FAME WP6-8 SPATIAL APPROACH

Ecoregion 15/Baltic province

REFERENCE AND DEGRADED CONDITIONS

DRAFT MULTIMETRIC INDEX

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Contents

Preclassification

River types

Following agreement during Lyon meeting in October, sites for river typology and establishment of reference conditions were selected on the bases of 5 priority variables of impact class ≤ 2.

The results of principle component analysis, cluster analysis, and, finally, canonical discriminant analysis figure out 7 river types in ER 15. The 8-th river type (which was figured out by the means of PCA using data on actual and historical presence/absence of species) is represented only by one river, thus it was excluded from subsequent analysis of metrics. River types and their description are in the Table 1.

Table 1. River types and determinant physiographic variables

River type	**Definition**	**Catchments size class, km^2**	**Gradient slope, m/km**	
			average	range
HR1	Salmonid streams	<50	3,93	1,30-5,44
HR2	Salmonid streams	50-100	2,34	1,15-4,85
HR3	Salmonid streams	100-500	2.59	1,10-5,09
EP1	Salmonid-Cyprinid streams	100-500	0,84	0,65-1,1
EP2	Salmonid-Cyprinid rivers	500-5000	0,76	0,36-1,53
EP3	Salmonid-Cyprinid rivers	5000-50 000	0,41	0,28-0,76
MP1	Cyprinid streams	100-500	0,37	0,13-0,65
MP2	Cyprinid rivers	>50 000	0,12	0,10-0,15

For analysis of reference and degraded conditions only those sites were selected, which fulfill requirements for segment length/width ratio (length of the sampled segment is 10 times greater, than width). In addition, sites, which showed great seasonal variation, were excluded. Overall, 239 sites were analyzed.

Distribution of impact variables of priority per different river types

The distribution of impact classes within 5 impact variables of priority and between impact variables is uneven in the rivers of different types (Table 2). In addition, intermediate or the greatest impact classes are missing quite often. According to connectivity_segment, hydrological_regime and morphological_condition variables, the majority of sites are of impact class 1 and 2. Almost all the sites are of impact class 1 according to the impact variable toxic_acidification, except few sites in the river types EP1, EP2 and MP1. According to multiscale_connectivity (the new variable, which replaced connectivity_segment in the late stage of analysis), the majority of sites distribute within impact classes 1 and 3.

Table 2. Numbers of sites per impact class and per river type

Impact variable	Impact class	RIVER TYPE HR1	HR2	HR3	EP1	EP2	EP3	MP1
Connectivity_segment	1	24	30	36	33	51	16	26
	2	2	0	2	0	1	0	0
	3	0	1	0	0	0	0	0
	4	1	0	0	0	0	0	1
	5	1	1	3	0	4	0	6
Hydrological_regime_site	1	10	16	24	16	18	0	11
	2	15	16	12	13	27	15	17
	3	3	0	5	4	9	1	4
	4	0	0	0	0	2	0	1
	5	0	0	0	0	0	0	0
Morphological_condition_site	1	19	21	35	25	55	16	19
	2	6	2	4	2	1	0	6
	3	1	4	1	2	0	0	3
	4	2	5	1	4	0	0	5
	5	0	0	0	0	0	0	0
Nutrients_organic_input_site	1	13	7	9	8	12	0	13
	2	11	11	12	11	4	0	5
	3	3	9	12	9	25	14	8
	4	1	5	7	2	8	2	3
	5	0	0	1	3	7	0	4
Toxic_acidification_site	1	28	32	41	31	53	16	30
	2	0	0	0	2	1	0	1
	3	0	0	0	0	1	0	1
	4	0	0	0	0	1	0	1
Multiscale_connectivity	1	6	12	23	9	29	16	11
	2	7	2	4	2	6	0	1
	3	14	17	9	22	17	0	14
	4	0	0	2	0	0	0	1
	5	1	1	3	0	4	0	6

In Fig. 1 is distribution of overall impact classes within different river types, and the number of sites. The sites with overall degradation impact class 4 (the sum of 5 metrics of priority is >15) were present only in 3 river types (HR3, EP2 and MP1), but the number of such sites is too low. Besides that, there are no sites with impact class 5. That means that only primarily responses to overall degradation could be detected correctly in the course of analysis. The largest epipotamal rivers (EP3 type) where excluded from the analysis too, because according to overall impact, all the sites are of impact class 2 (sum of variables varies from 8 to10).

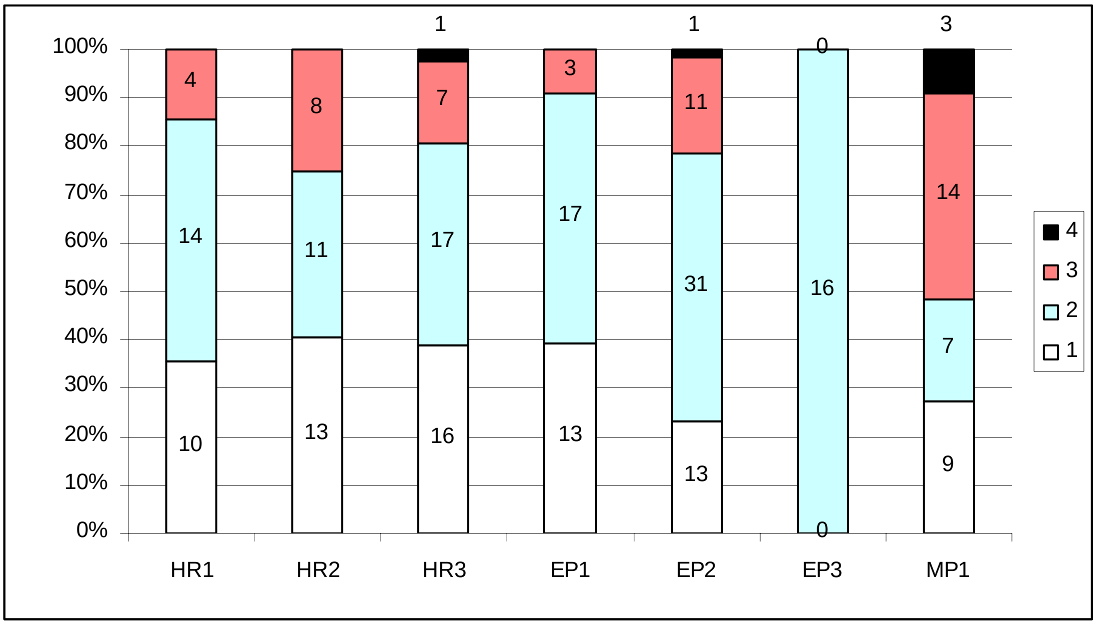


Fig. 1. Distribution of overall impact classes within different river types, and the number of sites

Metrics screening and selection

We did not consider metrics, related to presence/absence of alien species, i.e. only native species-based metrics were used in metric selection procedure. Alien species are present only in 24 fishing occasions in database of ER 15. More than one alien species was registered only in 4 of them, and there was no occasions with more than 2 species. The share of aliens was greater than 10% only in eight fishing occasions.

