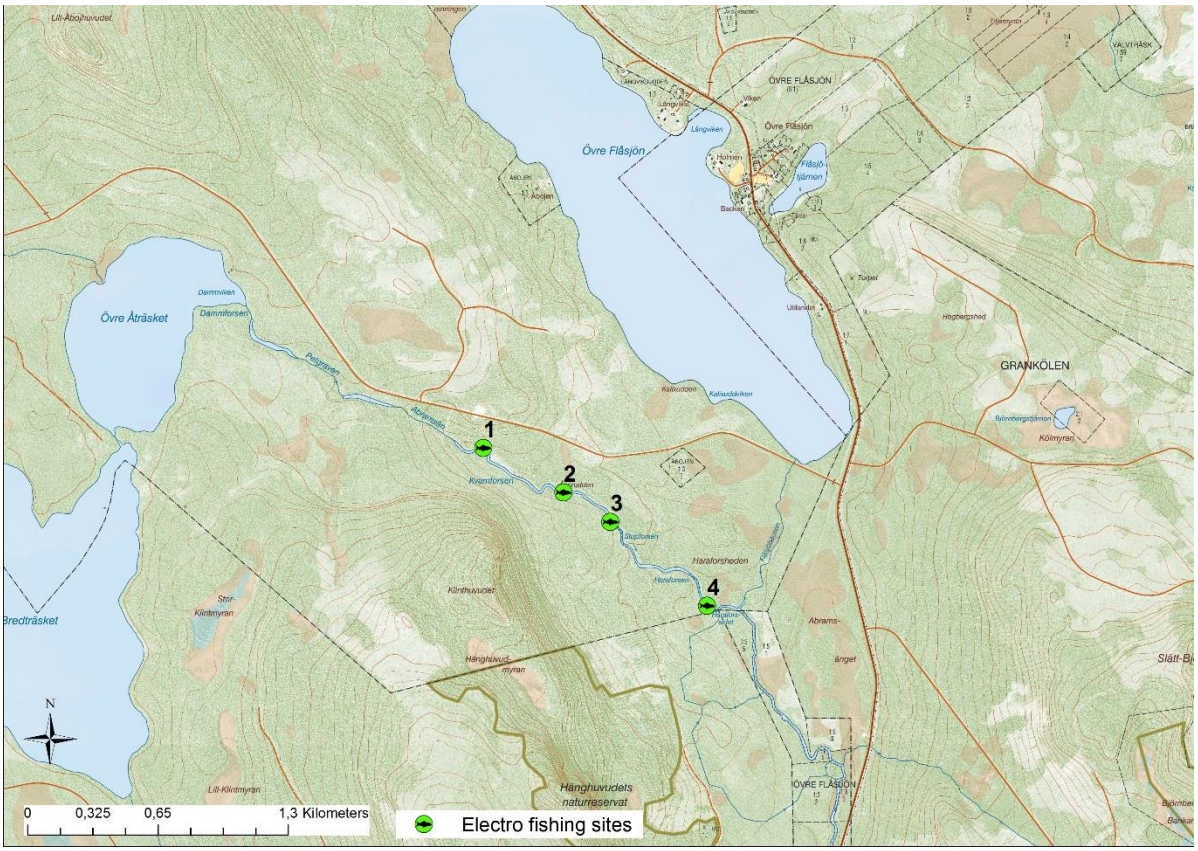

Figure 4. *Location of the four different electro fishing sites in River Abramsån. © Lantmäteriet.*

