Juvenile salmon densities and habitats in the rivers Karasjoki and Jiesjoki

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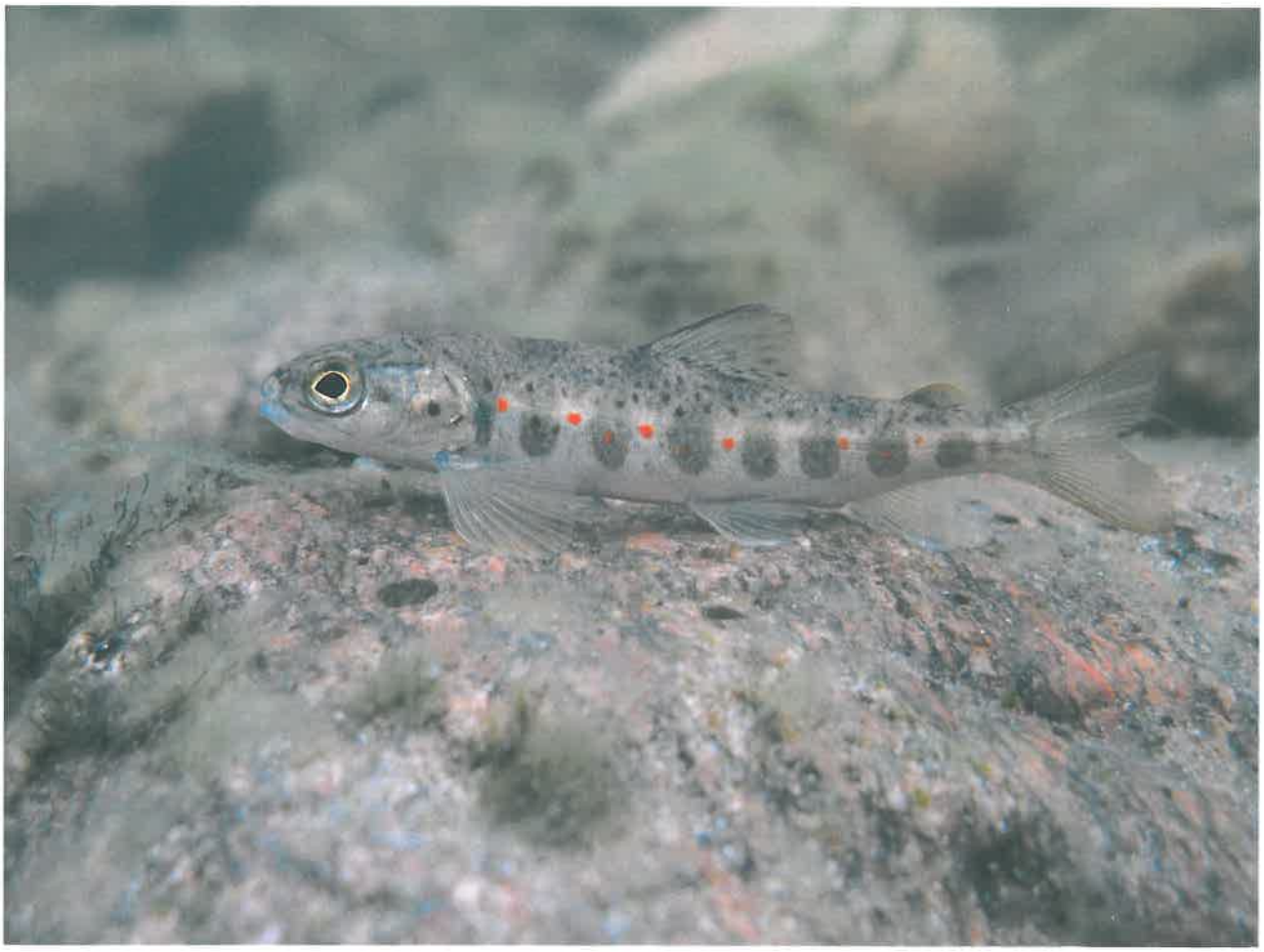

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1. Introduction

The River Teno (Tana in Norwegian) is located in northern Norway and northern Finland and it runs via Tanafjord into the Barents Sea (Fig. 1). The river system (drainage area 16386 km^2) is one of the most important Atlantic salmon, *Salmo salar* L., rivers in the world with annual in-river catches of 60-250 t and more than 1200 km of rivers accessible to migrating adult salmon. The river Teno system supports at least 20 genetically differentiated salmon populations in the main stem and in its tributaries (Vähä et al., 2007, 2008). The salmon production is entirely dependent on natural reproduction; release of reared fish and eggs is forbidden.

The salmon stocks of the River Teno system are monitored annually by the Finnish Game and Fisheries Research Institute (FGFRI) in close co-operation with Norwegian institutions and authorities. The long-term monitoring programmes includes estimation of the salmon catch, electrofishing for assessment of salmon parr densities in nursery habitats, and collection of adult salmon scale samples to determine the sea-age distribution and growth of salmon and their origin (wild/reared). Spatial coverage of the annual monitoring programme is rather wide, including the Teno mainstem and two large tributaries (Inarijoki and Utsjoki, Fig. 1). However, in this large river system, considerable portion of the salmon production area has not been monitored intensively during the last decades.

In recent years concerns has arisen about the status of the salmon populations in the headwater rivers of the River Teno, especially in the rivers Karasjoki (Karasjok, Kárašjohka) and Jiesjoki (Iešjok, Iešjohka) (Fig. 1). These rivers constitute about one third of the whole River Teno watershed (drainage area 5019 km^2) and are historically known to be important spawning areas for multi-sea-winter salmon (MSW, 2-5 sea-winters, large salmon). In 2006, Fylkesmannen i Finnmark and FGFRI agreed to start collection of information from the rivers Karasjoki and Jiesjoki with an aim to update the knowledge about the status of salmon stocks in these rivers by examining the juvenile salmon densities by electrofishing. Results from the years 2006 and 2007 have been summarized in an earlier report (Orell et al. 2008).

This report presents results from the electrofishing surveys conducted in Karasjoki and Jiesjoki in 2009 in relation to the earlier information (2006-2007). Corresponding information from the mainstem Teno and its tributaries Utsjoki and Inarijoki (Fig. 1), as well as data from the River Näätämöjoki (Neidenelva), are also presented for comparison. In addition, we report results of a meso-scale habitat survey of the River Karasjoki. Finally, earlier established microhabitat preference model for depth, water velocity, and substrate size was used to assess the habitat-parr density –relationship among the electrofishing sampling sites in the rivers Karasjoki and Jiesjoki.

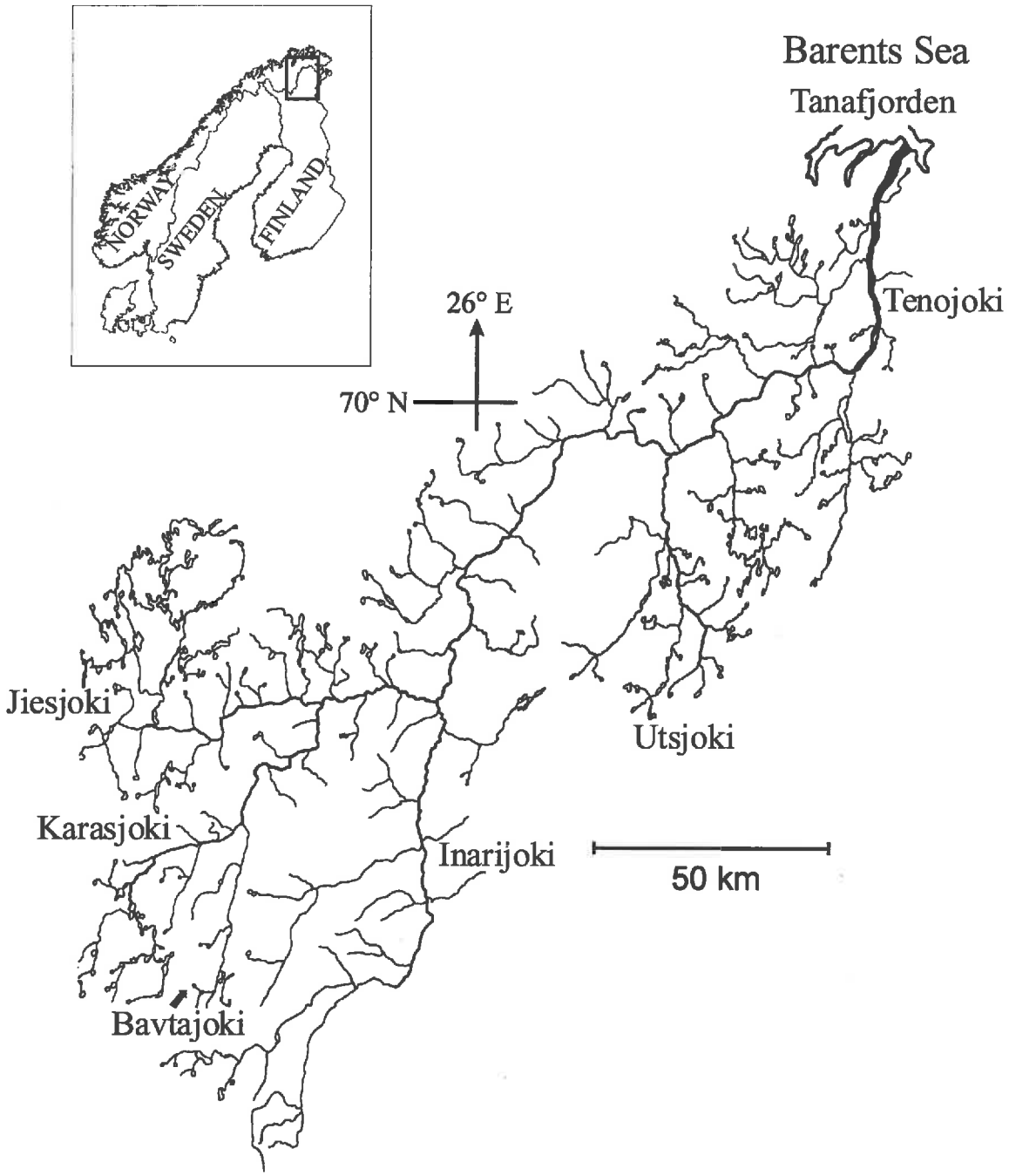

Figure 1. Map of the River Teno system including the rivers where electrofishing studies were carried out in 2006-2009.

2. Materials and methods

2.1. Electrofishing

The electrofishing surveys were conducted by a three-person group with generator-powered equipment (Hans Grassl GmbH, ELT 60II GI) using pulsed direct current (700-900 V, 0.2 A). In each study site one member of the fishing crew used the anode and two persons collected the stunned fish with dipnets (Fig. 2). All electrofishing sites were fished by one removal sampling to enable larger number and wider coverage of sampling sites compared to the traditional three pass method. The salmon densities are therefore expressed as catches of juveniles on one pass/100 m^2. Electrofishing sites were selected to represent running water habitats, different types of rapids and glides, in an approximately same proportion as they are found in the river systems. The electrofishing surveys of all study sites were conducted during August-early October.

As in 2007 the River Karasjoki electrofishing sites (n=18, sites 12-29) in 2009 were distributed between Bavtajoki rivermouth (upstream) and Suolggasavu (downstream). In 2006, the survey was started farther upstream from Vuottasluoppal and a total of 29 sites were electrofished (Appendix 1). In the River Bavtajoki, a tributary of Karasjoki, 14 sites were sampled in 2007.

In the River Jiesjoki, 12 electrofishing sites (sites 1-12) were sampled between Lake Suosjärvi and the Jiesjoki/Karasjoki confluence in 2006-2007 and 2009 (Appendix 2). In 2007, additional 15 sites were sampled above the Lake Suosjävri and 4 additional sites below the Lake Suosjärvi (Appendix 2).

Figure 2. Electrofishing team and a typical 0+ salmon habitat in the lower part of the River Karasjoki, electrofishing site 25. Photo: J. Kuusela.

2.2. Habitat mapping and measurements

2.2.1. Meso-scale habitat mapping

A meso-scale habitat classification was conducted in the river Karasjoki. The area surveyed started above the Vuottasluoppal Lake and continued c. 1.5 km downstream from the electrofishing site 29 (see appendix 1). Five different habitat types were used in these habitat surveys including rapid, glide, pool, flowing pool and lake (Appendix 3). The data on habitat types were collected in the field by canoeing downstream the river and taking GPS-positions at the upstream starting point of each individual habitat area. This information was then transported to a base map in ArcView software (version 9.2) and different habitat areas (polygons) were created by using the collected GPS data and the base map. Surface areas for each habitat were calculated using the ArcView.

Maps including the surveyed mesohabitats and the electrofishing sites were produced (see appendix 4).

In the River Jiesjoki only rapid areas were classified above the Lake Suosjärvi using the method described above and maps including the rapids and electrofishing sites were produced (see appendix 5). Surface areas of different habitat types (rapid, glide, pool and lake) for the whole Jiesjoki system are also presented, but they are based on an earlier habitat survey conducted by Jorma Mattson in the mid-1990-s (Mattson 1997). Therefore the surface areas are not fully comparable to those of the River Karasjoki.

2.2.2. Habitat characteristics at the electrofishing sites

Habitat preference criteria (preference indices for water depth, flow velocity and substrate size, Fig. 3), developed by Mäki-Petäys et al. (2002), were used to conduct a preliminary assessment whether the salmon parr (older than age 0+) densities parallel the habitat quality at the electrofishing sites.

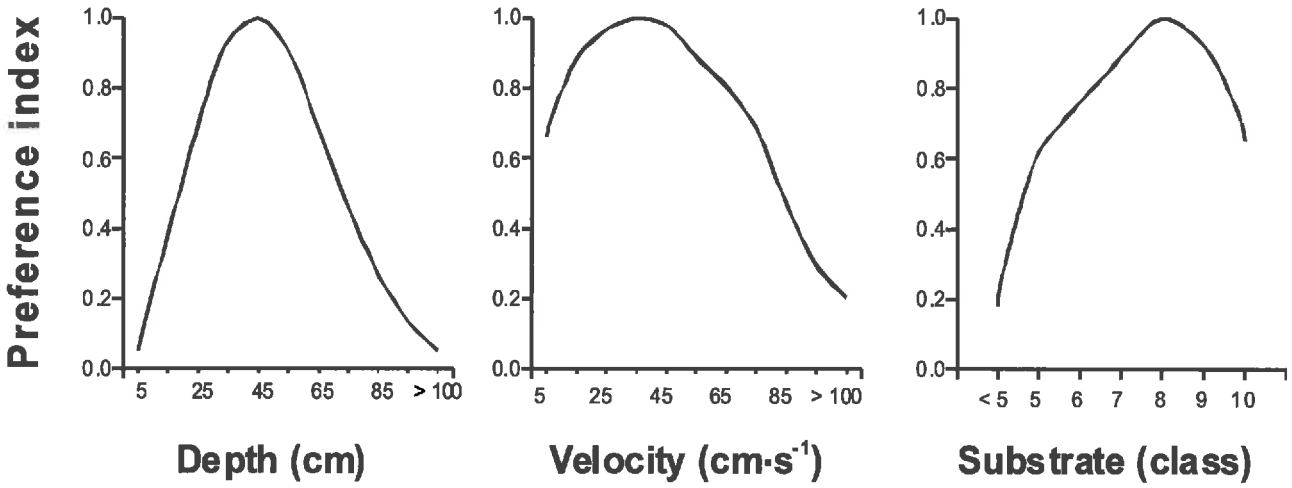

Figure 3. Generalized habitat suitability criteria for depth, mean water velocity and substrate size for salmon parr. Modified from Mäki-Petäys et al. (2002).

Habitat characteristics were measured at 8 and 27 electrofishing sites in rivers Jiesjoki and Karasjoki, respectively. At these sites, depth, water velocity, and substrate size were measured or estimated along four equidistant transects, which included three measurement points: one meter from the shoreline, at the outer border of sampling site (typically 5–10 m from the shore), and in the middle between the two other points, resulting in a total 12 measurement points per site. Water depth was measured to nearest cm, and flow velocities were measured at 0.6 x depth with a Schiltknecht MiniAir 2 flow meter (Schiltknecht Messtechnik AG, Gossau, Switzerland) fitted with a 20-mm propeller. Substrate class proportions were estimated on a ¼ m^2 circular area using a 28 cm radius (a piece of string) around the shaft of the current meter. Substrate size was classified to 10 classes by a modified Wentworth scale (1=Organic, 2=0–0.5 mm, 3=0.5–2 mm, 4=2–16 mm, 5=16–60 mm, 6=60–130 mm, 7=130–250 mm, 8=250–500mm, 9= >500mm and 10=bedrock). The proportion of every substrate size class was estimated for each measurement point and the median particle size value per site was calculated from cumulative percentage distribution of classes 1–10 by interpolation.