For selection of metrics we used Spearman‘s rank correlation between potential metrics and:

1 - Impact variables of priority (including multiscale_connectivity);
2 - The sum of 5 impact variables;
3 - Three impact classes – calibration, moderate and strong impact (sum of five impact variables of priority 5-10 = imp. cl. 1, 11-15 = 2, >15 = 3);
4 - Five impact classes - sum of 4 imp. var. + connectivity_segment (5-6 = imp. cl. 1, 7-10 = 2, 11-15 = 3, 15-20 = 4, >20 = 5),
5 - 4 - Five impact classes - sum of 4 imp. var. + multiscale_connectivity (5-6 = imp. cl. 1, 7-10 = 2, 11-15 = 3, 15-20 = 4, >20 = 5).

According to Spearman's rank order correlation, the most significantly correlate hydrological_regime and morphological_condition, nutrient_organic_imput variables. Because of the lack of sites with impact class greater than 1, the impact variable toxic_acidification does not correlate with other impact variables as well as three systems of overall degradation (Table 3). Correlation of variables multiscale_connectivity - connectivity_segment is also quite weak. Hydrological_regime, morphological_condition, and nutrient_organic_imput variables are well correlated with all three systems of overall degradation, but hydrological_regime and nutrient_organic_imput variebles have higher correlation with 5-tierd system, which includes conectivity_segment.

Table 3. Spearman's rank order correlations between impact variables of priority. ($p<0.05$)

	Connectivity_segment	Hydrological_regime_site	Morphological_condition_site	Toxic_acidification_site	Nutrients_organic_input_site	Multiscale_connectivity	5 impact classes-segment	5 impact classes-multiscale	3 impact classes
Connectivity_segment	1,00	0,19	0,13	0,02	0,10	*0,38*	*0,37*	0,29	0,53
Hydrological_regime_site		1,00	0,45	0,09	0,43	0,26	0,72	0,63	0,44
Morphological_condition_site			1,00	0,03	0,08	0,32	0,48	0,56	0,48
Toxic_acidification_site				1,00	0,27	0,09	0,20	0,26	0,26
Nutrients_organic_input_site					1,00	-0,03	0,72	0,54	0,33
Multiscale_connectivity						1,00	0,25	0,64	*0,39*
5 impact classes-segment							1,00	0,76	0,63
5 impact classes-multiscale								1,00	0,57
3 impact classes									1,00

On the scale of all rivers (not separated into types) eight ecological guilds (EURY, OMNI, INSV, INTO, LITH, RH, TOLE, PM), as well as abundance of *Salmo trutta fario* and *Cottus gobio* correlate significantly with overall degradation - sum of impacts, 3 impact classes and 5 impact classes, derived from 4 impact variables of priority + connectivity_segment variable (Table 4). INSV, INTO, LITH, RH, PM, abundance of *Salmo trutta fario* and *Cottus gobio* correlate negatively, while that of EURY, OMNI and TOLE – positively. Metrics response to 5 impact class system, derived from 4 impact variables of priority + multiscale_connectivity variable is much weaker. Only few metrics correlate significantly with this system of overall degradation. Majority of metrics correlate significantly with hydrological_regime and morphological_condition impact variables, slightly less – with nutrient_organic_imput. Three ecological guilds (EURY, RH and TOLE) correlate with connectivity_segment variable, and only metrics related to long distance migrating species showed clear correlation with multiscale_connectivity variable. Since multiscale_connectivity variable, and 5 impact classes - multiscale_connectivity system appeared to be week predictor (except for diadromous fish species), it was not further used in metric selection procedure for different river types. None of the metrics has showed any significant correlation with toxic_acidification impact variable, because there are only few sites with impact class greater than 1 for this variable. Therefore, correlation results are not included into table 3. However, toxic_acidification further proved to make very strong impact on river ecological status.

Table 4. Spearman correlation of metrics with impact variables and different overall assessment systems in all rivers