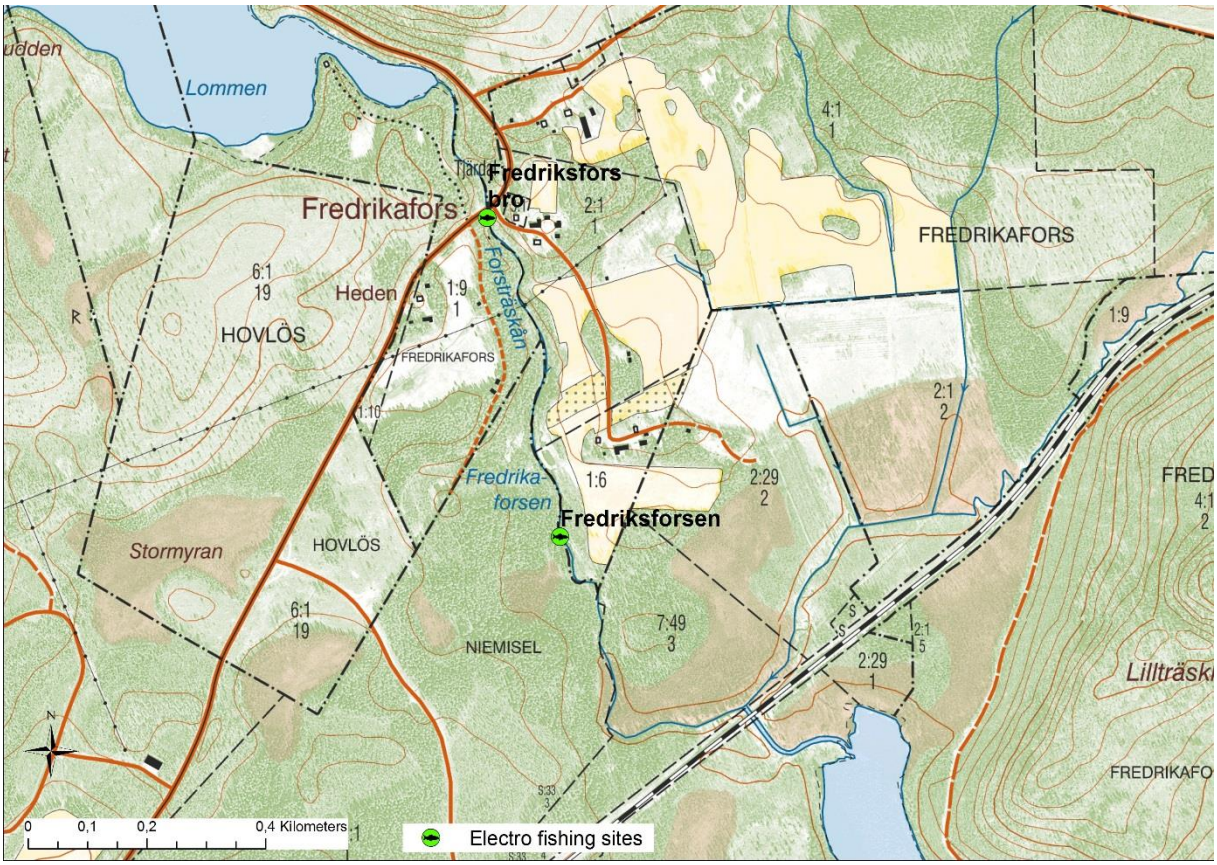

Figure 5. *Location of the two different electro fishing sites in River Forsträskån. © Lantmäteriet.*

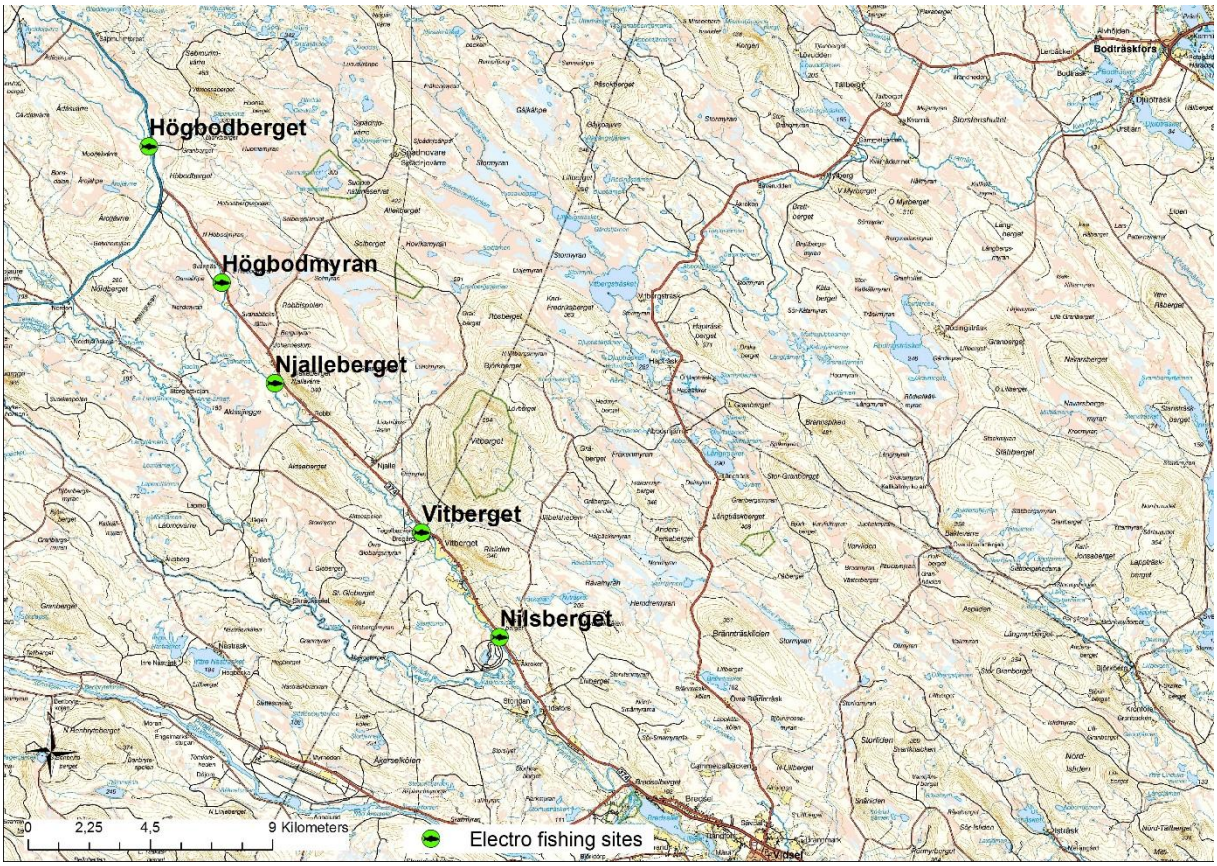

Figure 6. *Location of the five different electro fishing sites in River Vitbäcken. © Lantmäteriet.*