2.3. Habitat data analysis

Values of habitat measurements were (i) converted to a range of 0.0-1.0 (0.0 unsuitable, 1.0 optimal habitat for fish) using the general preference indices for juvenile Atlantic salmon (ages >0+), as presented by Mäki-Petäys et al. (2002), (ii) weighted by its representative area in relation to the whole site, and (iii) added up to gain weighted usable area (WUA) per 100 m^2 for each electrofishing site. WUA was calculated for substrate, because this variable is more stable and independent on seasonal variation compared to depth and flow, and it has also been shown in earlier studies that substrate has often sufficient and the highest ability in predicting juvenile salmonid abundance (e.g. Mäki-Petäys et al. 1999). However, the suitability of fish habitat is commonly evaluated by WUA estimates based on composite preference indices (e.g., the composite index of depth, water velocity and substrate, see Mathur et al. 1985). Therefore, we also calculated the geometric mean of the suitability index of depth, velocity, and substrate, to form composite WUA for these variables.

3. Results

3.2. Juvenile densities

3.2.1. Karasjoki

In the River Karasjoki salmon fry (0+) were found from 16 out of 18 sites in 2009 (Fig. 4). The fry density peaked in sites 12-14 at upper part of the study area and again in sites 26-29 in the lower part of the study reach. Poor fry densities were observed in the sites 15-20, the same phenomenon was evident in 2006-2007 also (Fig. 4). The mean fry density of sites 12-29 was slightly larger (18.4 individuals/100 m^2) compared to years 2006-2007 (14.3-15.9 individuals/100 m^2, Table I).

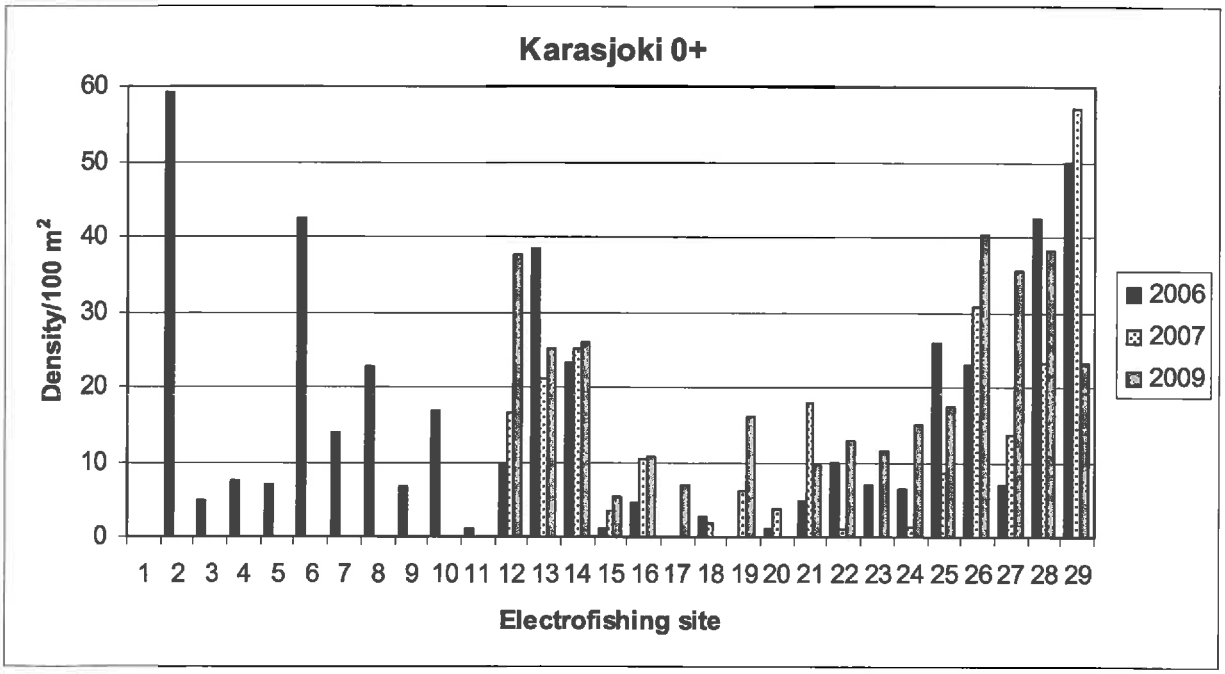

Figure 4. The densities (individuals/100 m^2, one pass electrofishing) of salmon fry (0+) in the River Karasjoki electrofishing sites in 2006-2007 and in 2009. The numbering of the electrofishing sites starts from the upstream end of the study section. Only sites 12-29 were electrofished in all three years.

Salmon parr (>0+) were found from all the electrofishing sites (12-29) in 2009, and their density varied between 5.7 and 44.3 individuals/100 m^2 (Fig. 5). The density of parr peaked at sites 12-13,

17, 21 and 24. The mean parr density of sites 12-29 (21.9 individuals/100 m^2) was at the level observed in 2006 and somewhat higher than in 2007 (Table I).

In the River Bavtajoki, a tributary of Karasjoki, high density of salmon fry was observed in 2007 (Table I, Fig. 6). The density of parr was in line with the densities observed in the main stem Karasjoki in 2006-2009 (Table I, Fig. 6).

Table I. Mean densities of salmon fry (0+) and parr (>0+) in the rivers Karasjoki (sites 12-29), Jiesjoki (sites 1-12) and Bavtajoki (sites 1-14) in 2006-2007 and 2009. The mean densities are based on catches of salmon juveniles on one electrofishing pass/100 m^2.

	Karasjoki		Jiesjoki		Bavtajoki	
Year	0+	>0+	0+	>0+	0+	>0+
2006	14.3	22.5	8.3	21.3		
2007	13.5	15.9	5.9	19.6	36.4	17.5
2009	18.4	21.9	5.2	9.6		

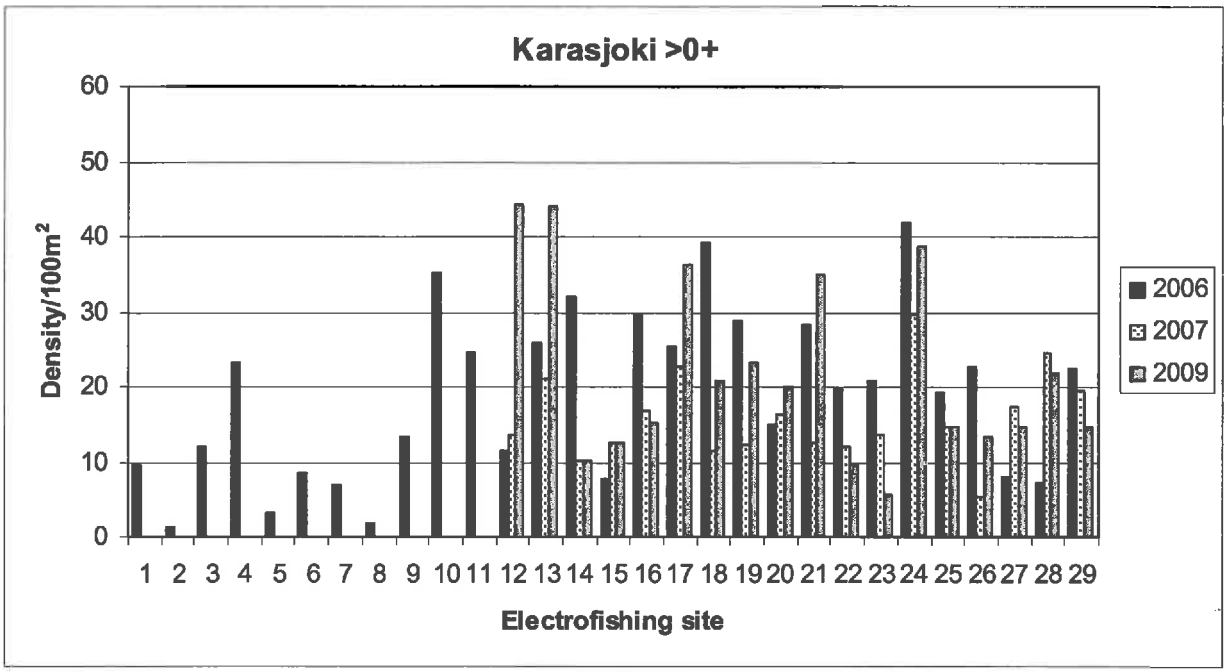

Figure 5. The densities (individuals/100 m^2, one pass electrofishing) of salmon parr (>0+) in the River Karasjoki electrofishing sites in 2006-2007 and in 2009. The numbering of the electrofishing sites starts from the upstream end of the study section. Only sites 12-29 were electrofished in all three years.

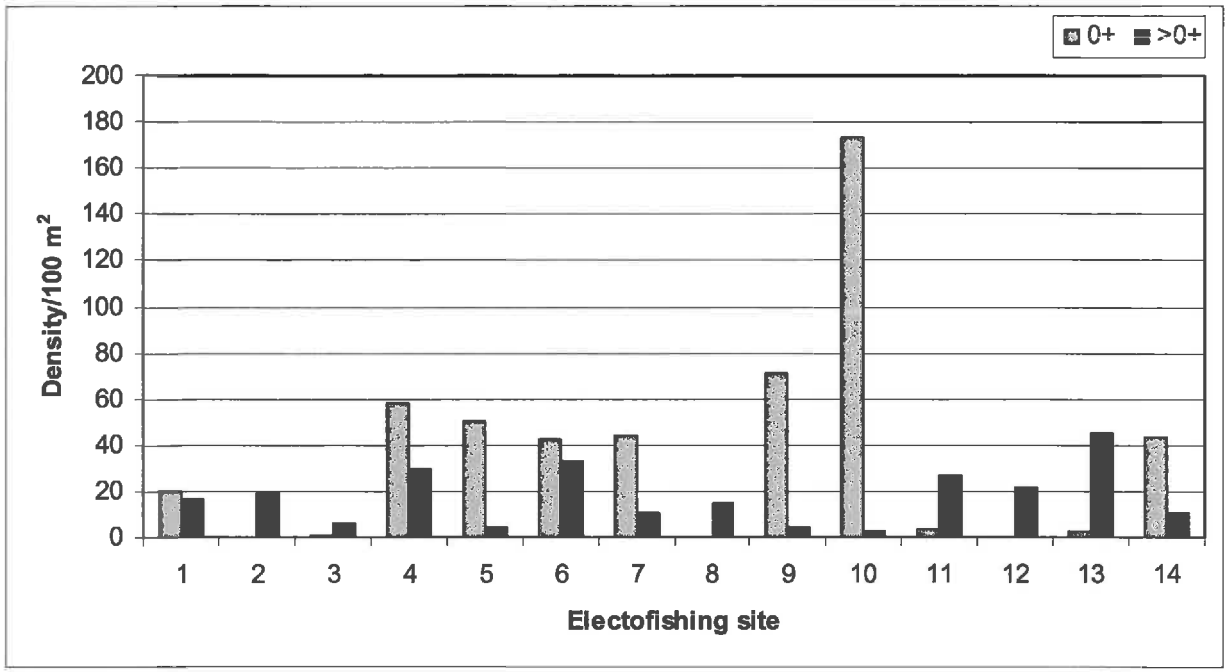

Figure 6. The densities (individuals/100 m^2, one pass electrofishing) of salmon fry (0+) and parr (>0+) in the River Bavtajoki in 2007. The numbering of the electrofishing sites starts from the upstream end of the study section. Note the density scale on the y-axis that is different from other figures.

3.2.2. Jiesjoki

In the River Jiesjoki salmon fry were found from 9 out of 12 sites and the densities were generally very low in 2009 (Fig. 7). Only one notable peak in fry density was observed, at site 10. Sites without a single fry caught (5-6 and 12) were the same as in 2006-2007 (Fig. 7). The mean fry density in 2009 (5.2/100 m^2) was somewhat lower than in 2006-2007 (5.9-8.3 individuals/100 m^2, Table I).

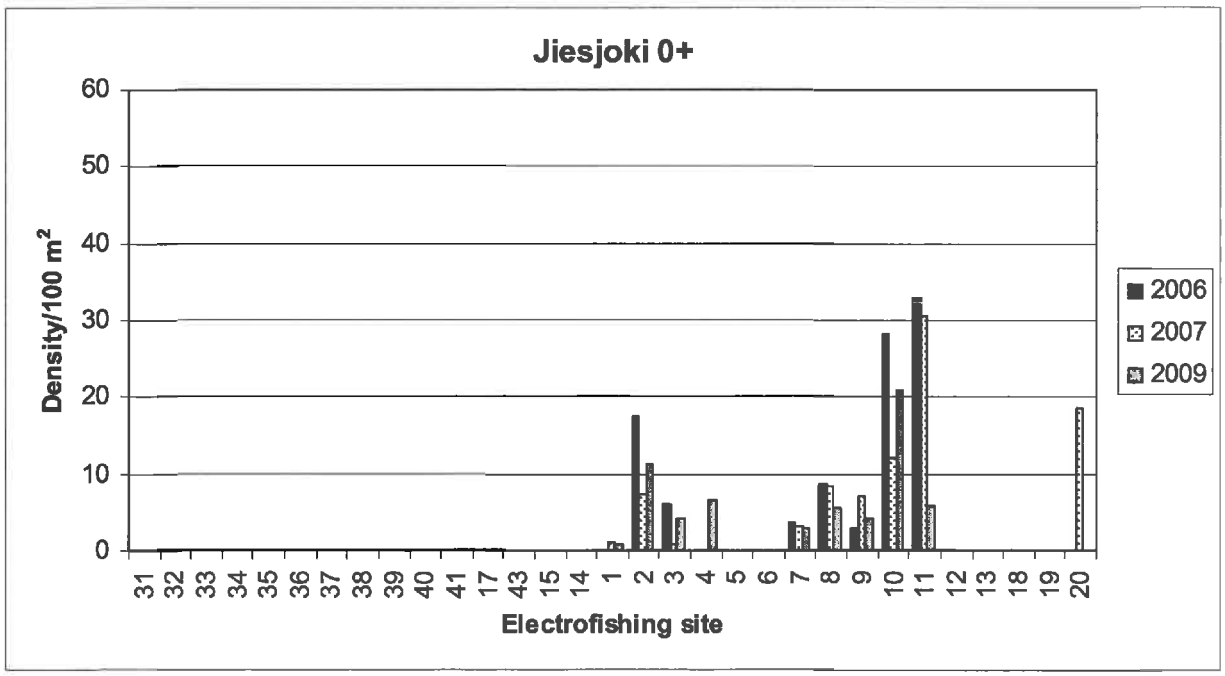

Figure 7. The densities (individuals/100 m^2, one pass electrofishing) of salmon fry (0+) in the River Jiesjoki electrofishing sites in 2006-2007 and in 2009. Sites 31-14 above the Lake Suosjärvi were fished only in 2007. Sites 1-12 below Lake Suosjärvi were electrofished in all three years. Sites 13-20 were electrofished only in 2007.

As in the River Karasjoki, salmon parr were present in all electrofishing sites (sites 1-12) of the River Jiesjoki in 2009 (Fig. 8). Peaks in parr density observed in 2006-2007 (e.g. sites 2, 4 and 11) were not observed in 2009. The mean parr density in 2009, 9.6 individuals/100 m^2, was considerably lower that in 2006-2007 (Table I).

Above the Lake Suosjärvi (sites on the left half of the figure, 31-14), no salmon fry were found in a survey that was conducted in 2007 (Fig. 7). Salmon parr were found from six sites, but the densities were very low (Figs. 8-9).