	Connectivity_segment	Multiscale_connectivity	Hydrological_regime_site	Morphological_condition_site	Nutrients_organic_input_site	Sum of impacts*	3 impact classes**	5 impact classes-segment***	5 impact classes-multiscale***
CotGobkgha%	-0,25	-0,05	-0,38	-0,30	-0,45	-0,50	-0,35	-0,50	-0,23
CotGobkgha	-0,23	-0,05	-0,51	-0,46	-0,29	-0,53	-0,49	-0,45	-0,24
CotGobnha%	-0,29	0,02	-0,31	-0,18	-0,43	-0,43	-0,29	-0,52	-0,24
CotGobNha	-0,25	-0,04	-0,51	-0,40	-0,32	-0,52	-0,44	-0,50	-0,24
Perc_kgha_Hab_eury	0,42	0,21	0,35	0,35	0,23	0,51	0,42	0,47	0,33
Kg_ha_Hab_eury	0,35	0,08	0,16	0,20	0,40	0,45	0,27	0,50	0,19
Perc_nha_Hab_eury	0,43	0,20	0,30	0,24	0,13	0,43	0,33	0,39	0,35
N_ha_Hab_eury	0,41	0,10	0,14	0,13	0,30	0,41	0,23	0,47	0,21
N_sp_Hab_eury	0,22	-0,06	0,16	0,26	0,43	0,45	0,22	0,46	0,09
Perc_sp_Hab_eury	0,37	0,23	0,44	0,44	0,35	0,62	0,47	0,62	0,40
Perc_kgha_Fe_insev	-0,32	-0,07	-0,44	-0,45	-0,66	-0,71	-0,54	-0,67	-0,36
Kg_ha_Fe_insev	-0,32	-0,15	-0,68	-0,61	-0,34	-0,69	-0,69	-0,55	-0,39
Perc_nha_Fe_insev	-0,36	-0,04	-0,33	-0,35	-0,63	-0,63	-0,49	-0,68	-0,30
N_ha_Fe_insev	-0,32	-0,18	-0,54	-0,51	-0,45	-0,65	-0,63	-0,58	-0,39
N_sp_Fe_insev	-0,34	-0,23	-0,58	-0,53	-0,47	-0,70	-0,60	-0,61	-0,44
Perc_sp_Fe_insev	-0,13	-0,09	-0,29	-0,40	-0,49	-0,55	-0,33	-0,43	-0,27
Perc_kgha_Intol	-0,30	-0,06	-0,44	-0,45	-0,64	-0,70	-0,52	-0,64	-0,34
Kg_ha_Intol	-0,26	-0,14	-0,67	-0,62	-0,33	-0,66	-0,66	-0,52	-0,38
Perc_nha_Intol	-0,34	-0,02	-0,31	-0,33	-0,61	-0,60	-0,45	-0,64	-0,28
N_ha_Intol	-0,15	-0,14	-0,50	-0,54	-0,42	-0,58	-0,57	-0,48	-0,34
N_sp_Intol	-0,11	-0,23	-0,55	-0,51	-0,48	-0,63	-0,47	-0,55	-0,41
Perc_sp_Intol	-0,19	-0,04	-0,30	-0,33	-0,64	-0,58	-0,32	-0,52	-0,32
Perc_kgha_Re_lith	-0,38	-0,21	-0,49	-0,50	-0,53	-0,74	-0,58	-0,75	-0,39
Kg_ha_Re_lith	-0,31	-0,30	-0,67	-0,65	-0,16	-0,63	-0,73	-0,45	-0,36
Perc_nha_Re_lith	-0,39	-0,19	-0,56	-0,52	-0,50	-0,76	-0,59	-0,75	-0,42
N_ha_Re_lith	-0,24	-0,27	-0,47	-0,45	-0,08	-0,43	-0,53	-0,29	-0,37
N_sp_Re_lith	-0,26	-0,40	-0,70	-0,54	-0,18	-0,61	-0,62	-0,57	-0,43
Perc_sp_Re_lith	-0,32	-0,25	-0,63	-0,52	-0,46	-0,73	-0,53	-0,70	-0,45
N_sp_Re_phyt	0,23	-0,05	0,32	0,37	0,30	0,46	0,39	0,41	0,01
Perc_kgha_Mi_potad	-0,20	-0,10	-0,51	-0,55	-0,40	-0,64	-0,52	-0,49	-0,19
Kg_ha_Mi_potad	-0,16	-0,13	-0,66	-0,64	-0,22	-0,62	-0,60	-0,43	-0,17
Perc_Nha_Mi_potad	-0,19	-0,14	-0,43	-0,45	-0,30	-0,52	-0,42	-0,38	-0,23
N_ha_Mi_potad	-0,10	-0,15	-0,61	-0,65	-0,24	-0,60	-0,57	-0,41	-0,25
N_sp_Mi_potad	-0,01	-0,17	-0,57	-0,41	-0,15	-0,41	-0,34	-0,30	-0,25
Perc_kgha_Fe_omni	0,43	0,11	0,03	0,02	0,31	0,32	0,12	0,27	0,27
Kg_ha_Fe_omni	0,34	-0,04	-0,05	0,00	0,39	0,31	0,06	0,30	0,12
Perc_nha_Fe_omni	0,42	0,14	0,11	0,03	0,07	0,23	0,11	0,16	0,30
N_ha_Fe_omni	0,40	0,03	0,08	0,06	0,33	0,38	0,14	0,37	0,18
Perc_sp_Fe_omni	0,28	0,15	0,14	0,08	0,30	0,36	0,09	0,40	0,33
Perc_kg_ha_Hab_rh	-0,45	-0,22	-0,35	-0,33	-0,24	-0,51	-0,43	-0,47	-0,33
Kg_ha_Hab_rh	-0,39	-0,28	-0,54	-0,41	0,12	-0,39	-0,53	-0,20	-0,31
Perc_n_ha_Hab_rh	-0,44	-0,22	-0,33	-0,28	-0,14	-0,46	-0,37	-0,41	-0,36
N_sp_Hab_rh	-0,37	-0,41	-0,68	-0,52	-0,04	-0,55	-0,64	-0,52	-0,41
Perc_sp_Hab_rh	-0,40	-0,24	-0,50	-0,48	-0,27	-0,63	-0,52	-0,59	-0,40
SalFarkgha%	-0,31	-0,11	-0,53	-0,59	-0,47	-0,72	-0,58	-0,61	-0,34
SalFarkgha	-0,31	-0,13	-0,67	-0,66	-0,26	-0,68	-0,64	-0,52	-0,36
SalFarNha%	-0,31	-0,12	-0,48	-0,54	-0,36	-0,63	-0,52	-0,54	-0,36
SalFarNha	-0,31	-0,15	-0,62	-0,67	-0,28	-0,69	-0,65	-0,55	-0,38

(Table 4; follow-up)

	Connectivity_segment	Multiscale_connectivity	Hydrological_regime_site	Morphological_condition_site	Nutrients_organic_input_site	Sum of impacts*	3 impact classes**	5 impact classes-segment***	5 impact classes-multiscale***
Perc_kgha_Tol	0,44	0,20	0,21	0,18	0,34	0,46	0,24	0,41	0,33
Kg_ha_Tol	0,39	0,07	0,12	0,12	0,42	0,44	0,19	0,44	0,20
Perc_nha_Tol	0,45	0,23	0,29	0,17	0,19	0,42	0,24	0,33	0,35
N_ha_Tol	0,42	0,12	0,14	0,11	0,30	0,41	0,20	0,40	0,23
Perc_sp_Tol	0,40	0,26	0,32	0,21	0,25	0,45	0,26	0,47	0,39
Perc_kgha_Mi_long	-0,15	-0,41	-0,14	-0,25	0,02	-0,08	-0,19	-0,22	-0,31
Kg_ha_Mi_long	-0,14	-0,41	-0,14	-0,25	0,01	-0,08	-0,19	-0,23	-0,31
Perc_Nha_Mi_long	-0,14	-0,41	-0,14	-0,25	0,01	-0,08	-0,19	-0,23	-0,31
N_ha_Mi_long	-0,15	-0,41	-0,14	-0,25	0,02	-0,08	-0,18	-0,22	-0,31
N_sp_Mi_long	-0,15	-0,42	-0,13	-0,25	0,02	-0,08	-0,18	-0,22	-0,31
Perc_sp_ Mi_long	-0,14	-0,41	-0,14	-0,25	0,01	-0,08	-0,19	-0,23	-0,32

* - sum of 5 impact variables of priority.