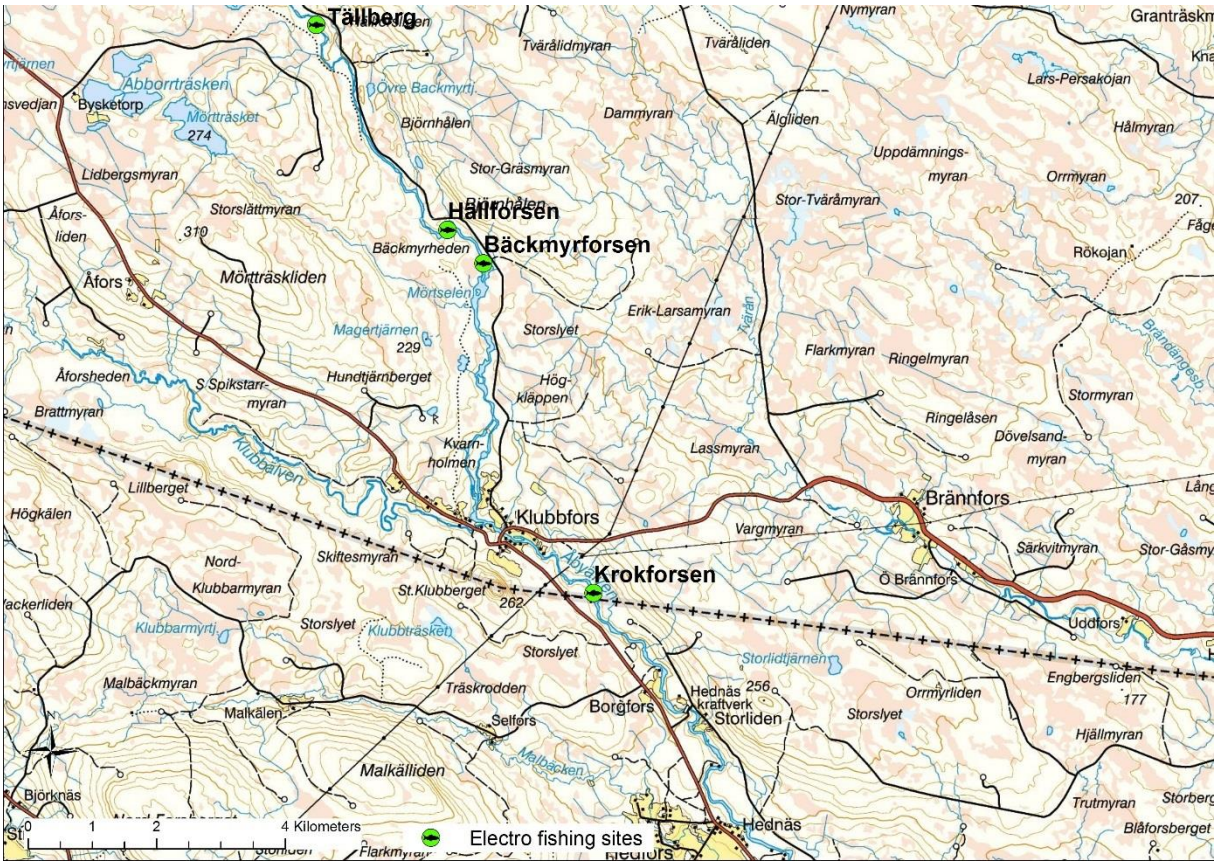

Figure 7. *Location of the four different electro fishing sites in River Åbyälven. © Lantmäteriet.*