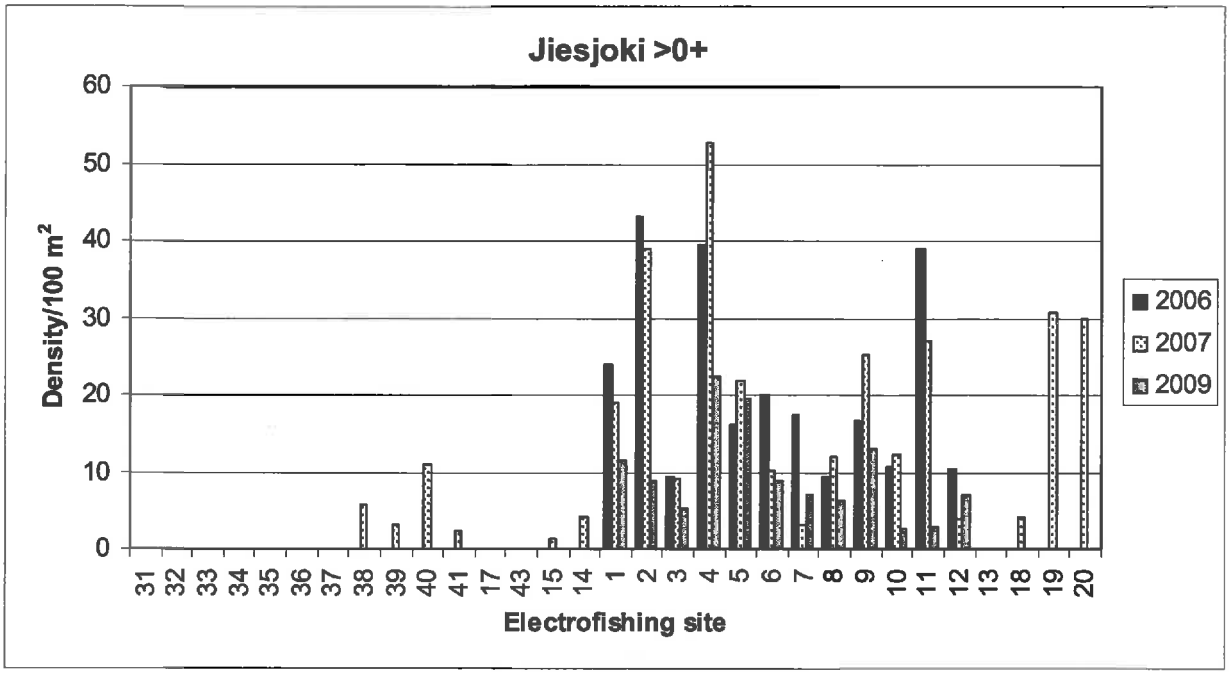

Figure 8. The densities (individuals/100 m^2, one pass electrofishing) of salmon parr (>0+) in the River Jiesjoki electrofishing sites in 2006-2007 and in 2009. Sites 31-14 above the Lake Suosjärvi were fished only in 2007. Sites 1-12 below Lake Suosjärvi were electrofished in all three years. Sites 13-20 were electrofished only in 2007.

3.3. Density levels as compared to other rivers

The mean density of salmon fry (0+) observed in the River Karasjoki in 2009 was significantly lower than those in other parts of the River Teno (Teno, Utsjoki and Inarijoki) in the same year, but on the other hand, higher than those observed in the River Näätämöjoki system (Table II). The mean fry density in Karasjoki was also higher or at the same level than the long-term (1979-2009) mean densities observed in different parts of the River Teno (Table III, see also figs. 10-12).

In 2009 the River Jiesjoki salmon fry mean density was extremely low compared to other parts of the River Teno or the River Näätämöjoki (Table II). The observed mean fry density of the River Jiesjoki was among the lowermost mean densities ever observed in the River Teno system (Figs. 10-12) and also significantly lower than the long-term mean fry densities of the River Teno system (Table III).

Salmon parr (>0+) mean density of the River Karasjoki was comparable to the other parts of the River Teno system in 2009 (Table II). Mean density of the Karasjoki parr was also higher than the long-term mean densities observed in the rivers Tenojoki, Utsjoki and Inarijoki (Table III).

The mean parr density observed in the River Jiesjoki in 2009 was roughly halved compared to the earlier study years (2006-2007, see Table I) and it was clearly the lowermost when compared to other parts of the River Teno or to the River Näätämöjoki in 2009 (Table II).

Figure 9. Good salmon juvenile habitat in the River Jiesjoki, few kilometers upstream from the Lake Suosjärvi. Upstream from the lake, no salmon fry were found and the parr densities were extremely low. Photo: J. Erkinaro.

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Table II. Number of electrofishing sites, mean densities and standard deviations of 0+, >+0 and total salmon juveniles in the rivers Karasjoki (sites 12-29), Jiesjoki (sites 1-12), Tenojoki, Inarijoki, Utsjoki, Näätämöjoki Finnish side (F) and Näätämöjoki Norwegian side (N) in 2009. The mean densities are based on catches of salmon juveniles on one electrofishing pass/100 m^2.

River	n-sites	0+	Std.	>0+	Std.	Total	Std.
Karasjoki	18	18.4	13.0	21.9	12.3	40.3	18.6
Jiesjoki	12	5.2	6.0	9.6	6.1	14.8	7.0
Tenojoki	32	32.0	36.5	17.4	10.6	49.4	34.8
Inarijoki	10	35.9	62.1	27.3	16.1	63.2	64.5
Utsjoki	12	28.6	27.8	15.1	11.9	43.7	29.2
Näätämöjoki (F)	17	12.7	15.5	15.6	14.6	28.2	27.9
Näätämöjoki (N)	13	9.1	7.2	43.5	16.4	52.6	19.6

Table III. Long-term (1979-2009) mean densities of 0+, >0+ and all salmon juveniles in the rivers Tenojoki, Utsjoki and Inarijoki. The mean densities are based on catches of salmon juveniles on one electrofishing pass/100 m^2.

	River		
Mean density	Tenojoki	Utsjoki	Inarijoki
0+	14,1	20,0	15,7
>0+	11,5	17,8	16,4
All	25,6	37,8	32,1

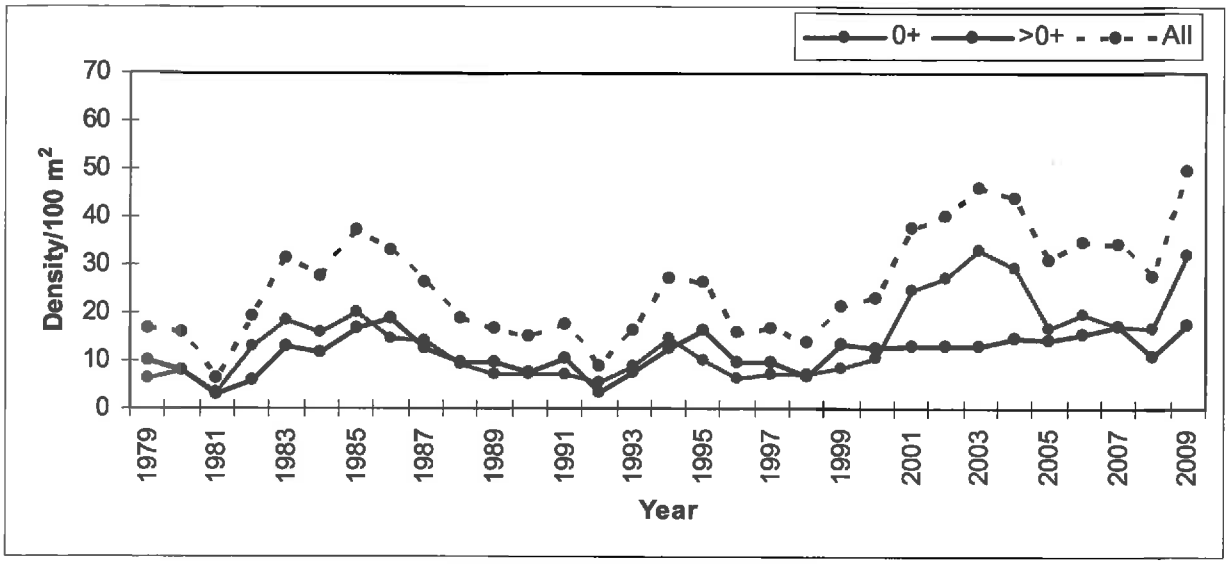

Figure 10. The mean densities of 0+ (fry), >0+ (parr) and all salmon juveniles in the River Teno electrofishing sites in 1979-2009. The densities are expressed as individuals/100 m^2 on one pass electrofishing.

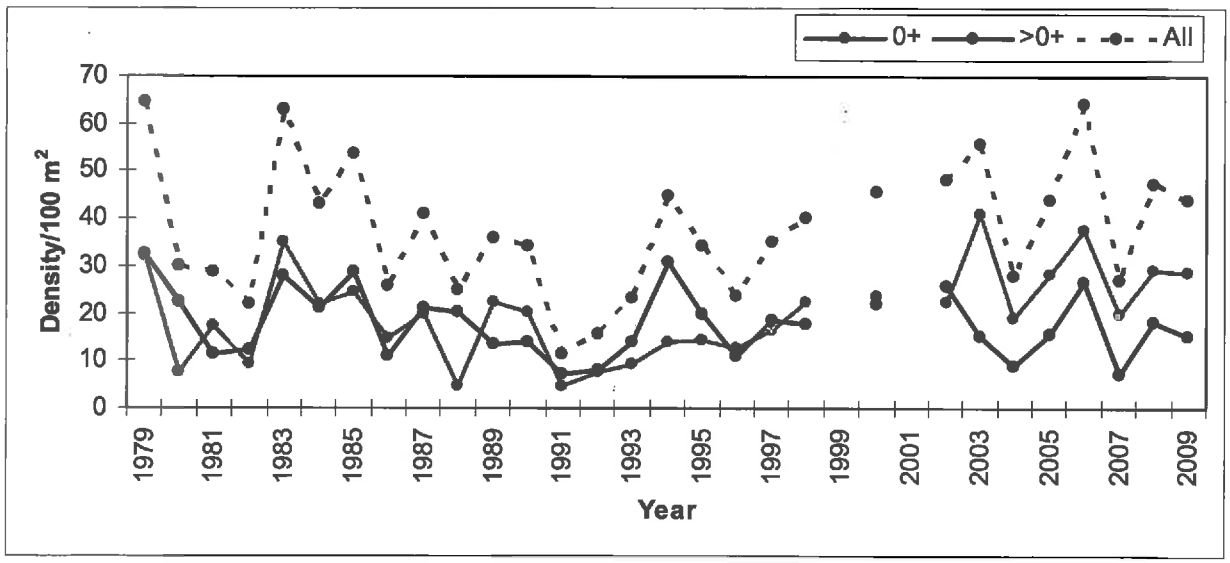

Figure 11. The mean densities of 0+ (fry), >0+ and all salmon juveniles in the River Utsjoki electrofishing sites in 1979-2009. The densities are expressed as individuals/100 m^2 on one pass electrofishing.

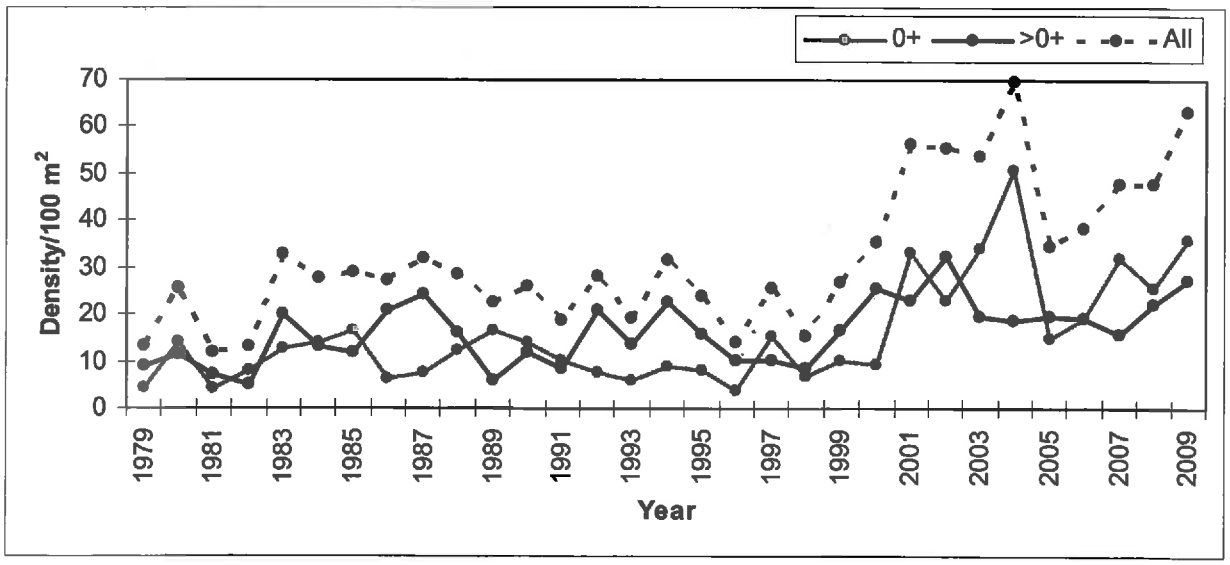

Figure 12. The mean densities of 0+ (fry), >0+ and all salmon juveniles in the River Inarijoki electrofishing sites in 1979-2009. The densities are expressed as individuals/100 m^2 on one pass electrofishing.

3.4. Habitats vs. densities

There was larger variation in habitat quality for juvenile salmon among electrofishing sites when the habitat quality was based on the composite WUA compared to the case when substrate only was used (Fig. 13 a, b),. Habitat quality at the electrofishing sites of the upper part of the Jiesjoki appeared to be at least comparable to that of the Karasjoki sites. However, juvenile salmon densities in the upper Jiesjoki were markedly lower compared to the general level in Karasjoki (Fig. 13). In many sites, the observed fish abundance was not closely linked with the habitat quality, and deviations both to the directions of higher and lower than expected were observed.

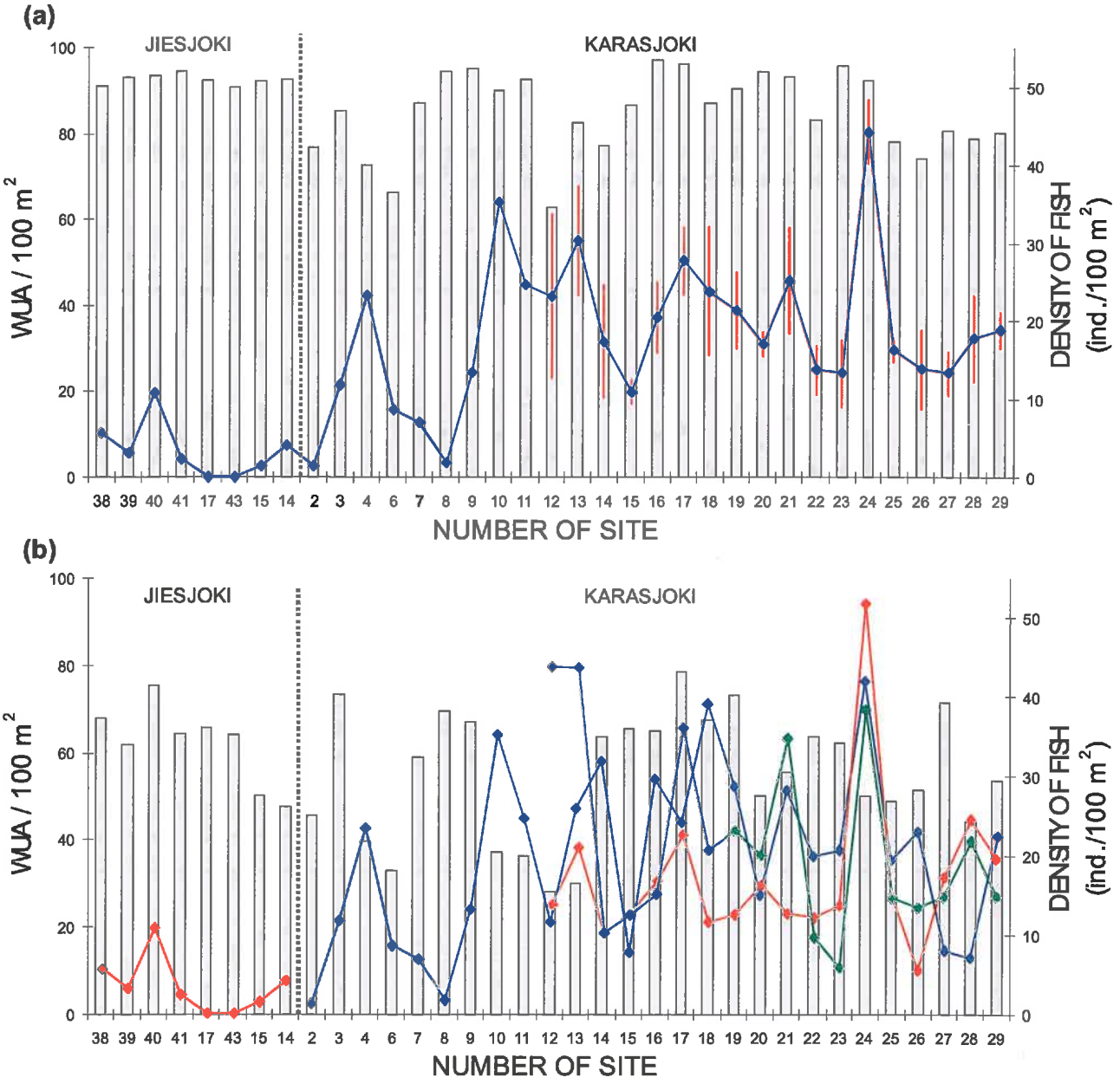

Figure 13. Salmon parr densities (lines) in relation to the amount of suitable habitat at the electrofishing sites indicated by weighted usable area (WUA; bars) for substrate alone (a) and by a composite value of depth, velocity and substrate (b) in electrofishing sites of the rivers Jiesjoki and Karasjoki. Densities of parr in 2006, 2007, and 2009 for sites 12-29 in river Karasjoki, are demonstrated as an overall average ± SE (a), and years separately by using blue, red, and green lines, respectively (b).