**- impact classes: 1 - sum of imp. = 5-10; 2 = 11-15; 3 = >15

***- impact classes: 1 – sum of imp. = 5-6; 2 = 7-10; 3 = 11-15; 4 = 16-20 (connectivity_segment variable used)

****- impact classes as previous, multiscale_connectivity variable used.

In general, impairment is represented better by the sum of impact variables and 5 impact classes rather than 3 impact classes. The response of metrics to 3 impact class system quite often was weaker than to sum of impact variables and 5 impact class system. The main reason is the lack of sites with impact class 3 (sum of impact variables of priority >15). Response of metrics to sum of impact variables and 5 impact class system is similar in the majority of cases.

Spearman correlation, Fisher's LSD test and metrics selection

Results of Spearman correlation and Fisher's LSD test

Since SBA index has to be based on impact classes, 5 impact class system was used further in the analysis of metrics response in the different river types. System of 3 overall impact class was tested too, however in the majority of cases only impact classes 1 and 2 were present.

Results of Spearman correlations per river types are in the **Annex I**. Guild metrics, which correlate well with overall degradation were re-tested using Fisher's LSD test for significance of differences. Despite of significant Spearman correlations, Fisher’s LSD test’s revealed that differences in range and medians of some metrics within different impact classes are not well represented. All these metrics were excluded from further analysis.

Correlation of metrics with 5 and 3 overall impact class systems varied per river type. In the river types HR2, HR3, EP1 and MP1 metrics correlate with both systems in a quite similar way. However, in the river types HR1 and EP2 some metrics correlate with 3-tierd, others – with 5-tierd system of overall degradation. However, Fisher's LSD tests showed that number of occasions with significant differences between impact classes is greater using 5-tierd system. This is valid even when the Spearman correlations are less significant, than in the case of 3-tierd system.

Finally, only the most representative guild metrics according to 5-tierd system of overall degradation were selected for each river type.

Metrics of sentinel species were analyzed in the same way. Correlations of river type specific sentinel species with 5-tierd system of overall degradation are in the Table 5. However, some sentinel species, such as *Salmo salar, Salmo trutta* were present mainly at the impact class 1 and their occurrence per fishing occasion was too low. The same concerns *Thymallus thymallus*: despite of more or less significant correlations in river types HR3 and EP1, frequency of occurrence and number of individuals was too low to use this sentinel species as metric for multimetric index development.

Table 5. Spearman correlation of sentinel species metrics with overall degradation

	HR1	**HR2**	**HR3**	**EP1**	**EP2**	**MP1**
CotGobBha%		-0,499	-0,621	-0,397	-0,338	
CotGobBha		-0,534	-0,560	-0,335	-0,320	
CotGobNha%		-0,429	-0,666	-0,327	-0,337	
CotGoBNha		-0,525	-0,535	-0,407	-0,315	
SalFarBha%	-0,497	-0,724	-0,619			
SalFarBha	-0,540	-0,685	-0,606			
SalFarNha%	-0,578	-0,627	-0,585			
SalFarNha	-0,635	-0,686	-0,589			
SalTruBha%			-0,370			
SalTruBha			-0,370			

SalTruNha%	-0,391			
SalTruNha	-0,387			
ThyTHyBha%	*-0,451*	*-0,343*		
ThyTHyBha	*-0,448*	*-0,355*		
ThyTHyNha%	*-0,400*	*-0,363*		
ThyTHyNha	*-0,460*	*-0,372*		
SalTruBha%			*-0,484*	
SalTruBha			*-0,484*	
SalTruNha%			*-0,484*	
SalTruNha			*-0,484*	
SalSalNha			*-0,512*	
SalSalBha%			*-0,512*	
SalSalNha%			*-0,513*	
SalSalBha			*-0,512*	
AlbBipBha			-0,246	-0,374
AlbBipBha%			-0,168	-0,345
AlbBipNha			-0,267	-0,415
AlbBipNha%			-0,304	-0,629

Both, absolute and relative abundance and biomass of sentinel species showed similar response to overall degradation. However, when metrics were re-tested by Fisher's LSD test, relative values showed more significant differences between impact classes, dispersion of absolute values within impact classes was much greater.

The most representative guild and sentinel species metrics per river type are in the Table 6. Relative values of abundance, biomass and species number respond significantly to overall degradation much more often, than absolute values. Even 10 absolute value metrics out of 16 (listed in Table 6) showed clear response to overall degradation only once per all river types, 5 metrics - twice. Relative values showed clear response much more often, especially those of TOLE, RH, LITH, EURY ecological guilds. The share of number of species in the communities is week predictor for the lowest species number river type HR1.

Table 6. The most representative metrics per river type.

Metrics	**Salmonid rivers**			**Salmonid-cyprinid rivers**		**Cyprinid rivers**	**Nb. of occasions**
	HR1	**HR2**	**HR3**	**EP1**	**EP2**	**MP1**	
SalFarNha%	+	+	+				3
CotGobNha%		+	+	+	+		4
AlbBipNha%					+	+	2
Perc_sp_Tol	+	+	+	+		+	**5**
Perc_kgha_Tol	+	+	+	+	+	+	**6**
Kg_ha_Tol	+						1
Perc_nha_Tol	+	+	+	+	+	+	**6**
N_ha_Tol	+			+			2
N_sp_Tol				+			1
Perc_sp_Hab_rh	+	+		+		+	**4**
N_sp_Hab_rh				+	+		2
Perc_nha_Hab_rh	+	+	+	+	+	+	**6**
Perc_kgha_Hab_rh	+	+	+	+			**4**
N_sp_Fe_omni			+				1
Perc_sp_Fe_omni			+	+	+	+	**4**
Perc_nha_Fe_omni			+		+	+	**4**

Perc_kgha_Fe_omni			+		+		2
Perc_sp_Re_lith	+	+	+	+	+	+	**6**
Perc_nha_Re_lith	+	+	+	+	+	+	**6**
Perc_kgha_Re_lith	+	+	+	+	+	+	**6**
Kg_ha_Re_lith				+			1
N_sp_Re_lith					+	+	2
N_sp_Intol					+		**1**
Perc_sp_Intol		+	+	+	+		**4**
Perc_nha_Intol		+	+	+			**3**
Perc_kgha_Intol		+	+		+		**3**
N_ha_Intol	+						1
Kg_ha_Intol	+						1
Perc_sp_Fe_insev					+		1
N_sp_Fe_insev			+	+	+		3
Perc_nha_Fe_insev	+	+	+	+	+	+	**6**
Perc_kgha_Fe_insev	+	+	+				**3**
N_ha_Fe_insev				+			1
Kg_ha_Fe_insev				+			1
Perc_sp_Hab_eury	+	+	+	+	+	+	**6**
Perc_nha_Hab_eury	+		+		+	+	**4**
Perc_kgha_Hab_eury	+	+	+				**3**
N_ha_Hab_eury		+	+	+			3
Kg_ha_Hab_eury		+	+				2
N_sp_Hab_eury			+				1