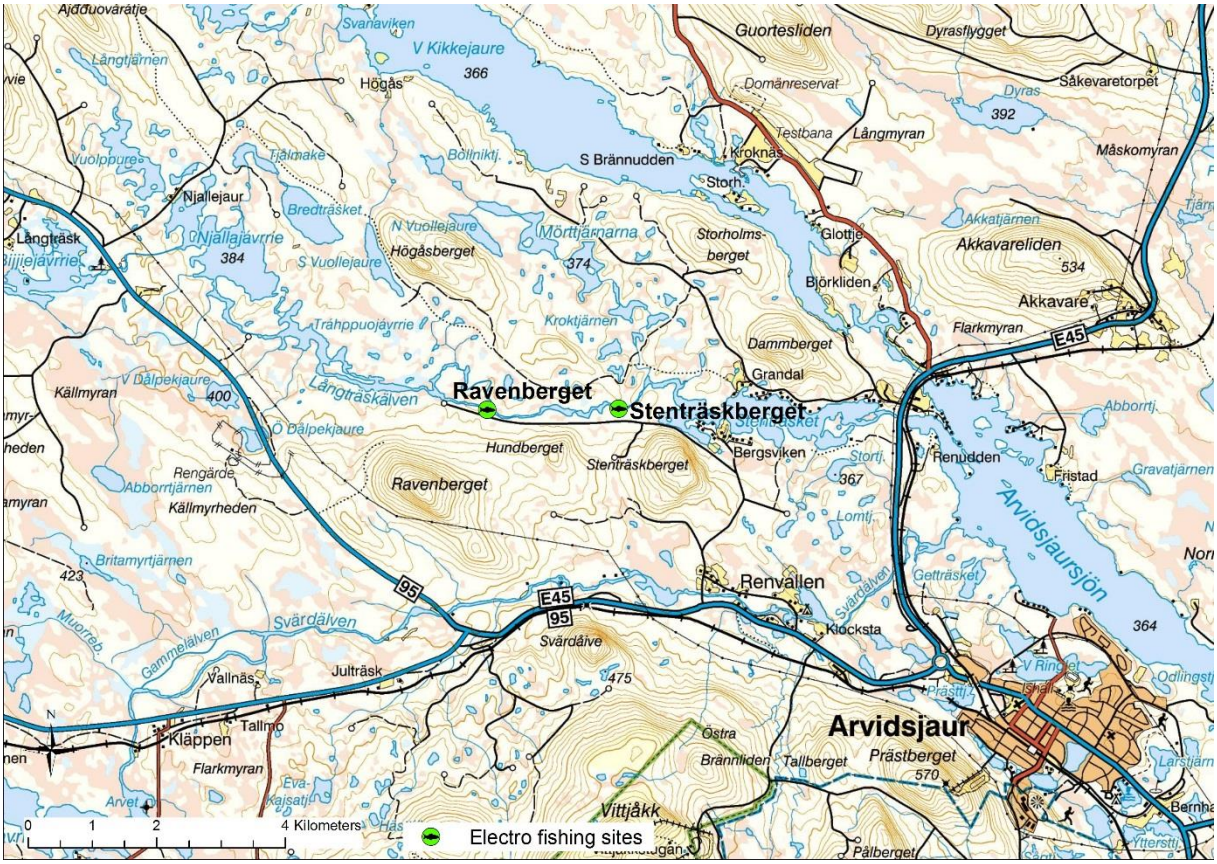

Figure 8. *Location of the two different electro fishing sites in River Långträskälven. © Lantmäteriet.*

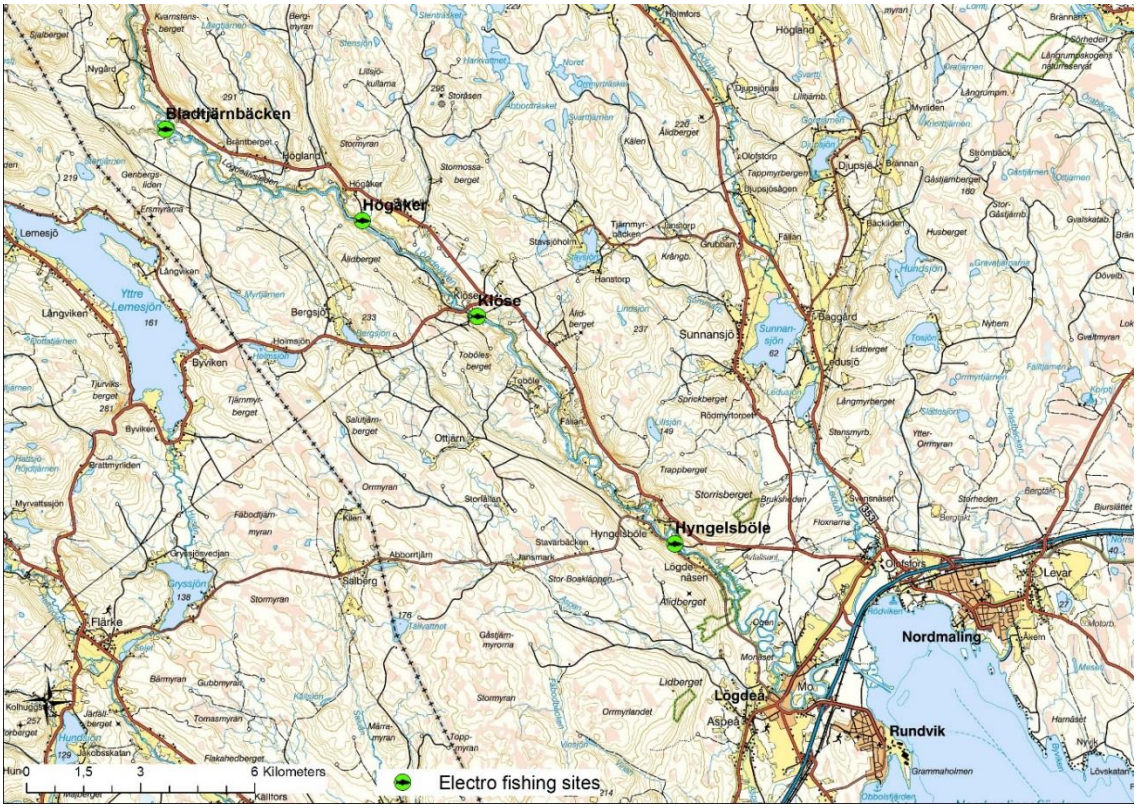

Figure 9. *Location of the three of the electro fishing sites in River Lögdeälven and the one in River Bladtjärnbäcken. © Lantmäteriet.*