3.5. Meso-scale habitat mapping

The meso-scale habitat data from the River Karasjoki are shown in Appendix 3 and presented in maps in Appendix 4. In total 241 separate habitat areas were defined from the surveyed river section with a total surface area of 344 hectares (Table IV). The most frequently found habitat types were rapids and pools, together comprising > 60 % of the total surface area of the surveyed river section (Table IV).

Table IV. The occurrence (number of areas, hectares, %) of different mesohabitat types in the River Karasjoki. For more information, see appendices 3-4.

Habitat type	Number of areas	Total area (ha)	%
Rapid	92	109	31,5
Glide	47	26	7,6
Flowing pool	60	43	12,4
Pool	34	104	30,2
Lake	8	63	18,3
Total	241	344	100,0

The maps presenting the rapid areas and electrofishing sites of the River Jiesjoki above the Lake Suosjärvi are presented in Appendix 5. In total, the surface area of the rapids above the Lake Suosjärvi was estimated at 42.1 hectares.

The surface area of different habitat types in the whole Jiesjoki river system is presented in Table V. This information is based on an earlier survey conducted in 1990s (Mattson 1997) and may not be fully comparable with the data collected from the River Karasjoki in 2006.

Table V. The occurrence (surface area, hectares and pecentages) of different mesohabitat types in the the River Jiesjoki above the Lake Suosjärvi (AS) and below the Lake Suosjärvi (BS). The Jiesjoki (AS) component includes also the surface area of the Lake Suosjärvi. Data compiled from Mattson (1997).

Habitat type	Jiesjoki (AS)	Jiesjoki (AS) %	Jiesjoki (BS)	Jiesjoki (BS) %
Rapid	42	4,6	107	27,5
Glide	19	2,1	54	13,9
Pool	98	10,7	123	31,6
Lake	754	82,6	105	27,0
Total	913	100,0	389	100,0

4. Conclusion and future recommendations

Despite the general agreement between the juvenile salmon abundance between Karasjoki-Jiesjoki and other parts of the Teno, as well as Näätämöjoki, the year 2009 seems to be an exception. After a relatively good year for MSW salmon runs in Teno, the 0+ densities in the Teno main stem and Inarijoki were on a very high level, but this did not seem to be the case in Karasjoki system, although the 0+ densities in 2009 were generally higher than in earlier years This is raising questions about the possible differences in fishing mortality between different sub-populations within the Teno system in 2009, or alternatively, indications towards a longer term development that may explain the lack of such response in juvenile fish abundance in Karasjoki.

Catch statistics have indicated very low salmon catches in the Karasjoki over the recent years, but the juvenile densities reflect relatively similar status as in some other parts of the Teno system. This mismatch could potentially be explained by decreasing fishing effort and thus lower catches that could still enable relatively good spawning stock, as indicated by the juvenile fish abundance. However, this may nevertheless indicate a gradually declining total population size if the spawning stock remains relatively unchanged but the catches dramatically decline. Another unknown factor is whether the juvenile fish are progeny of 1SW or MSW salmon.

The extremely low fish densities in Jiesjoki in 2009 could partly be explained by an unfortunately late sampling time (30.9.-2.10.). However, there have been relatively low densities in earlier years too, but – on the other hand – it appears that the sampling programme has been especially unsuccessful in covering spawning areas and 0+ habitats in a representative manner. Therefore, additional sampling areas from 0+ fish habitats should be added to the monitoring programme. No 0+ salmon were detected in 2007 in the upper part of the Jiesjoki, above the lake Suosjärvi, which is another worrying factor that suggests low spawning population in this system.

We recommend continuation of the juvenile monitoring programme in Karasjoki-Jiesjoki, and further establishment of a permanent monitoring programme, including both counts of ascending and/or spawning salmon (e.g. fish counters and snorkelling surveys), and monitoring of juvenile salmon densities.

The main branches of the River Karasjoki system, Karasjoki and Jiesjoki, include considerable areas of classical, running-water habitats (rapids and glides) for juvenile Atlantic salmon production, in addition to pools and lakes that could also play a role during the juvenile phases (e.g. Erkinaro et al. 1998). When the habitat quality was assessed on a smaller scale, at the electrofishing sites, there was a considerable mismatch between the WUA value and the observed fish abundance. In some cases, it appeared that there were more salmon parr than the WUA value would have predicted for the site. For example, at sites 13 and 14 in 2009, the parr densities were considerable high, although the habitat was more suitable for salmon fry (0+), and the parr densities in other years were markedly less than in 2009. In 2009, the water level was much higher than in earlier years and therefore the composite WUA values for these sites would have been higher for older parr if they were estimated in 2009, and thus the match between habitat value and fish abundance would have been better. This demonstrates the sensitivity of the composite value, as a consequence of variation in flow and water level, compared to the substrate-based WUA. Nevertheless, it is obvious that many areas with high habitat quality show less-than-expected juvenile salmon densities, especially in the River Jiesjoki.

Habitat survey should be conducted also in the River Jiesjoki in a comparable manner with the Karasjoki survey, to enable appropriate comparison. However, the estimation of the rapid areas above the Lake Suosjavri resulted in a similar estimate with the earlier survey by Mattsson (1997), suggesting little deviation between the methods. In addition, future analyses should be expanded towards comparisons between different rivers by utilizing similar habitat measurements and fish

data from electrofishing sites in the Teno mainstem, Utsjoki, Inarijoki and Näätämöjoki (see Erkinaro et al. 2004). In addition, habitat measurements at the electrofishing sites, similar to those carried out in Karasjoki and upper parts of the Jiesjoki, should be conducted in the lower part of the Jiesjoki as well.

5. References

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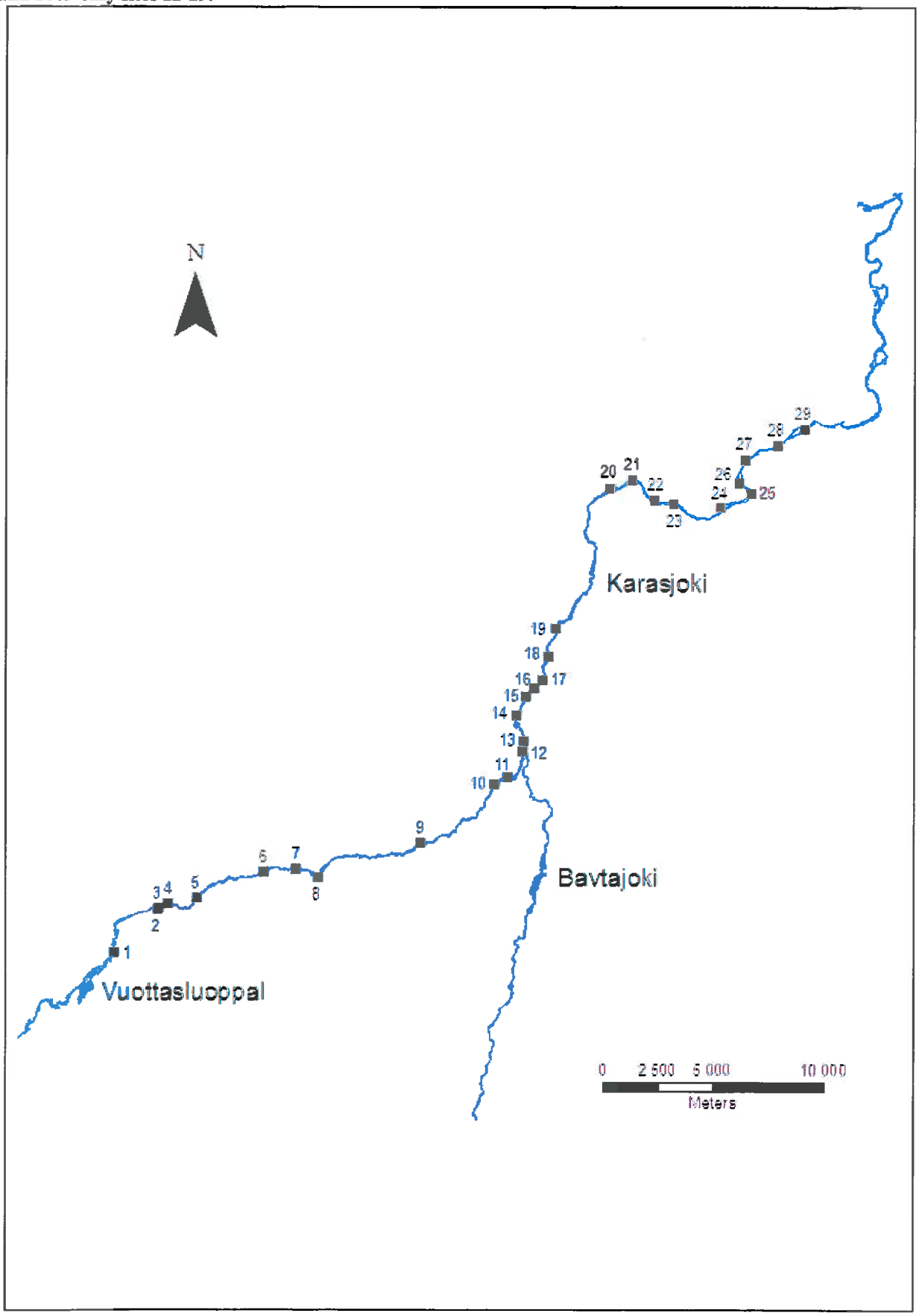
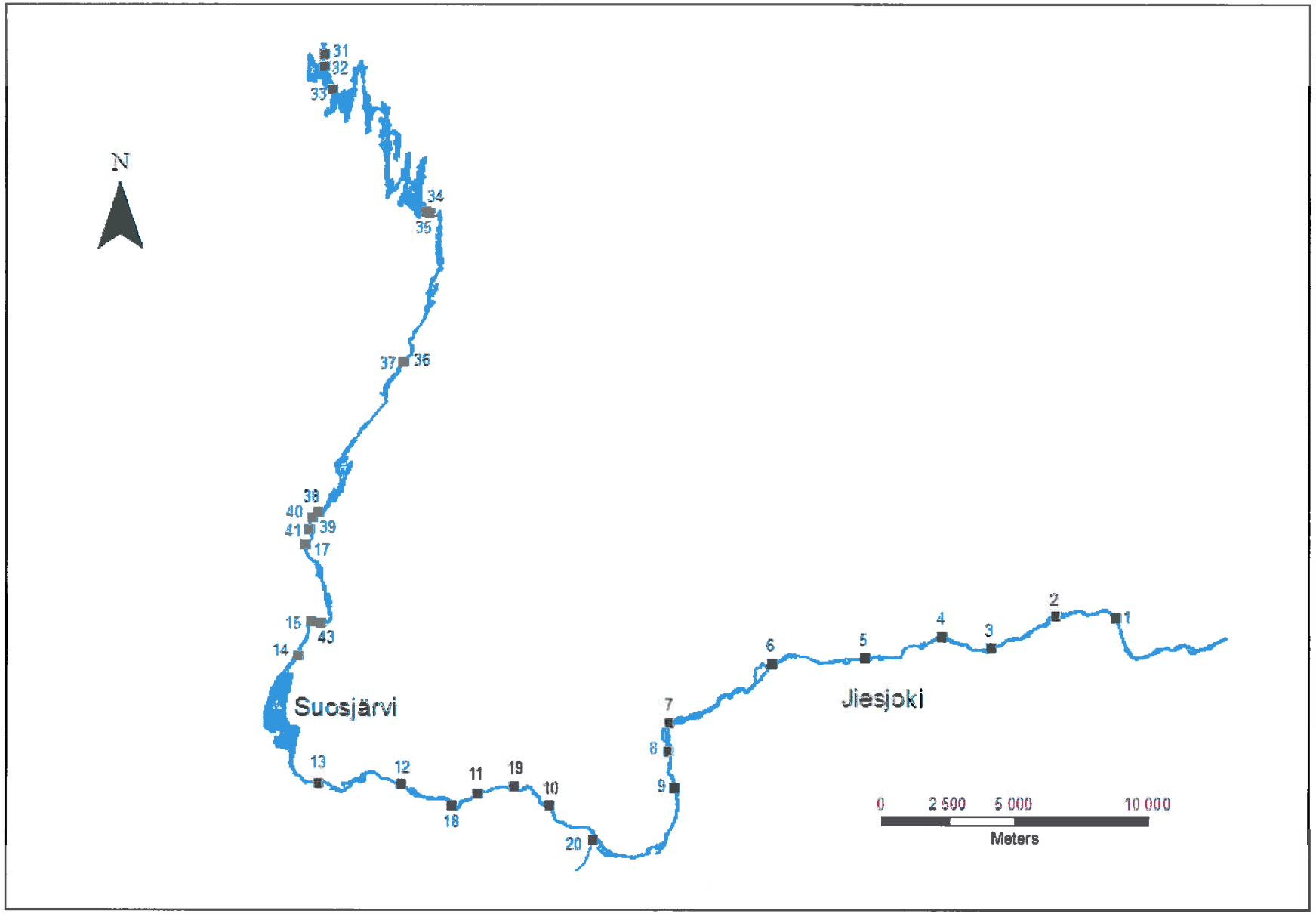
Appendix 1. Map of the electrofishing sites in the River Karasjoki. In 2006 all sites were electrofished; in 2007 and 2009 only sites 12-29.



Appendix 2. Map of the electrofishing sites in the River Jiesjoki. Sites 31-14 (grey squares) above the Lake Suosjärvi were electrofished only in 2007. Sites 1-12 below the Lake Suosjärvi were electrofished in 2006-2007 and in 2009, but sites 13-20 only in 2007 (black squares).



Appendix 3. Meso-scale habitat data from the River Karasjoki including area number, habitat code, habitat type, Surface area (m^2) and coordinates (X, Y) of the upstream starting point of each habitat area. The river was classified to five different habitat types, including rapid (R), glide (G), pool (P), flowing pool (F) and lake (L).