Metrics with absolute values were skipped from further analysis and correlation matrix was calculated only for metrics with relative values for each river type (Table 7). In all river types highly correlated INTO and INSV guilds (r=0,95-1,0). Besides that, relative density of river trout is highly correlated with relative density of potamodromous species in HR1 and HR2 river types. All metrics of LITH and RH guilds (% of abundance, % of biomass and % of number of species) are highly correlated in all river types too (r = 0,85-0,97), except the river type HR2. Rheophilic guild significantly negatively correlate with eurytopic guilds (r=-0,97 – -1,0). LITH species metrics correlate with EURY guild too (except the river type HR2), but correlations are slightly less (r= -0,84 – -0,96). Correlation of tolerant and eurytopic guilds is greater than 0,8 (r=0,82-0,96) in the majority of cases. The share of abundance, biomass and number of tolerant species significantly correlate with those of RH guild (HR3, EP1, EP2 and MP1 river types; r=-0,84 – -0,97). Relative abundance of individuals of TOLE and LITH guilds also correlate in the majority of river types.

Table 7. Correlation matrix of guild metrics per river type (only metrics with occurrence of r>0,8 are indicated).

HR1	Perc_kgha_Intol	Perc_nha_Intol	Perc_kgha_Re_lith	Perc_nha_Re_lith	Perc_kgha_Mi_potad	Perc_nha_Mi_potad	Perc_kgha_Hab_rh	Perc_nha_Hab_rh	SalFarN%	Perc_nha_Tol
Perc_kgha_Hab_eury	-0,54	-0,31	-0,91	-0,68	-0,53	-0,41	-0,99	-0,74	-0,48	0,60
Perc_nha_Hab_eury	-0,23	-0,39	-0,58	-0,85	-0,19	-0,36	-0,71	-0,98	-0,39	0,96
Perc_kgha_Fe_insev	0,99	0,76	0,70	0,44	0,96	0,75	0,56	0,28	0,80	-0,21
Perc_nha_Fe_insev		0,96	0,47	0,54	0,74	0,84	0,35	0,41	0,89	-0,41
Perc_kgha_Re_lith			1,00	0,76	0,69	0,54	0,91	0,60	0,58	-0,48
Perc_nha_Re_lith				1,00	0,42	0,52	0,68	0,85	0,50	-0,83
Perc_kgha_Mi_potad					1,00	0,81	0,54	0,26	0,81	-0,18
Perc_nha_Mi_potad						1,00	0,42	0,40	**0,92**	-0,36
Perc_nha_Hab_rh								1,00	0,41	-0,97

HR2	Perc_nha_Hab_eury	Perc_kgha_Intol	Perc_nha_Intol	Perc_nha_Re_lith	Perc_kgha_Mi_potad	Perc_nha_Mi_potad	Perc_kgha_Hab_rh	Perc_nha_Hab_rh	Perc_sp_Hab_rh	SalFarN%	Perc_kgha_Tol	Perc_nha_Tol	Perc_sp_Tol
Perc_kgha_Hab_eury	0,82	-0,54	-0,41	-0,60	-0,41	-0,24	-0,99	-0,81	-0,69	-0,32	0,70	0,68	0,42
Perc_nha_Hab_eury	1,00	-0,30	-0,34	-0,58	-0,14	-0,02	-0,84	-0,99	-0,63	-0,25	0,67	0,76	0,37
Perc_sp_Hab_eury		-0,49	-0,43	-0,58	-0,35	-0,16	-0,73	-0,64	-0,93	-0,26	0,58	0,59	0,73
Perc_kgha_Fe_insev		1,00	0,78	0,58	0,81	0,56	0,53	0,29	0,43	0,63	-0,40	-0,29	-0,27
Perc_nha_Fe_insev			0,99	0,56	0,57	0,45	0,40	0,32	0,36	0,61	-0,42	-0,29	-0,17
Perc_kgha_Intol			0,78	0,57	0,80	0,57	0,54	0,30	0,45	0,63	-0,41	-0,29	-0,28
Perc_kgha_Re_lith				0,89	0,63	0,42	0,74	0,49	0,64	0,44	-0,55	-0,49	-0,50
Perc_sp_Re_lith					0,47	0,26	0,53	0,40	0,82	0,22	-0,45	-0,51	-0,74
Perc_kgha_Mi_potad					1,00	0,82	0,41	0,14	0,31	0,74	-0,32	-0,26	-0,29
Perc_nha_Mi_potad						1,00	0,24	0,03	0,10	**0,82**	-0,26	-0,26	-0,17
Perc_kgha_Hab_rh							1,00	0,84	0,71	0,32	-0,73	-0,72	-0,45
Perc_kgha_Tol											1,00	0,87	0,61

HR3	Perc_nha_Hab_eury	Perc_kgha_Intol	Perc_nha_Intol	Perc_kgha_Re_lith	Perc_nha_Re_lith	Perc_sp_Re_lith	Perc_nha_Fe_omni	Perc_kgha_Hab_rh	Perc_nha_Hab_rh	Perc_sp_Hab_rh	Perc_kgha_Tol	Perc_nha_Tol	Perc_sp_Tol
Perc_kgha_Hab_eury	0,85	-0,38	-0,38	-0,85	-0,76	-0,59	0,70	-0,97	-0,84	-0,65	0,86	0,81	0,48
Perc_nha_Hab_eury	1,00	-0,41	-0,39	-0,81	-0,93	-0,61	0,83	-0,88	-1,00	-0,68	0,81	0,96	0,56
Perc_sp_Hab_eury		-0,53	-0,43	-0,70	-0,70	-0,93	0,59	-0,71	-0,70	-0,99	0,63	0,66	0,84
Perc_kgha_Fe_insev		1,00	0,76	0,54	0,51	0,60	-0,44	0,43	0,43	0,54	-0,44	-0,41	-0,57
Perc_nha_Fe_insev		0,75	0,99	0,46	0,45	0,45	-0,31	0,41	0,40	0,45	-0,40	-0,34	-0,37
Perc_sp_Intol				0,68	0,64	0,83	-0,56	0,59	0,57	0,75	-0,62	-0,56	-0,75
Perc_kgha_Re_lith				1,00	0,85	0,67	-0,68	0,87	0,81	0,68	-0,79	-0,76	-0,51
Perc_nha_Re_lith					1,00	0,68	-0,80	0,78	0,93	0,69	-0,76	-0,91	-0,58
Perc_sp_Re_lith						1,00	-0,53	0,60	0,62	0,93	-0,60	-0,58	-0,84
Perc_nha_Fe_omni							1,00	-0,69	-0,83	-0,57	0,73	0,86	0,52
Perc_sp_Fe_omni							-0,47	-0,54	-0,64	0,58	0,56	0,81	
Perc_kgha_Hab_rh								1,00	0,88	0,68	-0,84	-0,81	-0,52
Perc_nha_Hab_rh									1,00	0,68	-0,81	-0,96	-0,57
Perc_sp_Hab_rh										1,00	-0,60	-0,63	-0,85
Perc_kgha_Tol											1,00	0,83	0,58