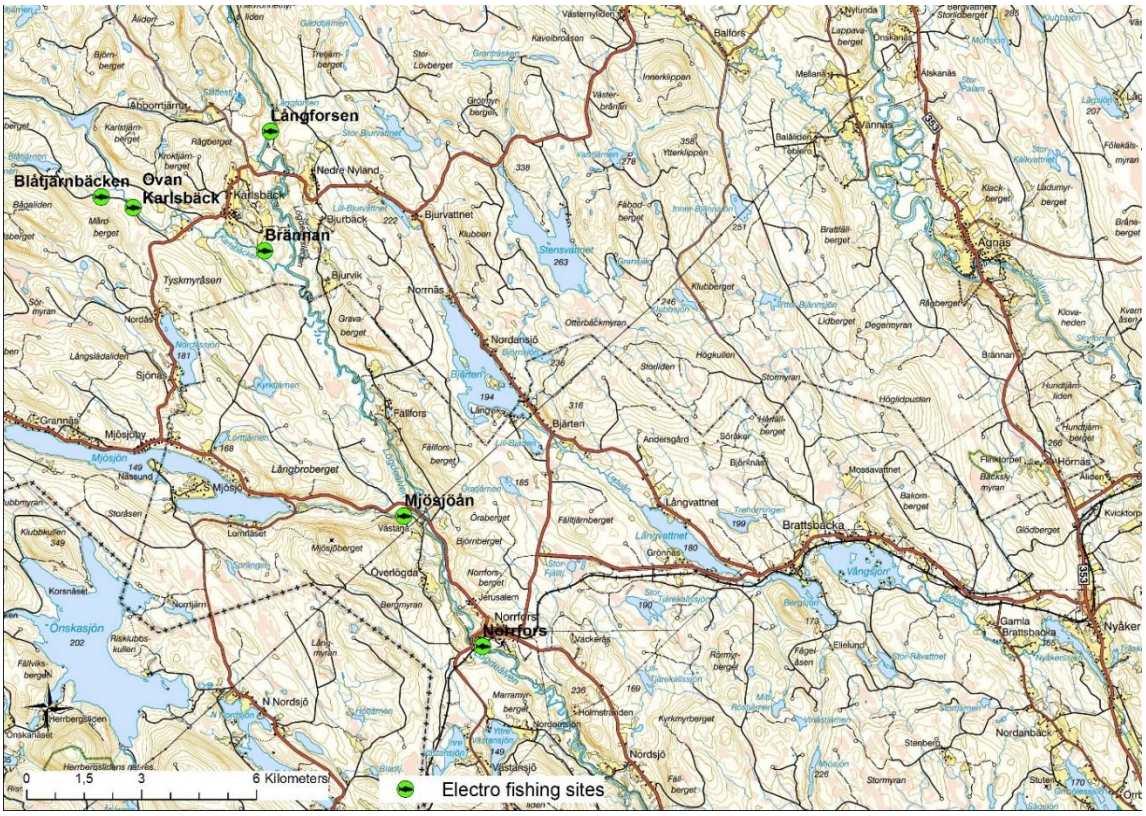

Figure 10. *Location of the two of the electro fishing sites in River Lögdeälven, the one in River Mjösjöån, the one in Blåtjärnbäcken and the two in River Karlsbäcken. © Lantmäteriet.*