Area nr	Habitat code	Habitat type	Surface area (m^2)	X	Y	Comment
0	F	Flowing pool	29309	389404	7666900	
0	F	Flowing pool	6389	389550	7667218	
0	F	Flowing pool	1345	389781	7667305	
0	F	Flowing pool	2932	392782	7669297	
0	F	Flowing pool	5759	392826	7669375	
0	F	Flowing pool	1321	392879	7669546	
0	F	Flowing pool	3891	392843	7669991	
0	F	Flowing pool	636	392891	7670099	
0	F	Flowing pool	697	392892	7670541	
0	F	Flowing pool	406	392883	7670576	
0	F	Flowing pool	18917	395454	7671613	
0	F	Flowing pool	2397	395885	7671433	
0	F	Flowing pool	5171	396125	7671457	
0	F	Flowing pool	2065	396258	7671502	
0	F	Flowing pool	3276	396398	7671727	
0	F	Flowing pool	3527	396438	7671856	
0	F	Flowing pool	1277	399378	7673000	
0	F	Flowing pool	1148	399556	7673158	
0	F	Flowing pool	1619	400041	7673302	
0	F	Flowing pool	2635	400785	7673207	
0	F	Flowing pool	4302	400889	7673226	
0	F	Flowing pool	4064	401056	7673166	
0	F	Flowing pool	2965	401386	7673215	
0	F	Flowing pool	3399	402214	7673057	
0	F	Flowing pool	3906	402243	7673193	
0	F	Flowing pool	2066	402291	7673116	
0	F	Flowing pool	1337	402413	7673288	
0	F	Flowing pool	2254	402408	7673370	
0	F	Flowing pool	1754	402477	7673372	
0	F	Flowing pool	16396	403311	7673801	
0	F	Flowing pool	23499	404151	7673802	
0	F	Flowing pool	3670	404566	7673775	
0	F	Flowing pool	32269	404891	7673826	
0	F	Flowing pool	6297	407908	7674777	
0	F	Flowing pool	18296	408115	7674842	
0	F	Flowing pool	1114	410746	7677441	
0	F	Flowing pool	691	410788	7677434	
0	F	Flowing pool	1647	410772	7677356	
0	F	Flowing pool	2310	411221	7677799	
0	F	Flowing pool	1786	411250	7677840	
0	F	Flowing pool	3340	411260	7677901	
0	F	Flowing pool	1129	411266	7677957	
0	F	Flowing pool	2593	411475	7678575	
0	F	Flowing pool	3454	411429	7679101	
0	F	Flowing pool	7708	411388	7679232	
0	F	Flowing pool	4316	411344	7679353	
0	F	Flowing pool	12554	411130	7680334	
0	F	Flowing pool	2181	411348	7680708	
0	F	Flowing pool	10185	412500	7683022	
0	F	Flowing pool	1841	412785	7683760	
0	F	Flowing pool	6992	412904	7684289	
0	F	Flowing pool	37530	415956	7690650	
0	F	Flowing pool	26077	420520	7689648	
0	F	Flowing pool	2163	420575	7689793	

0	F	Flowing pool	11939	421271	7691059	
0	F	Flowing pool	32865	423729	7693140	
1	R	Rapid	5549	389263	7666541	
2	G	Glide	3133	389489	7667133	
3	R	Rapid	8079	389686	7667277	
4	R	Rapid	3262	389822	7667287	
5	P	Pool	150590	390439	7667245	
7	R	Rapid	4808	392092	7668511	
8	R	Rapid	4557	392222	7668640	
9	G	Glide	728	392296	7668692	
10	R	Rapid	3889	392347	7668768	
11	G	Glide	479	392442	7668827	
12	R	Rapid	124	392771	7669243	
13	G	Glide	572	392796	7669333	
14	R	Rapid	2277	392860	7669485	Electrofishing site 1
15	G	Glide	1408	392879	7669583	
16	L	Lake	25878	392825	7669779	
17	R	Rapid	472	392880	7669893	
18	R	Rapid	1530	392858	7670064	
19	R	Rapid	3680	392937	7670181	
20	L	Lake	26615	392961	7670379	
21	R	Rapid	256	392884	7670563	
22	R	Rapid	1406	392885	7670617	
23	P	Pool	61554	393330	7670971	
25	P	Pool	9000	394495	7671437	
26	R	Rapid	4622	394649	7671377	
27	F	Flowing pool	4872	394734	7671408	Spawning area
28	R	Rapid	24063	395015	7671600	Electrofishing sites 2-4
29	F	Flowing pool	8061	395735	7671522	
29	G	Glide	2906	395735	7671522	
30	G	Glide	2032	395885	7671433	
31	R	Rapid	7458	396005	7671473	
32	R	Rapid	4947	396212	7671471	
33	R	Rapid	12203	396350	7671599	
34	R	Rapid	1738	396407	7671811	
35	G	Glide	9644	396544	7671930	Electrofishing site 5
36	P	Pool	153868	397701	7672578	
37	R	Rapid	10913	399237	7672942	
38	R	Rapid	11004	399472	7673070	Electrofishing site 6
39	G	Glide	2015	399604	7673155	
40	P	Pool	22264	399815	7673223	
41	G	Glide	943	400014	7673297	
42	R	Rapid	15769	400282	7673284	
43	P	Pool	10717	400570	7673234	
44	R	Rapid	2383	400710	7673200	
45	G	Glide	665	400833	7673223	
46	R	Rapid	4665	400976	7673214	
47	R	Rapid	3960	401114	7673153	Electrofishing site 7
48	F	Flowing pool	11690	401239	7673213	Spawning area
49	G	Glide	1471	401343	7673209	
50	R	Rapid	2151	401447	7673197	
51	R	Rapid	32356	401797	7673067	
52	R	Rapid	21875	402100	7672895	Electrofishing site 8
53	R	Rapid	2908	402229	7673091	
54	G	Glide	4899	402343	7673196	
55	R	Rapid	652	402385	7673253	
56	G	Glide	1443	402435	7673332	
57	R	Rapid	10683	402587	7673509	

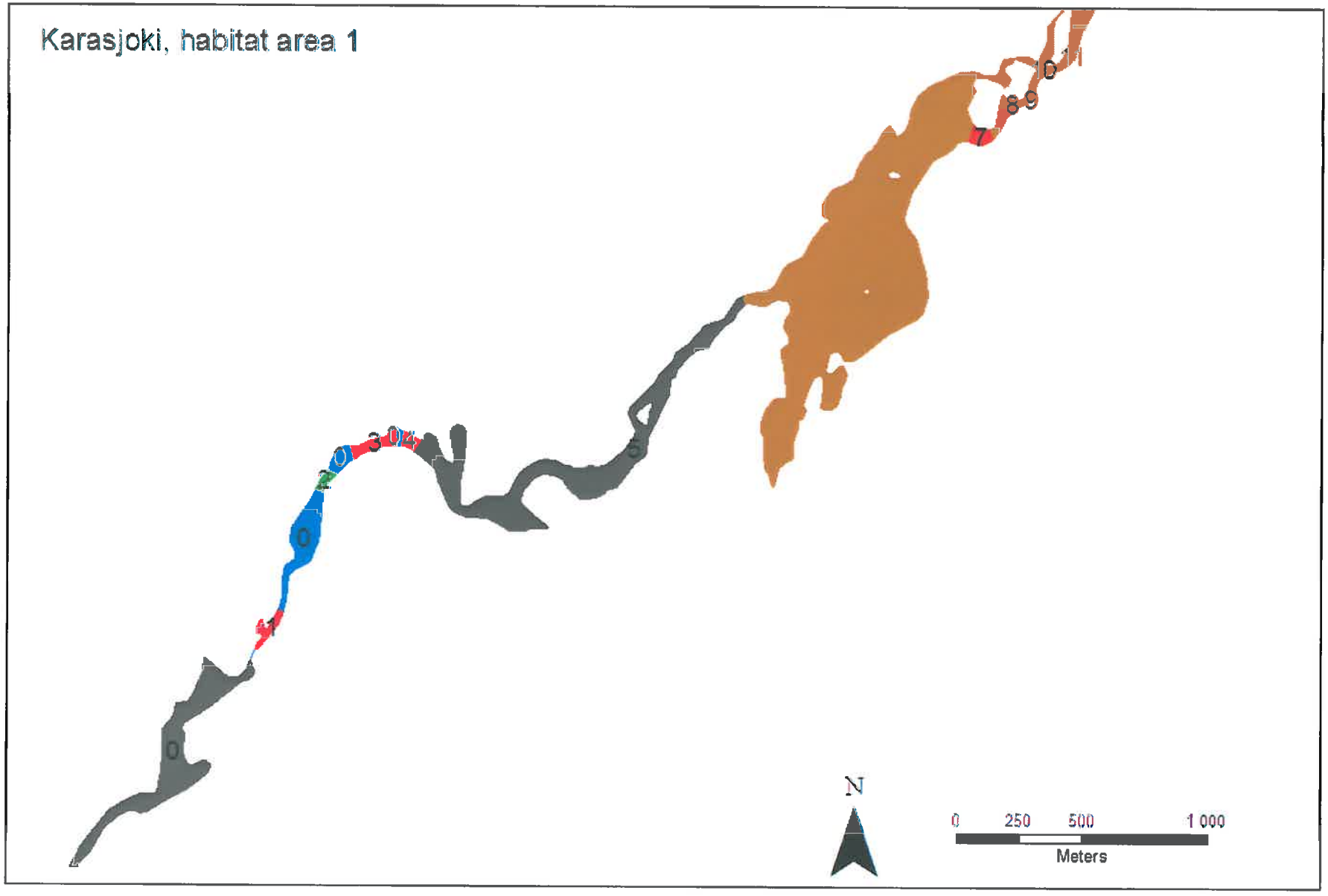
58	P	Pool	6250	402781	7673675	
59	R	Rapid	1515	402867	7673720	
60	P	Pool	5141	402933	7673744	
61	R	Rapid	2155	403016	7673768	
62	P	Pool	5935	403088	7673780	
63	G	Glide	5206	403165	7673785	
64	R	Rapid	27843	403683	7673829	
65	R	Rapid	3578	404416	7673740	
66	R	Rapid	1314	404640	7673794	
67	R	Rapid	1428	405144	7673853	
68	P	Pool	4360	405202	7673863	
69	G	Glide	4716	405282	7673879	
70	R	Rapid	3596	405354	7673904	
71	P	Pool	29483	405575	7673921	
72	G	Glide	1671	405826	7673906	
73	P	Pool	35663	406110	7673999	
74	R	Rapid	57339	406793	7674364	Electrofishing site 9
75	R	Rapid	20786	407468	7674601	
76	R	Rapid	5671	407789	7674769	
77	G	Glide	1306	407975	7674746	
78	R	Rapid	12974	408315	7675018	
79	P	Pool	37003	408573	7675369	
80	R	Rapid	1986	408793	7675459	
81	P	Pool	20394	408963	7675518	
82	R	Rapid	10846	409249	7675606	
83	P	Pool	2564	409327	7675743	
84	R	Rapid	6511	409378	7675851	
85	P	Pool	11198	409495	7675967	
86	G	Glide	981	409588	7676028	
87	P	Pool	5544	409634	7676092	
88	R	Rapid	1775	409643	7676181	
89	P	Pool	52233	409849	7676640	
90	R	Rapid	6416	410138	7677094	Electrofishing site 10
91	P	Pool	27689	410401	7677287	
92	R	Rapid	5857	410680	7677392	Electrofishing site 11
94	G	Glide	694	410768	7677439	
95	R	Rapid	3265	410816	7677384	
96	P	Pool	39769	410999	7677444	
97	R	Rapid	3342	411189	7677747	
98	G	Glide	707	411239	7677822	
99	G	Glide	875	411255	7677861	
100	G	Glide	533	411262	7677941	
101	G	Glide	362	411267	7677970	
102	P	Pool	7950	411279	7678029	
103	R	Rapid	27414	411356	7678319	
104	R	Rapid	2553	411403	7678568	Electrofishing site 12
105	P	Pool	28617	411405	7678784	
106	G	Glide	5387	411411	7678972	
107	R	Rapid	3780	411451	7679034	Electrofishing site 13
108	G	Glide	712	411410	7679147	
109	G	Glide	565	411366	7679305	
110	R	Rapid	17874	411261	7679538	
111	L	Lake	49114	411065	7679793	Spawning area
112	R	Rapid	14103	411029	7680107	Electrofishing site 14, spawning area
113	R	Rapid	11515	411263	7680561	
114	R	Rapid	546	411412	7680800	
115	R	Rapid	4902	411388	7680758	
116	R	Rapid	25886	411540	7681015	Electrofishing site 15

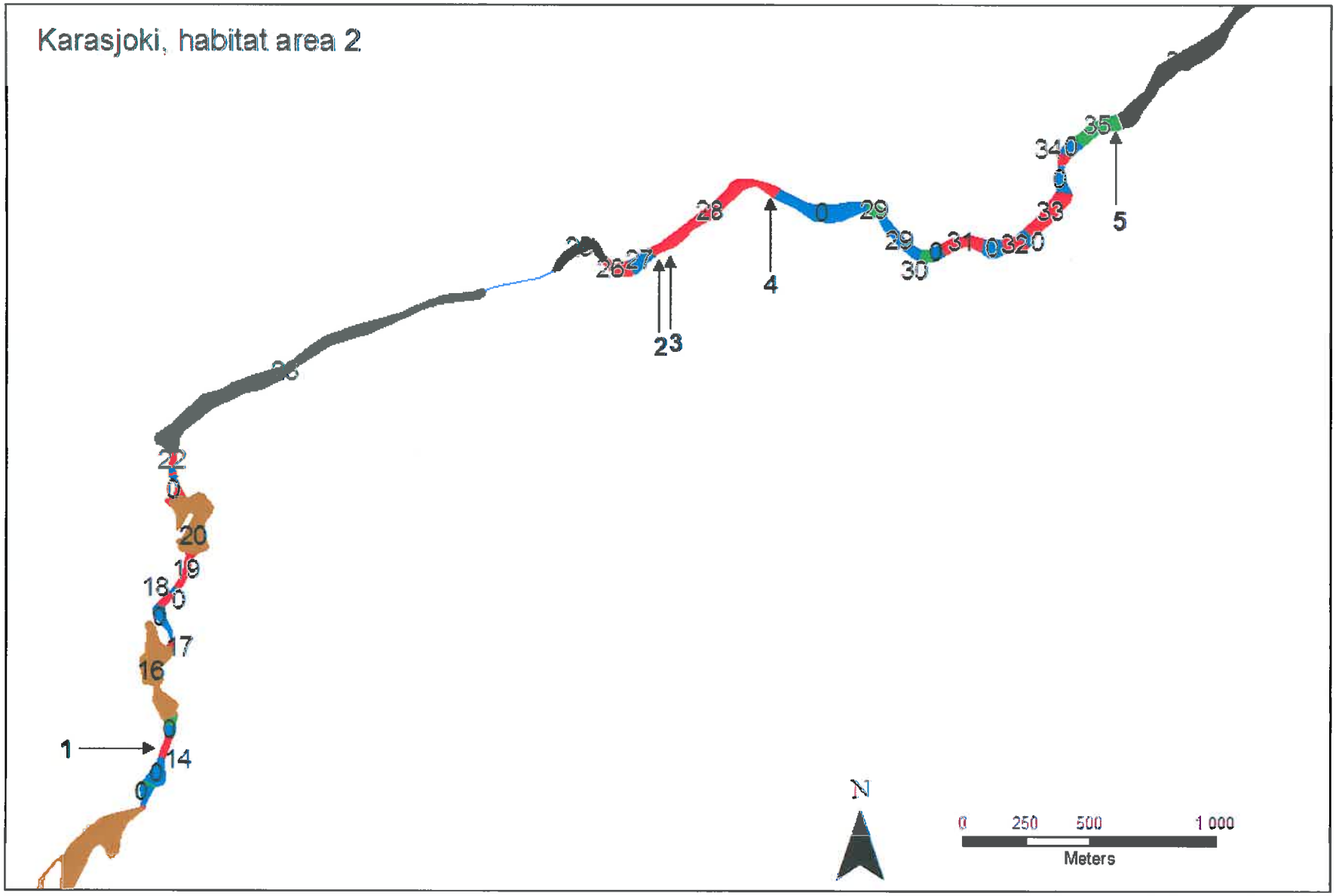
117	P	Pool	19145	411761	7681327	
118	R	Rapid	11518	411948	7681509	Electrofishing site 16
119	P	Pool	11591	412083	7681630	
120	R	Rapid	9203	412203	7681758	Electrofishing site 17
121	P	Pool	2613	412277	7681845	Spawning area
122	P	Pool	64816	412348	7682374	
123	R	Rapid	4509	412483	7682890	Electrofishing site 18
124	R	Rapid	17043	412474	7683264	
125	G	Glide	5102	412555	7683434	
126	R	Rapid	2788	412597	7683492	
127	G	Glide	5143	412636	7683565	
128	R	Rapid	3085	412684	7683620	
129	G	Glide	3966	412731	7683665	
130	R	Rapid	3099	412765	7683719	
131	R	Rapid	10399	412842	7683864	Spawning area
132	G	Glide	6065	412831	7684010	
133	R	Rapid	12321	412829	7684153	Electrofishing site 19
134	R	Rapid	39380	413178	7684459	
135	L	Lake	142348	413870	7685322	
136	G	Glide	972	414429	7686245	
137	L	Lake	170223	414540	7687071	
138	R	Rapid	75574	414262	7688650	
139	R	Rapid	776	414330	7689436	
140	R	Rapid	18076	414341	7689650	
141	G	Glide	6241	414843	7690121	
142	P	Pool	47295	414843	7690121	
143	R	Rapid	37568	415442	7690414	Electrofishing site 20
144	G	Glide	5536	416167	7690757	Spawning area
145	R	Rapid	45479	416510	7690759	Electrofishing site 21
146	P	Pool	67340	416966	7690237	
147	G	Glide	3395	417298	7689936	Electrofishing site 22
148	L	Lake	52567	417674	7689842	
149	R	Rapid	35387	418355	7689729	Electrofishing site 23
150	L	Lake	94140	418995	7689308	
151	R	Rapid	45067	419853	7689196	Spawning area
152	G	Glide	26016	420264	7689407	
153	R	Rapid	10465	420368	7689574	Electrofishing site 24
154	R	Rapid	914	420528	7689774	
155	L	Lake	67881	420879	7689821	
156	R	Rapid	43741	421425	7689954	
157	P	Pool	8505	421644	7690173	
158	R	Rapid	9811	421708	7690274	Electrofishing site 25
159	F	Flowing pool	4970	421780	7690321	Spawning area
160	R	Rapid	18649	421575	7690474	
161	P	Pool	21807	421313	7690648	
162	R	Rapid	10357	421193	7690792	Electrofishing site 26, spawning area
163	G	Glide	11457	421112	7690965	Spawning area
164	R	Rapid	20907	421180	7691223	Spawning area
165	G	Glide	14889	421331	7691512	Spawning area
166	R	Rapid	12496	421407	7691710	Electrofishing site 27, spawning area
167	G	Glide	39973	421709	7691913	
168	R	Rapid	11003	421950	7692089	
169	G	Glide	3537	422005	7692184	
170	R	Rapid	4527	422069	7692221	
171	G	Glide	4903	422186	7692230	
172	R	Rapid	5221	422276	7692238	
173	G	Glide	3754	422347	7692252	
174	P	Pool	13387	422484	7692269	