(Table 7; follow-up)

EP1	Perc_nha_Hab_eury	Perc_kgha_Intol	Perc_nha_Intol	Perc_kgha_Re_lith	Perc_nha_Re_lith	Perc_sp_Re_lith	Perc_kgha_Hab_rh	Perc_nha_Hab_rh	Perc_sp_Hab_rh	Perc_kgha_Tol	Perc_nha_Tol	Perc_sp_Tol
Perc_kgha_Hab_eury	0,85	-0,50	-0,38	-0,96	-0,87	-0,66	-0,99	-0,86	-0,65	0,86	0,81	0,62
Perc_nha_Hab_eury	1,00	-0,40	-0,48	-0,78	-0,89	-0,59	-0,83	-0,94	-0,63	0,81	0,98	0,64
Perc_sp_Hab_eury		-0,16	-0,26	-0,58	-0,60	-0,90	-0,65	-0,68	-0,98	0,64	0,63	0,89
Perc_kgha_Fe_insev		1,00	0,38	0,55	0,50	0,26	0,50	0,41	0,20	-0,43	-0,36	-0,17
Perc_nha_Fe_insev		0,37	0,99	0,42	0,56	0,30	0,38	0,49	0,28	-0,39	-0,43	-0,24
Perc_kgha_Re_lith				1,00	0,89	0,67	0,97	0,83	0,61	-0,84	-0,73	-0,57
Perc_nha_Re_lith					1,00	0,68	0,88	0,94	0,63	-0,81	-0,84	-0,63
Perc_sp_Re_lith						1,00	0,69	0,71	0,94	-0,67	-0,58	-0,84
Perc_kgha_Hab_rh							1,00	0,88	0,68	-0,86	-0,78	-0,64

Perc_nha_Hab_rh								1,00	0,71	-0,84	-0,91	-0,71
Perc_sp_Hab_rh									1,00	-0,66	-0,62	-0,91
Perc_kgha_Tol										1,00	0,84	0,74

EP2	Perc_kgha_Intol	Perc_nha_Intol	Perc_kgha_Re_lith	Perc_nha_Re_lith	Perc_nha_Fe_omni	Perc_kgha_Hab_rh	Perc_nha_Hab_rh	Perc_sp_Hab_rh	Perc_kgha_Tol	Perc_nha_Tol	Perc_sp_Tol
Perc_kgha_Hab_eury	-0,26	-0,38	-0,93	-0,65	0,60	-1,00	-0,71	-0,58	0,92	0,74	0,51
Perc_nha_Hab_eury	-0,38	-0,70	-0,64	-0,95	0,93	-0,70	-1,00	-0,66	0,70	0,97	0,56
Perc_sp_Hab_eury	-0,36	-0,45	-0,56	-0,66	0,62	-0,57	-0,66	-0,98	0,57	0,62	0,86
Perc_kgha_Fe_insev	0,99	0,51	0,32	0,45	-0,45	0,27	0,40	0,40	-0,25	-0,35	-0,33
Perc_nha_Fe_insev	0,54	0,95	0,29	0,71	-0,69	0,30	0,69	0,46	-0,32	-0,65	-0,43
Perc_kgha_Re_lith			1,00	0,64	-0,53	0,93	0,64	0,57	-0,85	-0,63	-0,45
Perc_nha_Re_lith				1,00	-0,90	0,64	0,95	0,67	-0,64	-0,90	-0,54
Perc_sp_Re_lith					-0,55	0,48	0,60	0,91	-0,46	-0,52	-0,72
Perc_nha_Fe_omni					1,00	-0,59	-0,93	-0,61	0,64	0,95	0,58
Perc_kgha_Hab_rh						1,00	0,71	0,58	-0,91	-0,73	-0,50
Perc_nha_Hab_rh							1,00	0,66	-0,70	-0,97	-0,56
Perc_sp_Hab_rh								1,00	-0,56	-0,62	-0,85

MP1	Perc_kgha_Intol	Perc_nha_Intol	Perc_kgha_Re_lith	Perc_nha_Re_lith	Perc_sp_Re_lith	Perc_nha_Fe_omni	Perc_kgha_Hab_rh	Perc_nha_Hab_rh	Perc_sp_Hab_rh	Perc_kgha_Tol	Perc_nha_Tol	Perc_sp_Tol
Perc_kgha_Hab_eury	-0,66	-0,61	-0,93	-0,58	-0,53	0,53	-0,99	-0,63	-0,56	0,72	0,55	0,31
Perc_nha_Hab_eury	-0,34	-0,60	-0,61	-0,96	-0,61	0,90	-0,63	-0,99	-0,61	0,61	0,94	0,55
Perc_sp_Hab_eury	-0,22	-0,27	-0,49	-0,53	-0,84	0,69	-0,53	-0,61	-0,96	0,56	0,63	0,82
Perc_kgha_Fe_insev	1,00	0,70	0,79	0,39	0,37	-0,23	0,66	0,34	0,26	-0,40	-0,24	0,01
Perc_nha_Fe_insev	0,71	0,99	0,72	0,64	0,41	-0,47	0,64	0,60	0,35	-0,40	-0,51	-0,17
Perc_kgha_Re_lith			1,00	0,62	0,58	-0,47	0,93	0,62	0,50	-0,67	-0,51	-0,25
Perc_nha_Re_lith				1,00	0,58	-0,83	0,59	0,96	0,54	-0,60	-0,90	-0,49
Perc_sp_Re_lith					1,00	-0,65	0,55	0,62	0,87	-0,53	-0,61	-0,70
Perc_kgha_Fe_omni						0,64	-0,53	-0,48	-0,41	0,85	0,59	0,45
Perc_nha_Fe_omni						1,00	-0,55	-0,88	-0,67	0,64	0,94	0,64
Perc_sp_Fe_omni							-0,26	-0,48	-0,69	0,47	0,60	0,86
Perc_nha_Hab_rh								1,00	0,62	-0,62	-0,95	-0,55