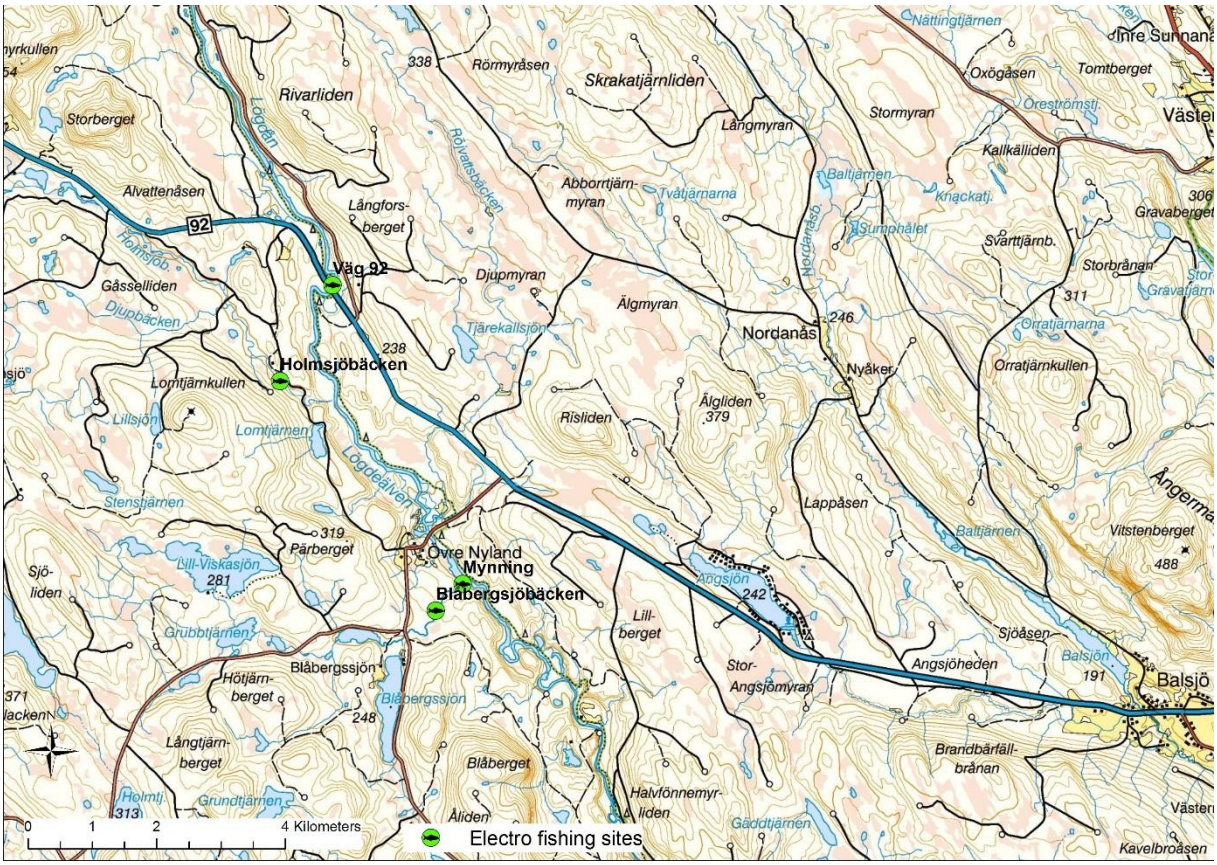

Figure 11. *Location of the one of the electro fishing sites in River Lögdeälven (Väg 92), the one in River Holmsjöbäcken, and the two in River Blåbergsjöbäcken . © Lantmäteriet.*

The infestation rate is given as the proportion of salmon and/or trout infected with larvae of the total number of caught species at an electro fished site. The number of larvae on a single fish is noticed in a five-degree scale 0-4; 0=0 larvae, 1=1-10 larvae, 2=11-50 larvae, 3=51-100 and 4=>100 larvae. Every class in the scale is given a point 0-4. Using the points, a weighted mean value can be calculated for each site. The weighted mean value can have a value between 0-4 and is calculated as follow: number of fishes per class multiplied with the class point number, the value is summarized and divided with the total number caught fishes. (modified from Wengström & Johansson 2015)

Results

During the weeks 22-24 of 2017 electrofishing was done at 35 sites in 13 different rivers. (Table 1 and 2).

Table 1. Results from the different sites. BD = County of Norrbotten. AC = County of Västerbotten.

River - site	County	Date	Elecrofished area (m2)	Water temperature (celsius)	Species	Number	Rate of infestation (%)	Weighted mean value
Åbyälven - Hällforsen	BD	170529	300	8,8	Salmon	8	0	0
Åbyälven - Tällberg	BD	170529	150	8,7	No catch	0	0	0
Åbyälven - Bäckmyrforsen	BD	170529	150	8,8	No catch	0	0	0
Åbyälven - Krokforsen	BD	170614	150	14,9	Salmon	8	50	0,5
Forsträskån - Fredriksfors bro	BD	170530	150	6,8	No catch	0	0	0
Forsträskån - Fredriksforsen	BD	170530	500	7,6	No catch	0	0	0
Abramsån - 1	BD	170530	325	7,7	No catch	0	0	0
Abramsån - 2	BD	170530	500	8	Trout	1	100	2
Abramsån - 3	BD	170531	200	7,6	Trout	3	67	0,67
Abramsån - 4	BD	170531	150	7,8	No catch	0	0	0
Långträskälven - Ravenberget	BD	170607	300	10,6	Trout	3	0	0
Långträskälven - Stenträskberget	BD	170607	600	10,9	Trout	6	0	0
Vitbäcken - Högbodberget	BD	170608	500	11,7	Trout	2	0	0
Vitbäcken - Högbodmyran	BD	170608	500	12,8	Trout	3	0	0
Vitbäcken - Njalleberget	BD	170608	500	12,6	Trout	2	50	0,5
Vitbäcken - Vitberget	BD	170608	300	14,1	Trout	1	100	1
Vitbäcken - Nilsberget	BD	170609	500	13,5	Trout	3	33	0,33
Vitbäcken - Nilsberget	BD	170609	500	13,5	Salmon	1	0	0
Råneälven - Pakkohällarna	BD	170613	300	15,5	Salmon	11	73	0,91
Råneälven - Snasko, nedre	BD	170613	500	17	Salmon	6	67	0,83
Råneälven - Färgmyrforsen	BD	170612	750	16,6	Salmon	19	95	1,05
Råneälven - Storåholm	BD	170612	300	16,4	Salmon	4	0	0
Lögdeälven - Hyngelsböle	AC	170607	700	12,7	Salmon	53	81	1,13
Lögdeälven - Hyngelsböle	AC	170607	700	12,7	Trout	4	0	0
Lögdeälven - Klöse	AC	170607	700	14,7	Salmon	5	60	1
Lögdeälven - Klöse	AC	170607	700	14,7	Trout	4	0	0
Lögdeälven - Högåker	AC	170614	700	14,6	Salmon	12	67	0,25
Lögdeälven - Högåker	AC	170614	700	14,6	Trout	8	25	1,25
Lögdeälven - Norrfors	AC	170613	700	12,3	Salmon	33	27	0,33
Lögdeälven - Norrfors	AC	170613	700	12,3	Trout	3	33	0,33
Lögdeälven - Långforsen	AC	170615	700	15,7	Salmon	2	0	0
Lögdeälven - Långforsen	AC	170615	700	15,7	Trout	1	0	0
Lögdeälven - Väg 92	AC	170616	700	13,2	Salmon	41	0	0
Bladtjärnbäcken - Bladtjärnbäcken	AC	170605	300	8,7	Salmon	11	0	0
Bladtjärnbäcken - Bladtjärnbäcken	AC	170605	300	8,7	Trout	10	10	0,1
Mjösjöån - Mjösjöån	AC	170614	300	15,8	Trout	2	0	0
Karlsbäcken - Brännan	AC	170615	400	15,2	Salmon	7	0	0
Karlsbäcken - Brännan	AC	170615	400	15,2	Trout	14	36	0,36
Karlsbäcken - Ovan Karlsbäck	AC	170609	400	13,2	Trout	14	29	0,29
Blåtjärnbäcken - Blåtjärnbäcken	AC	170609	100	11,7	Trout	2	0	0
Blåbergsjöbäcken - Blåbergsjöbäcken	AC	170604	300	15,8	Trout	1	100	4
Blåbergsjöbäcken - Blåbergsjöbäcken mynning	AC	170608	300	15,8	Salmon	43	0	0
Blåbergsjöbäcken - Blåbergsjöbäcken mynning	AC	170608	300	15,8	Trout	2	50	1
Holmsjöbäcken - Holmsjöbäcken	AC	170616	300	18,3	Trout	17	29	0,29