175	G	Glide	9526	422634	7692295	
176	R	Rapid	23143	422820	7692351	Electrofishing site 28
177	P	Pool	18784	423076	7692518	
178	G	Glide	19205	423259	7692702	
179	R	Rapid	17828	423436	7692829	
180	G	Glide	13895	423699	7692909	
181	R	Rapid	5889	423917	7693017	
182	G	Glide	3993	424009	7693095	
183	R	Rapid	7812	424078	7693159	Electrofishing site 29
184	G	Glide	19579	424305	7693295	
185	P	Pool	14121	424497	7693455	
187	R	Rapid	10071	424657	7693513	
188	P	Pool	21851	425026	7693367	

Appendix 4. The meso-scale habitat data illustrated in maps. The study reach was divided to 11 maps (habitat areas 1-11) for clarity of details. Single area numbers (area nr) are shown as well as the electrofishing sites (number+arrow, sites 1-29). The colour code for the different habitats is as follows:

rapid = red
glide = green
flowing pool = blue
pool = grey
lake = brown


Karasjoki, habitat area 1
N
0
250
500
1 000
Meters


Karasjoki, habitat area 2
1
23
4
5
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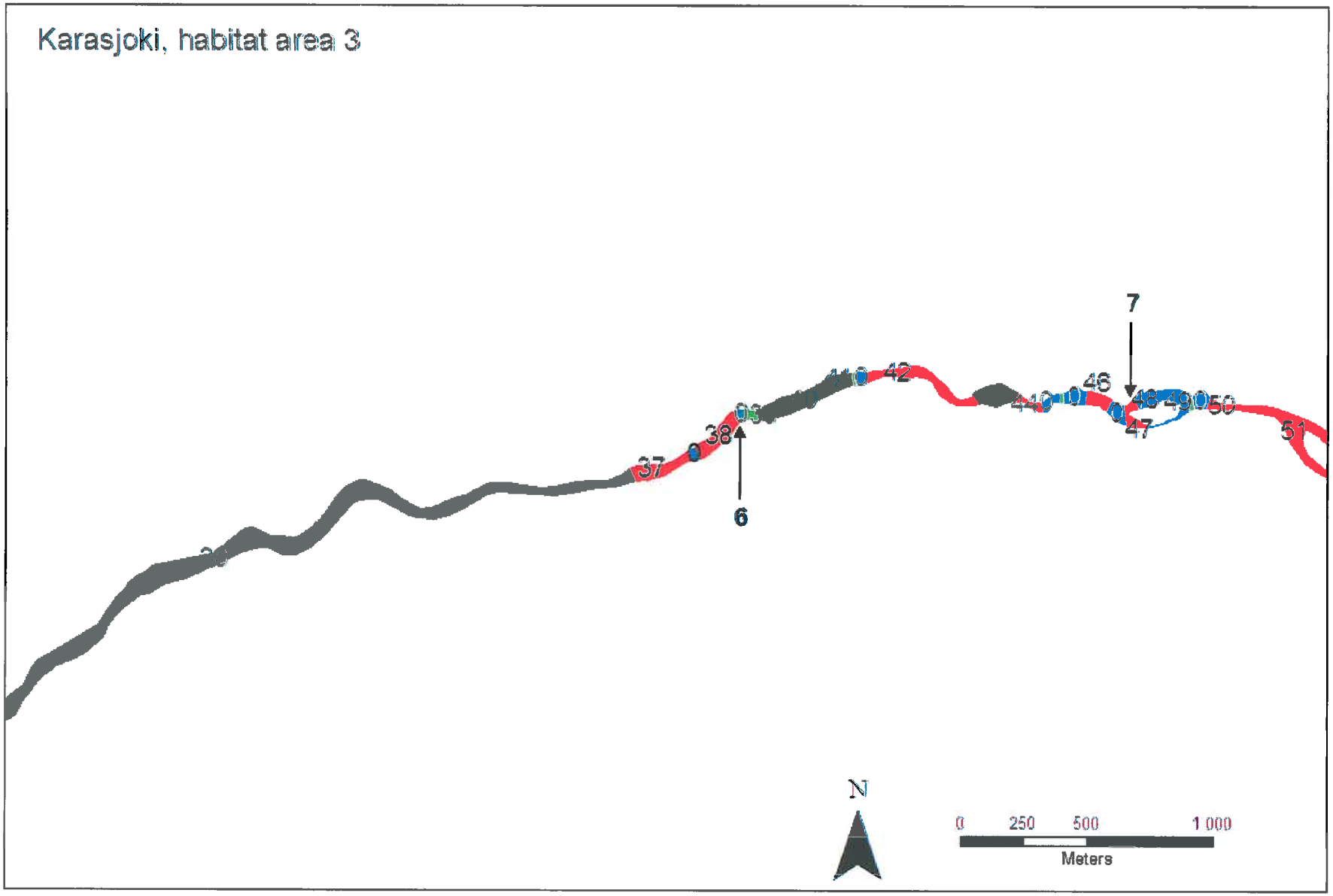
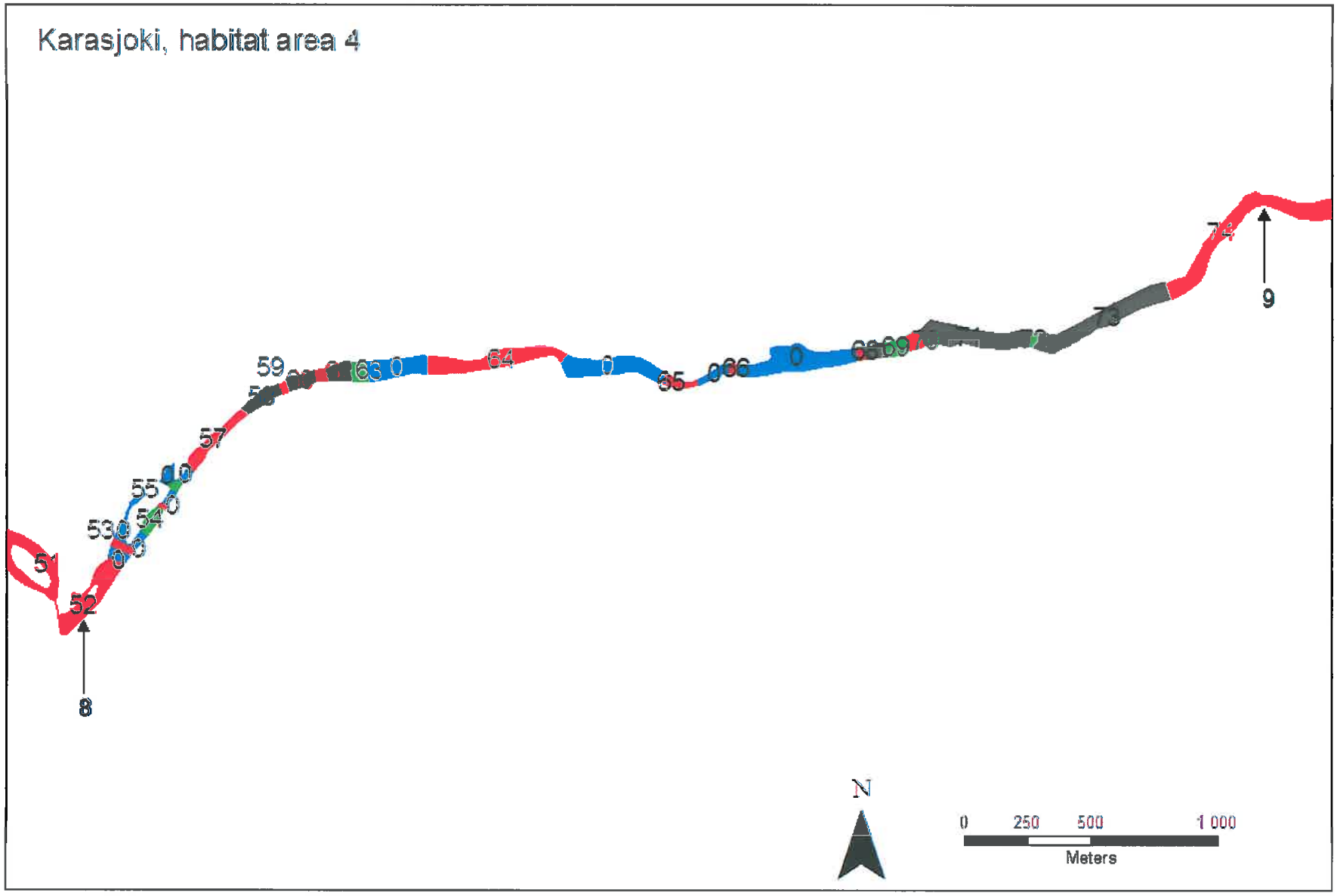
250
500
1 000
Meters


Karasjoki, habitat area 3
7
6
37
38
42
46
47
48
49
50
51
N
0
250
500
1 000
Meters


Karasjoki, habitat area 4
8
9
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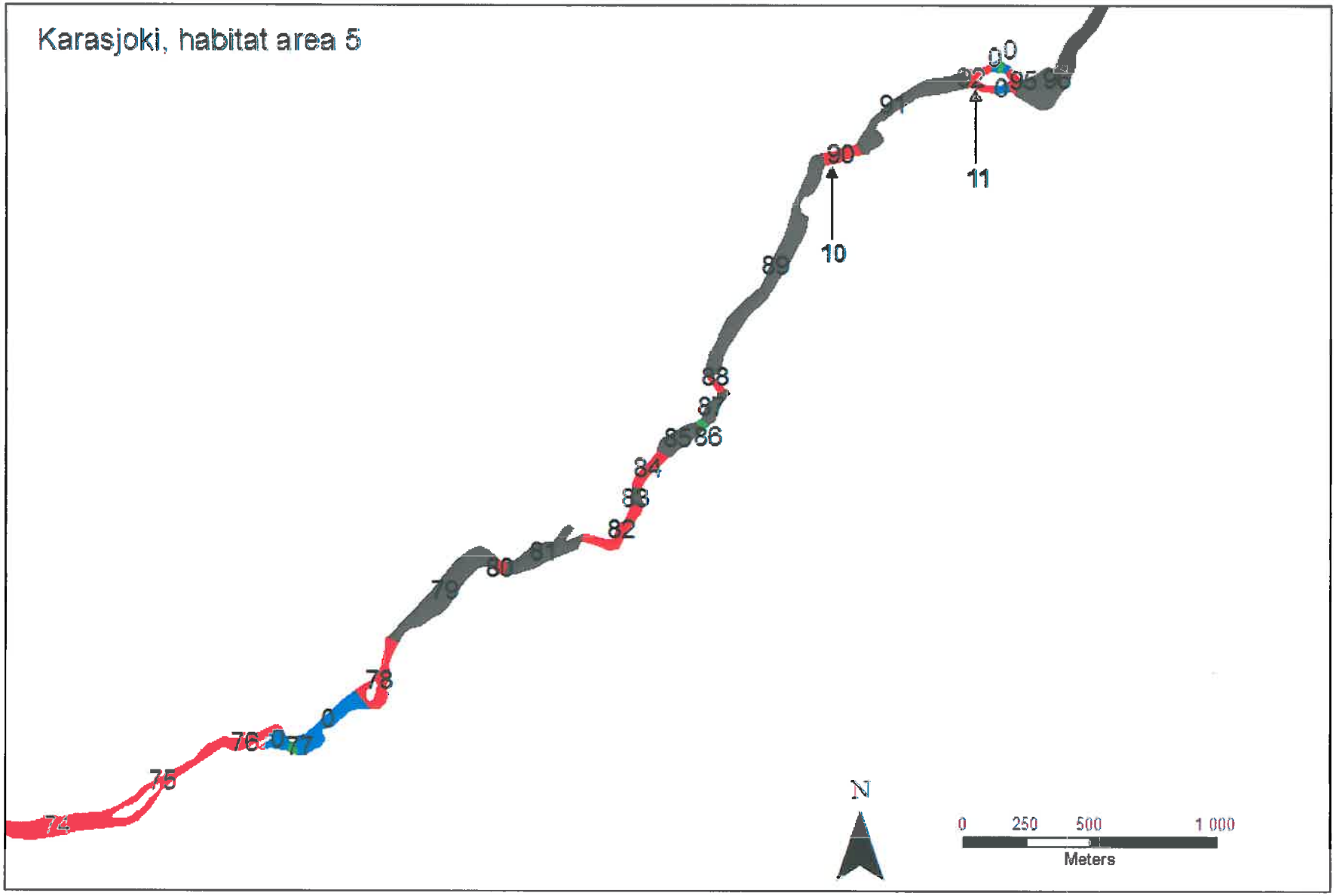
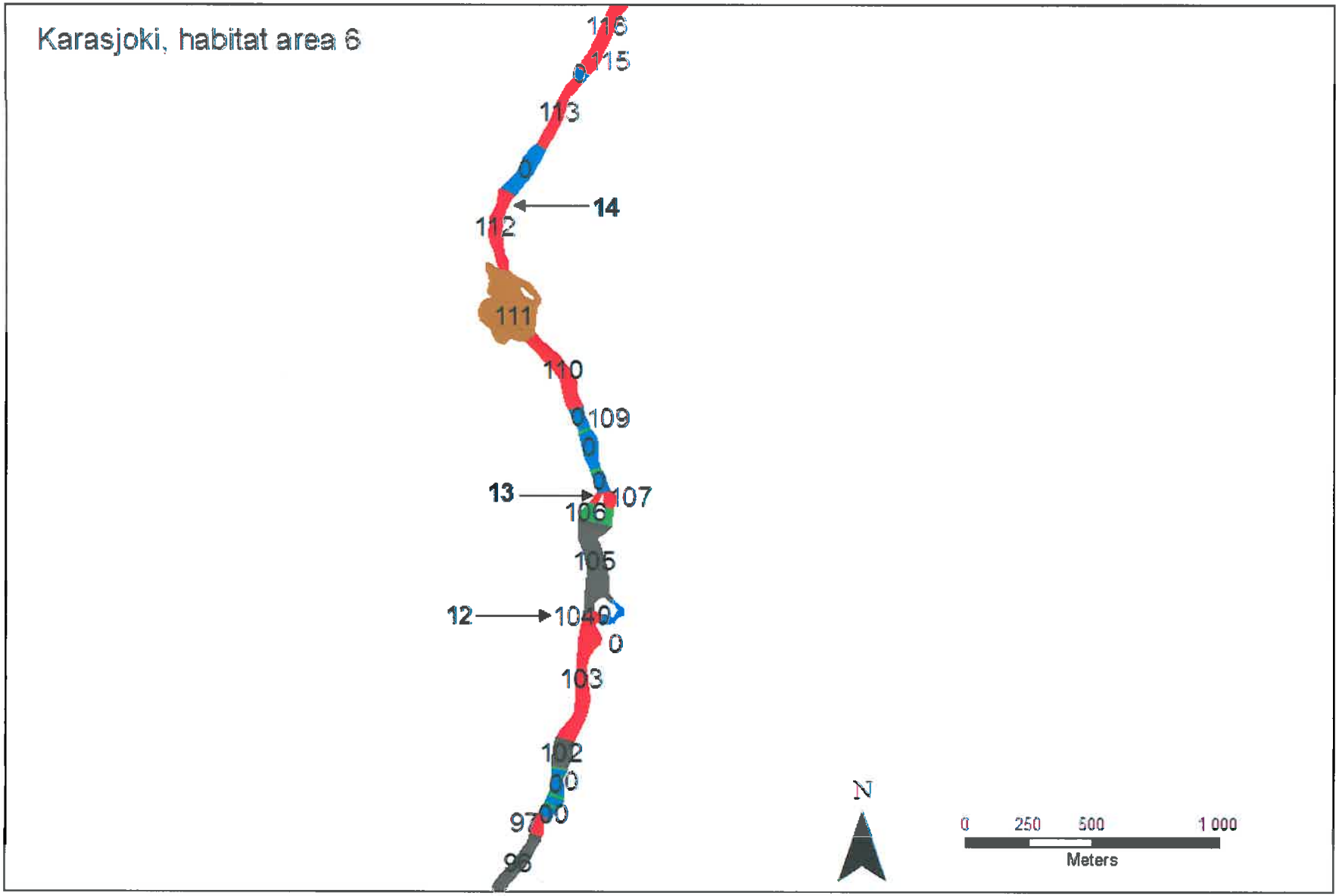
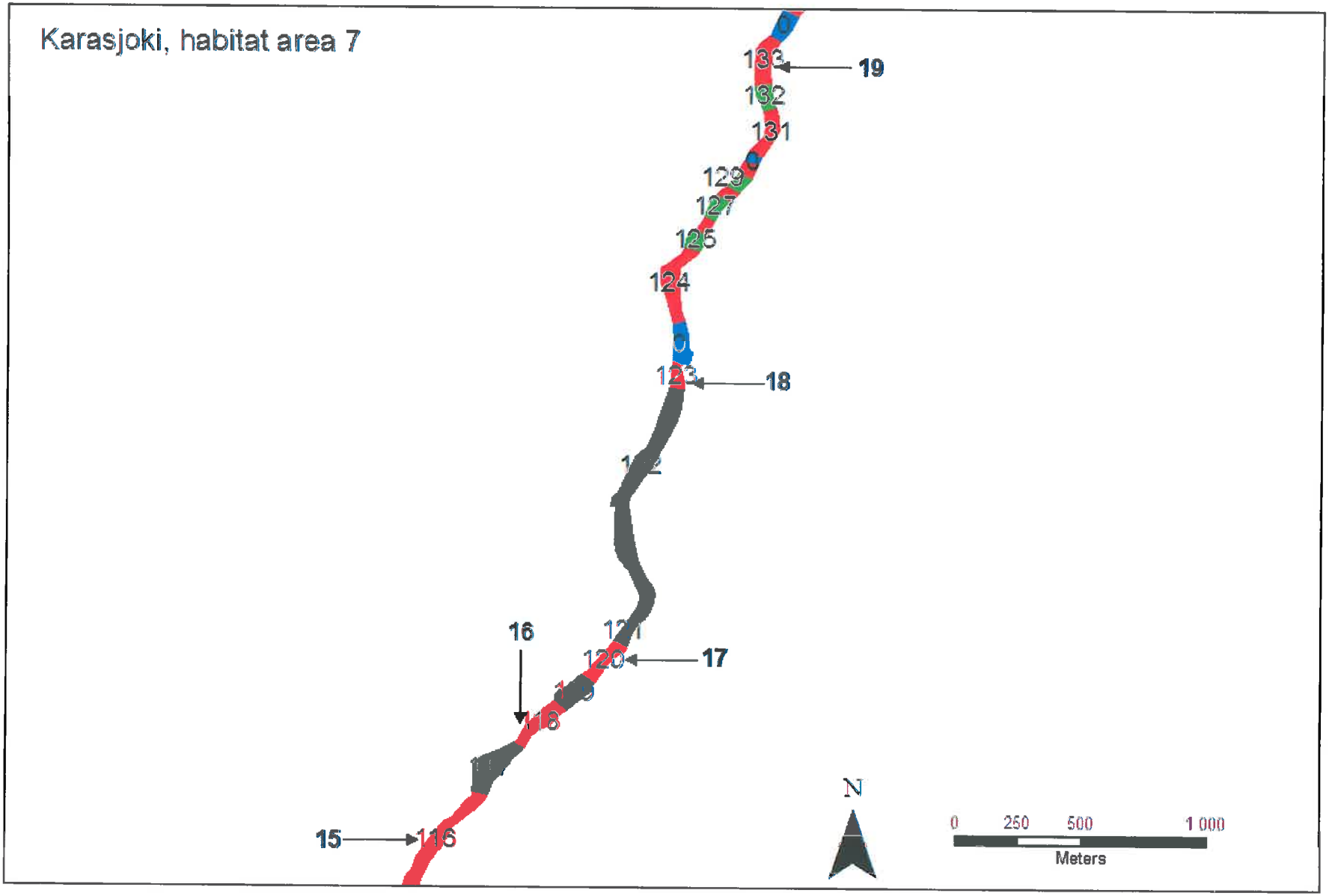
500
1 000
Meters