Selection of metrics

Sentinel species metrics

Overall, 8 fish species were identified as sentinels for rivers of ER 15. However, only three of them (*Salmo trutta fario*, *Cottus gobio*, and *Alburnoides bipunctatus)* show reliable response to degradation. Density and frequency of occurrence of other sentinel species was too low. Relative abundance of *Salmo trutta fario* is highly correlated with relative density of potamodromous species PM in small rivers (Types HR1 ir HR2). Since river trout is the main representative of potamodromous guild in these rivers, this guild was excluded from analysis. In addition, we decided to use relative abundance of native salmonids (sum of perc_nha of *Salmo trutta fario*, *Salmo trutta trutta* and *Salmo salar*) instead of relative abundance of river trout, because those species (specifically – juveniles of those species) require habitat of the same quality and almost the same structure. Spearman correlation shows, that native-salmonids_nha% metric correlate with impact variables and overall impact slightly better than SalFar_nha% alone (Table 8).

Table 8. Spearman correlation of relative abundance of different salmonid species and native-salmonids_nha% metric with impact variables and overall degradation

	SalSal_nha%	SalFar_nha%	SalTru_nha%	Native-salmonids_nha%
Connectivity_segment	-0,083913	-0,120490	-0,054241	-0,140062
Hydrological_regime_site	-0,028499	-0,394109	-0,260878	-0,407314
Morphological_condition_site	-0,137782	-0,321982	-0,209027	-0,348526
Nutrients_organic_input_site	-0,030099	-0,461538	-0,195764	-0,487770
multiscale_connectivity	-0,261513	-0,147085	-0,226113	-0,163996
Overall impact	-0,099502	-0,580509	-0,317774	-0,619252

Abundance and biomass metrics

The first metric that we selected for development of multimetric index is Perc_nha_Fe_insev. This metric showed significant negative correlation with degradation in all river types. All INSEV species are intolerant species in the rivers of 15-th ecoregion (see **ANNEX II**). INSEV and INTOL guilds are highly inter-correlated, thus Perc_nha_Fe_insev represents both guilds. Another reason, why we did not chose INTO species, that it is difficult to assess correctly the abundance of lampreys. All 3 species which are present in the rivers of ecoregion 15 are intolerant ones.

Next 2 metrics are Perc_nha_Re_lith and Perc_kgha_Re_lith. Those metrics showed the most significant correlation with overall degradation. Lithophils significantly correlate with rheophils. Absolute majority of lithophils are at the same time rheophils in 15-th ecoregion (**ANNEX II**), thus with this metric both guilds are represented. Besides that, lithophilic guild slightly less correlate with other ecological guilds, than rheophilic guild. Both, relative abundance and relative biomass of lithophilic fish were selected. Correlation of those 2 metrics is greater than 0,8 only in the river types HR2 and HR3 (r=0,83-0,87).

Next two metrics, Perc_nha_Tol and Perc_kgha_Tol represent tolerant ecological guild, which correlates positively with impact variables and overall degradation. These metrics showed significant response to overall degradation in all river types. Tolerant guild is highly correlated with Eurytopic guild. Majority of tolerant species are at the same eurytopic species (see **ANNEX II**), except *Pungitius*, *Tinca* and *Carassius carassius* – typical limnophils, which are rare in the rivers of ER 15. Absolute majority of tolerants are omnivorous species (except Perch and Eel). Besides that, only tolerant species are theoretically present in the rivers at the impact class 5. We selected both, relative abundance and relative biomass of tolerant fish. Correlation of those 2 metrics is greater than 0,8 in the river types HR2, HR3 and EP1 (r=0,83-0,87).

Abundance and biomass metrics, selected for multimetric index, represent three different ecological guilds: reproduction – lithophils, feeding – insectivorous/invertivorous species, and tolerance to habitat degradation - tolerant species.

Species composition metrics.

Relative number of species of two guilds - LITH and EURY correlate with overall degradation in all river types. Relative number of RH, OMNI, INTOL species also showed significant response to overall degradation in several river types. Response of the relative number of tolerant and eurytopic species to overall degradation is quite similar in different river types, these two metrics correlate significantly (r=0,82-0,96). Relative number of omnivorous species responds to overall degradation only in the salmonid-cyprinid and cyprinid rivers (types EP1, EP2, MP1). Only Perc_sp_Re_lith metric was selected for development of draft multimetric index at this stage.

Discriminant analysis and metrics selection

Multivariate analysis, namely – discriminant analysis was tested for metric selection. The use of this method for selection of metrics requires sufficient number of sites within each impact class. Due to the lack of data, it was impossible to perform this type of analysis for each river type separately. However, results of cluster analysis (one of statistical methods that was used for river typology) revealed, that all 3 types of HR (salmonid types) rivers are rather similar in respect of community structure. This same is true for EP-MP (salmonid-cyprinid and cyprinid types) rivers too. Therefore, for discriminant analysis of metrics we combined all types of salmonid rivers and all types of salmonid-cyprinid and cyprinid types. In this way, we got two major groups with sufficient number of sites at impact classes 1, 2 and 3. In parallel, we performed discriminant analysis of metrics for all sites (not divided into types). .

According to discriminant analysis, perc_kgha_Tol and perc_kgha_Re_lith metrics are significant predictors for all rivers (Table 9).