Table 2. Number of infected fishes divided into classes per investigated site.

River	Site name	Class 0 (0 larva)	Class 1 (1-10 larvae)	Class 2 (11-50 larvae)	Class 3 (51-100 larvae)	Class 4 (>100 larvae)
Lögdeälven	Hyngelsböle	14	29	12	1	1
Lögdeälven	Klöse	6	1	2	0	0
Lögdeälven	Högåker	11	3	4	2	0
Lögdeälven	Norrfors	26	8	2	0	0
Lögdeälven	Långforsen	3	0	0	0	0
Lögdeälven	Väg 92	41	0	0	0	0
Bladtjärnbäcken	Bladtjärnbäcken	20	1	0	0	0
Mjösjöån	Mjösjöaan	2	0	0	0	0
Karlsbäcken	Brännan	16	5	0	0	0
Karlsbäcken	Ovan Karlsbäck	10	4	0	0	0
Blåtjärnbäcken	Blåtjärnbäcken	2	0	0	0	0
Blåbergsjöbäcken	Blåbergsjöbäcken mynning	44	0	1	0	0
Blåbergsjöbäcken	Blåbergsjöbäcken	0	0	0	0	1
Holmsjöbäcken	Holmsjöbäcken	12	5	0	0	0
Åbyälven	Hällforsen	8	0	0	0	0
Åbyälven	Tällberg	0	0	0	0	0
Åbyälven	Bäckmyrforsen	0	0	0	0	0
Åbyälven	Krokforsen	4	4	0	0	0
Forsträskån	Fredriksfors bro	0	0	0	0	0
Forsträskån	Fredriksforsen	0	0	0	0	0
Abramsån	1	0	0	0	0	0
Abramsån	2	0	0	1	0	0
Abramsån	3	1	2	0	0	0
Abramsån	4	0	0	0	0	0
Långträskälven	Ravenberget	3	0	0	0	0
Långträskälven	Stenträskberget	6	0	0	0	0
Vitbäcken	Högbodberget	2	0	0	0	0
Vitbäcken	Högbodmyran	3	0	0	0	0
Vitbäcken	Njalleberget	1	1	0	0	0
Vitbäcken	Vitberget	0	1	0	0	0
Vitbäcken	Nilsberget	3	1	0	0	0
Råneälven	Pakkohällarna	3	6	2	0	0
Råneälven	Snasko, nedre	2	3	1	0	0
Råneälven	Färgmyrforsen	1	16	2	0	0
Råneälven	Storåholm	4	0	0	0	0

Project area Åbyälven

A total of 16 salmons were caught on two different sites (8+8). Only four salmons from one site had larvae on their gills and in very low numbers (min: 1, max: 2).

The mean value of infected salmons from all sites in River Åbyälven was 31 %.

All four investigated sites are in the main stem of River Åbyälven.

Project area Byskeälven

A total of nine trout were caught in River Långträskälven. None of the fishes were infected with glochidia larvae.

Project area Piteälven

A low number of trout (min: 1, max: 3) were caught at all five fished sites in River Vitbäcken. At three of the sites, Njalleberget, Vitberget and Nilsberget infected fish were found. The infestation rate was quite high (min: 33 %, max: 100 %) although the number of glochida larvae on each fish was low (min: 6, max: 9).

The mean value of infected trouts from all sites in River Vitbäcken was 27 %.

Project area Råneälven

River Råneälven – main stem

Salmon were caught on all four investigated sites (min: 6, max: 19). Infected fish were found on all sites except Storåholm and the infestation rate was quite high (min: 67 %, max: 95 %) but the number of larvae on each fish was low (min: 1, max: 15). The weighted mean value was between 0,83 and 1,05.

The mean value of infected salmons from all sites in River Råneälven was 75 %.