Karasjoki, habitat area 5
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
10
11
N
0
250
500
1 000
Meters


Karasjoki, habitat area 6
116
115
113
14
112
111
110
109
13
107
106
105
12
104
103
102
97
N
0
250
500
1 000
Meters


Karasjoki, habitat area 7
133
19
132
131
129
127
125
124
123
18
16
120
17
118
15
116
N
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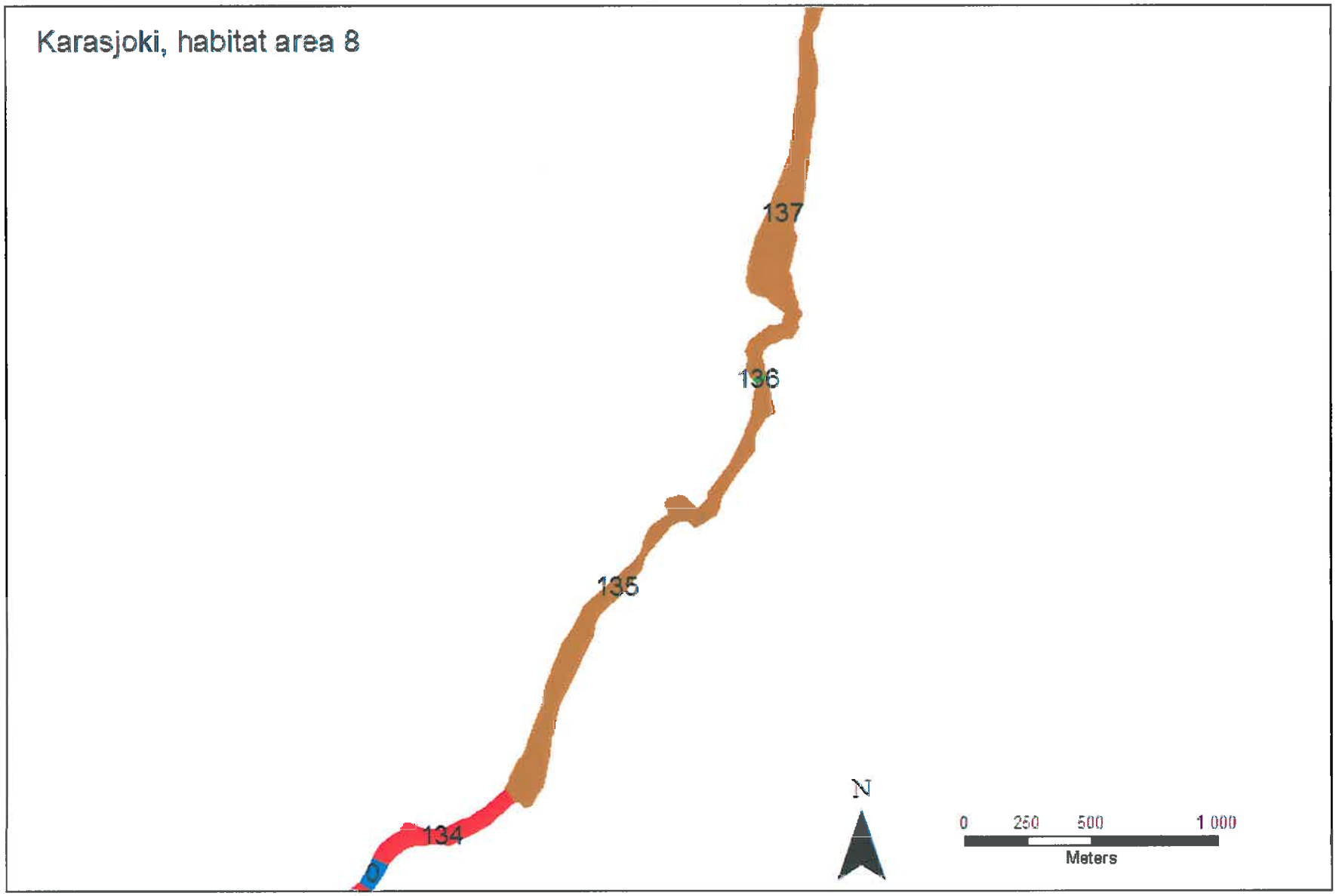
250
500
1 000
Meters


Karasjoki, habitat area 8
137
136
135
134
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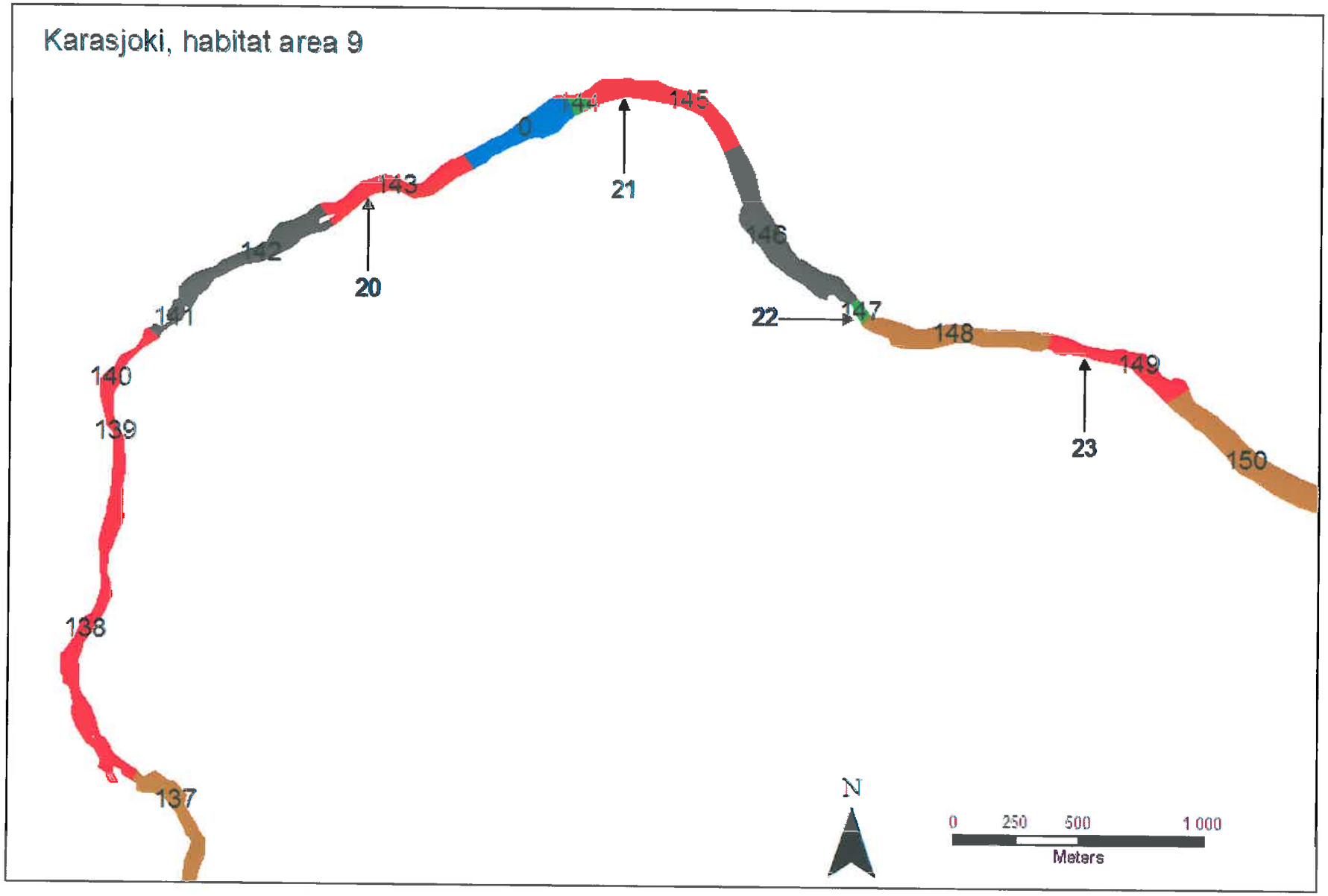
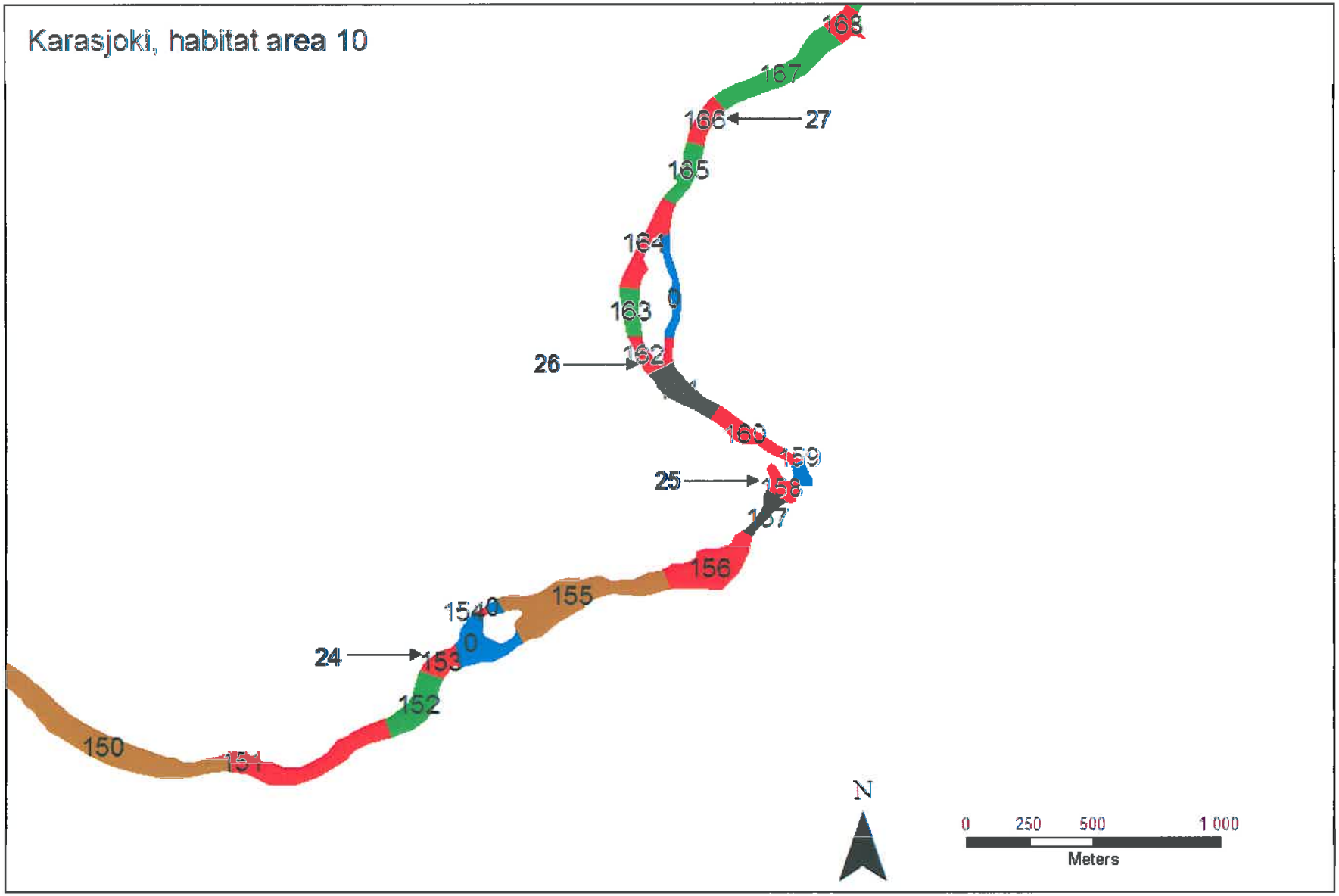
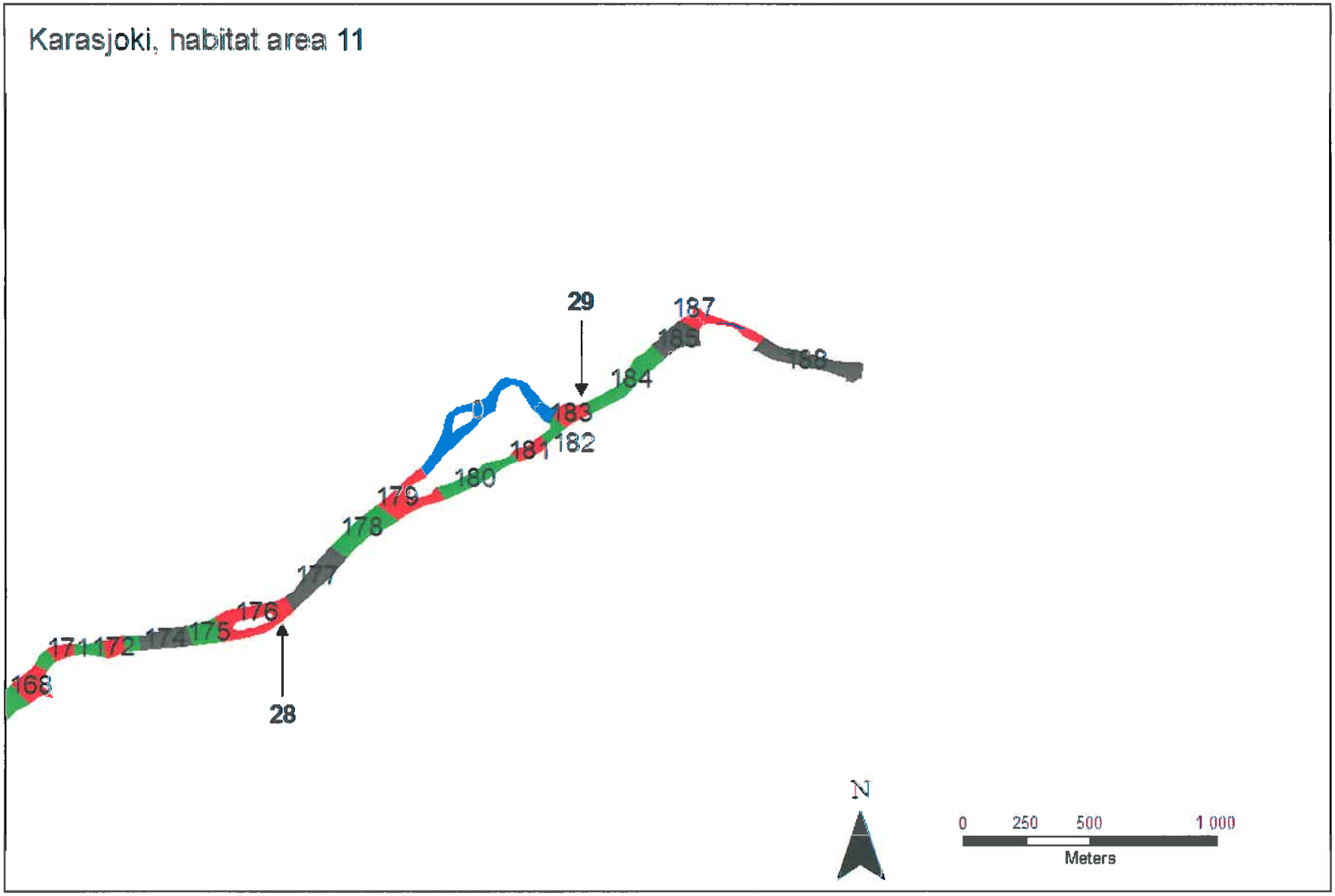
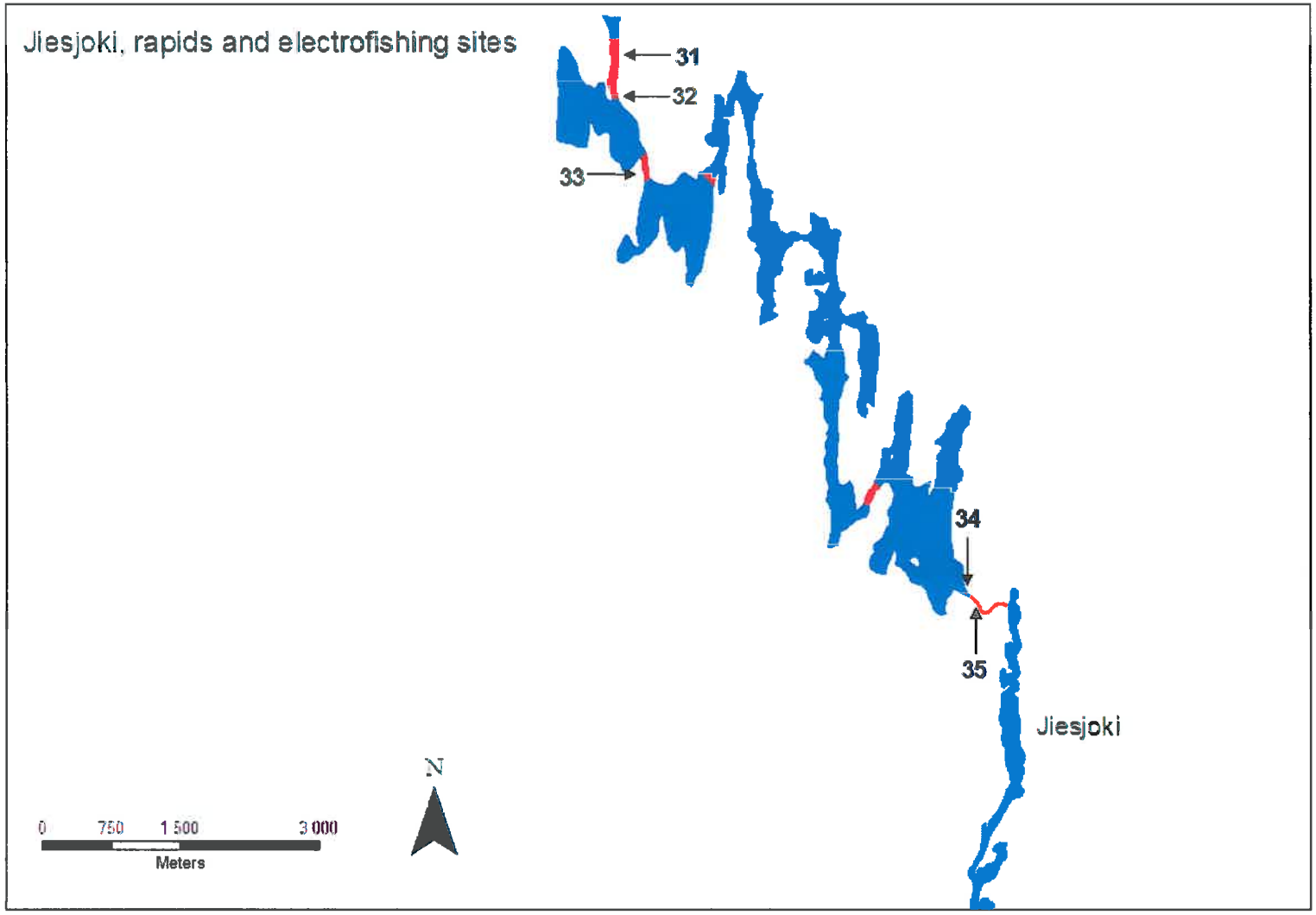
0
250
500
1 000
Meters

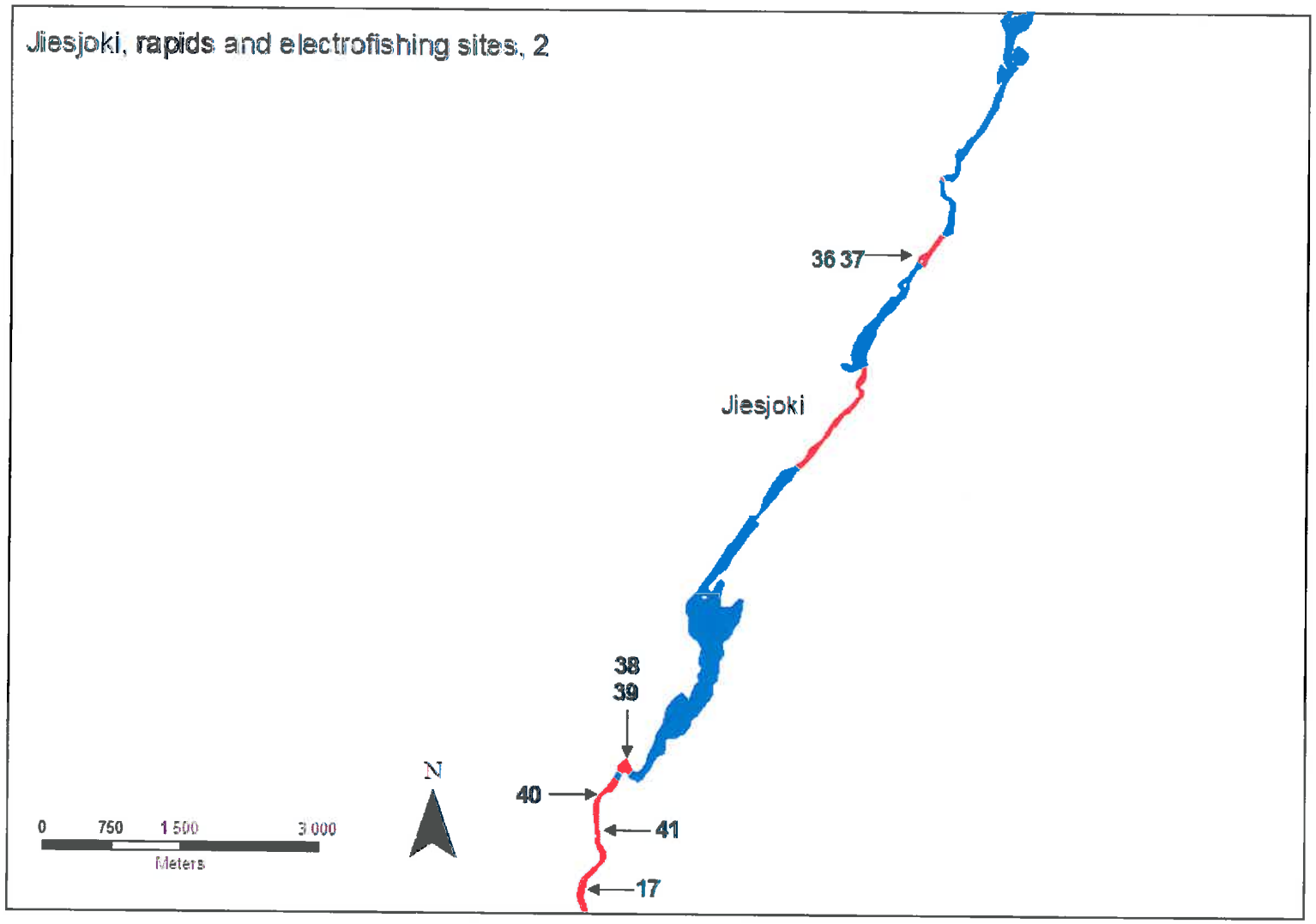

Karasjoki, habitat area 9
0
143
142
141
140
139
138
137
144
145
146
147
148
149
150
20
21
22
23
N
0
250
500
1 000
Meters

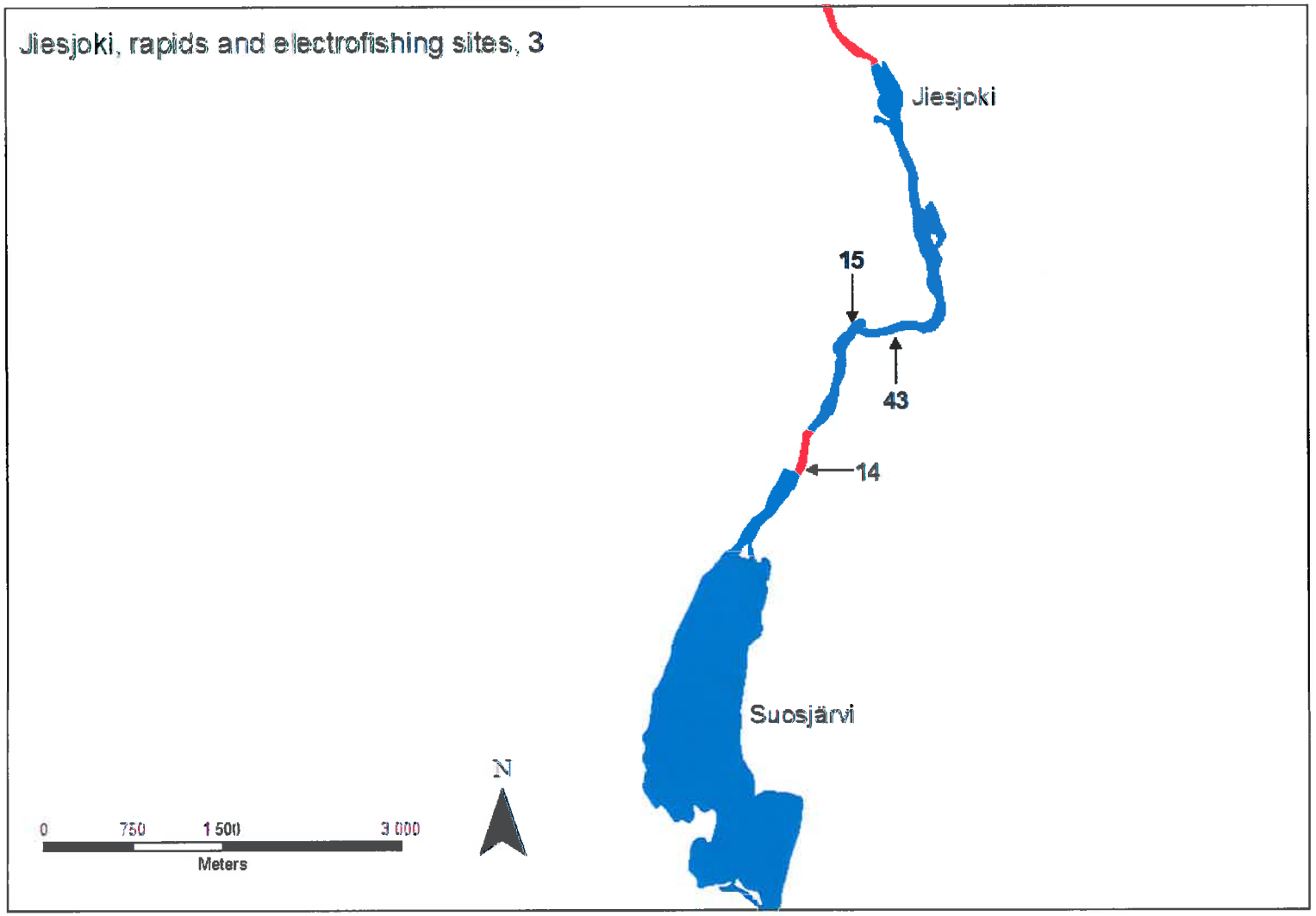

Karasjoki, habitat area 10
168
167
166
27
165
164
163
162
26
160
159
25
158
157
156
155
154
153
24
152
151
150
N
0
250
500
1 000
Meters


Karasjoki, habitat area 11
29
28
168
171
172
175
176
177
178
179
180
181
182
183
184
187
N
0
250
500
1 000
Meters

Appendix 5. Location of rapids (red colour) and electrofishing sites (numbers+arrows, sites 31-14) in the River Jiesjoki above the Lake Suosjärvi. Blue colour is illustrating all other habitat types (mainly pools and lakes) except rapids. The surveyed river section, between Lake Jiesjärvi and Lake Suosjärvi, is illustrated in three separate maps.




Jiesjoki, rapids and electrofishing sites, 2
36 37
Jiesjoki
38
39
40
41
17
N
0
750
1 500
3 000
Meters


Jiesjoki, rapids and electrofishing sites, 3
Jiesjoki
15
43
14
Suosjärvi
N
0
750
1 500
3 000
Meters