River Forsträskån - tributary

No salmon or trout were caught in River Forsträskån.

River Abramsån – tributary

A low number of trout (min: 1, max: 3) were caught on two of the four investigated sites. The infestation rate was high (min: 67 %, max: 100 %) although the number of glochidia larvae on each fish was low (min: 3, max: 13).

The mean value of infected trouts from all sites in River Abramsån was 75 %.

Project area Lögdeälven

River Lögdeälven – main stem

Both salmon and trout were caught on five of six of the investigated sites, on site Väg 92 only trout were caught. Salmon (min: 2, max: 53) were more common than trout (min: 1, max: 8). The infestation rate was higher on salmon (min: 27 %, max: 81 %) than on trout (min: 25 %, max: 33 %).

There was a difference in number of glochidia between the salmon and the trout. At site Högåker the salmons had between two and 77 larvae on their gills, the trouts had one and two larvae, respectively. The infected trout at Norråker had one larvae and the salmons between one and 37. The number of glochidia larvae on the salmons at Hyngelsböle was between one and > 100 and the corresponding figures for site Klöse was between two and 42.

The mean value of infected salmons from all sites in River Lögdeälven was 43 %.

River Bladtjärnbäcken – tributary

Eleven salmons and ten trouts were caught in River Bladtjärnbäcken. 10 % of the trouts were infected with glochidia larvae, none of the salmons. The one infected trout had only one larvae on its gills.

River Mjösjöån – tributary

Only two trouts were caught in River Mjösjöån, none of the fish had glochidia larvae on their gills.

River Karlsbäcken - tributary

At site Brännan seven salmons and 14 trouts were caught. At site Ovan Karlsbäck 14 trouts were caught. 36 % of the trouts at Brännan and 29 % of the trouts att Ovan Karlsbäck were infected, none of the salmons. The number of glochidia larvae were low, between two and seven at Ovan Karlsbäck and between one and two at Brännan.

The mean value of infected trouts from all sites in River Karlsbäcken was 32 %.

River Blåtjärnbäcken – tributary

Only two trouts were caught in River Blåtjärnbäcken, none of the fish had glochidia larvae on their gills.

River Blåbergsjöbäcken - tributary

One trout were caught at site Blåbergsjöbäcken and that fish had more than 100 glochidia larvae on its gills. At site Blåbergsjöbäcken mynning two trouts were caught and one of those where infected (22 larvae). Additional 43 salmons were caught, none was infected.

The mean value of infected trouts from all sites in River Blåbersjöbäcken was 67 %.

River Holmsjöbäcken – tributary

In River Holmsjöbäcken 17 trouts were caught. The infestation rate was 29 % but the number of glochidia larvae was very low (min: 1, max: 2).

Discussion

This study indicates that the salmon act as the host fish for the FPM in the main stems of River Lögdeälven, River Åbyälven and River Råneälven and that the host fish in the tributaries are brown trout.

In River Karlsbäcken and River Holmsjöbäcken no FPM have been found during earlier inventory of the species. The finding of glochidia infected trouts in these rivers indicates that the FPM may be able to colonize the rivers. This is more likely to occur when the rivers are restored and the habitats are improved. One idea is to take eDNA-samples in the summer to see if FPM is present during the period when no infected fish should be in the rivers. If positive results are gained from a eDNA-sample a traditionally inventory with aqua scope can be made to find and confirm the present of the FPM.

There is a general assumption that around 20 % of the host population carries 80 % of the parasites which also seems to be correct for large freshwater mussels (Wengström & Johansson 2015). In all the studied rivers where infection was registered, the overall infestation rate was above 20 %, except for River Bladtjärnbäcken (10 %). It is alarming that the number of glochidia larvae on each fish in general was very low (Table 2.). 74 % of all infected fishes in the study ended up in class 1 (1-10 larvae) and only 4 % of the fishes had more than 50 larvae attached to their gills.

The duck mussel (*Anodonta anatina*) is the only other large freshwater mussel species found in the northern part of Sweden. The duck mussel releases their larvae in spring/early summer and have a relatively short development time (around one month) so we cannot rule out the possibility that some of the glochidia larvae found on the gills of the fish in this study originates from the duck mussel. The duck mussel is quite common and can be found in most freshwater habitats, except the most nutrient poor. Our perception is that we more often find duck mussel in lakes and slow flowing parts of larger rivers with softer bottom substrate.

Duck mussel have been found in River Åbyälven, in a lake in the upper part of River Vitbäcken, in the outlet of River Långträskälven and in the most southern parts of River Råneälven. There is no known presence of duck mussel in River Forsträskån, River Abramsån or in the Lögde river system, but on the other hand there have not been much focus on mapping the presence of duck mussel either. An eDNA-sample to see if the duck mussel is present in the systems can be made to sort out the question. An alternative is to electro fish and look for glochidia larvae in the autumn when no duck mussel glochidia should be present.

There were quite few fishes caught at most sites in the study so the assumptions should be considered with caution. Still, this is important data that will enable comparison after the restoration measures have taken place. The study will be repeated at two different years (2020 and 2021) after the restoration. Results from the studies will also be combined with the standardized electrofishing that is done in autumn that focus on the fish populations in the

target rivers. A compilation on salmon and trout data have previously been done within the project (Larsson 2017).

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