Table 9. Results of discriminant analysis (relative abundance and biomass metrics;all rivers)

All sites (N=239)	Discriminant Function Analysis Summary					
	Wilks' Lambda	Partial Lambda	F-remove (2,9)	p-level	Toler.	1-Toler. (R-Sqr.)
perc_kgha_Tol	0,495353	0,974701	2,984889	0,042507	0,082249	0,917751
perc_kgha_Re_lith	0,500751	0,964194	4,270608	0,015098	0,055964	0,944036
perc_kgha_Hab_eury	0,492988	0,979377	2,421638	0,091037	0,054509	0,945491
perc_kgha_Fe_omni	0,488157	0,989068	1,271023	0,282508	0,138135	0,861865
perc_kgha_Fe_insev	0,484195	0,997162	0,327249	0,721239	0,165168	0,834832
perc_nha_Tol	0,487868	0,989654	1,202285	0,302388	0,035535	0,964465
perc_nha_Re_lith	0,494588	0,976207	2,802833	0,062711	0,069464	0,930536
perc_nha_Hab_rh	0,487225	0,990960	1,049114	0,351918	0,017767	0,982233
perc_nha_Hab_eury	0,485117	0,995268	0,546827	0,579534	0,013708	0,986292
perc_nha_Fe_omni	0,485878	0,993707	0,728239	0,483868	0,096846	0,903154
perc_nha_Fe_insev	0,482933	0,999768	0,026746	0,973611	0,313915	0,686085

The same is true for perc_sp_Re_lith and perc_sp_Hab_rh metrics (Table 10).

Table 10. Results of discriminant analysis (relative number of species; all rivers)

All sites (N=239)	Discriminant Function Analysis Summary					
	Wilks' Lambda	Partial Lambda	F-remove (2,9)	p-level	Toler.	1-Toler. (R-Sqr.)
perc_sp_Tol	0,270645	0,988679	0,55537	0,575672	0,025310	0,974690
perc_sp_Re_lith	0,303873	0,880567	6,57815	0,002094	0,030752	0,969248
perc_sp_Hab_rh	0,291701	0,917313	4,37180	0,015209	0,025894	0,974106
perc_sp_Hab_eury	0,268813	0,995415	0,22341	0,800194	0,045973	0,954027
perc_sp_Fe_omni	0,275908	0,969819	1,50931	0,226208	0,034634	0,965366
perc_sp_Fe_insev	0,270218	0,990239	0,47808	0,621423	0,430574	0,569426

While analyzing HR and EP-MP types separately, perc_sp_Re_lith metric is less significant in EP rivers, but the weight of perc_sp_Fe_insev increases. However, according to test of significance of differences, this metric responded significantly only in EP2 rivers. Besides that, for HR type rivers significant predictor is perc_sp_Hab_eury, while for EP and

MP types - perc_sp_Fe_omni (Tables 11 and 12). However, analysis of box plots suggests, that for EP1 river type perc_sp_Hab_eury metric is better, than perc_sp_Fe_omni.

Table 11. Results of discriminant analysis (relative number of species; HR rivers)

HR rivers (N=101)	Discriminant Function Analysis Summary					
	Wilks' Lambda	Partial Lambda	F-remove (2,9)	p-level	Toler.	1-Toler. (R-Sqr.)
perc_sp_Tol	0,270645	0,988679	0,55537	0,575672	0,025310	0,974690
perc_sp_Re_lith	0,303873	0,880567	6,57815	0,002094	0,030752	0,969248
perc_sp_Hab_rh	0,291701	0,917313	4,37180	0,015209	0,025894	0,974106
perc_sp_Hab_eury	0,288813	0,935415	3,22341	0,040194	0,035973	0,964027
perc_sp_Fe_omni	0,275908	0,969819	1,50931	0,226208	0,034634	0,965366
perc_sp_Fe_insev	0,270218	0,990239	0,47808	0,621423	0,430574	0,569426

Table 12. Results of discriminant analysis (relative number of species; EP-MP rivers)

EP-MP rivers (N=138)	Discriminant Function Analysis Summary					
	Wilks' Lambda	Partial Lambda	F-remove (2,9)	p-level	Toler.	1-Toler. (R-Sqr.)
perc_sp_Tol	0,395330	0,984510	0,684417	0,507079	0,084681	0,915319
perc_sp_Re_lith	0,389771	0,998552	0,063083	0,938909	0,119171	0,880830
perc_sp_Hab_rh	0,402389	0,967238	1,473412	0,234803	0,019834	0,980166
perc_sp_Hab_eury	0,414539	0,938891	2,831283	0,064380	0,023140	0,976860
perc_sp_Fe_omni	0,446723	0,871248	6,428381	0,002490	0,090506	0,909495
perc_sp_Fe_insev	0,417516	0,932194	3,164084	0,047156	0,268384	0,731616

The final list of metrics, selected for development of multimetric index, presented in Table 13.

Table 13. Final list of metrics

Metrics		Salmonid rivers			Salmonid-cyprinid rivers		Cyprinid rivers
		HR1	HR2	HR3	EP1	EP2	MP1
SalFarNha%	↘*	SF**	SF	SF			
CotGobNha%	↘		SF	SF	SF	SF	
AlbBipNha%	↘					S	SF
Perc_nha_Tol	↗	SF	SF	SF	SF	SF	SF
Perc_kgha_Tol	↗	SF(D)	SF(D)	SF(D)	SF(D)	SF(D)	SF(D)
Perc_nha_Re_lith	↘	SF	SF	SF	SF	SF	SF
Perc_kgha_Re_lith	↘	SF(D)	SF(D)	SF(D)	SF(D)	SF(D)	SF(D)
Perc_nha_Fe_insev	↘	SF	SF	SF	SF	SF	SF
Perc_sp_Fe_omni	↗					SF(D)	SF(D)
Perc_sp_Re_lith	↘		SF(D)	SF(D)	SF(D)	SF(D)	SF(D)
Perc_sp_Hab_eury	↗		SF(D)	SF(D)	SF		
Nb of impact classes		123	123	1234	123	1234	1234

* - Response of metrics to overall degradation: ↗ - increase; ↘ - decrease

** - S – Spearman correlation (R>0,3), F – Fisher's LSD test for significance of differences, D – discriminant analysis

Establishment of class boundaries

Despite of sound correlations and significant LSD tests, the range of metrics within impact classes is too wide to use the 10-th percentile, as REFCOND guidelines recommend. Besides that, the range of metrics within the same impact class differs in different river types, irrespective of those types are salmonid or cyprinid rivers. The possible reasons might be:
1 - general problem – insufficient number of sites;
2 - lack of sites with impact classes 3 and especially 4. No sites with impact class 5;
3 - electric fishing efficiency: abundance of small fish species, especially benthic ones might be underestimated in epipotamal and metapotamal rivers, which are usually deeper than salmonid streams. The same concerns small pelagic species (i.e. *Alburnoides bipunctatus*) and *Thymallus thymallus*;
4 - problems related with illegal electric fishing and sport fishing, especially in larger rivers: one can get unexpected results in such river, although according to variables of priority it is of impact class 1.

Therefore, it was not possible to use 10-th percentile to represent reference values and subsequent class boundaries. The use of 25-th percentile appeared also problematic, especially in the case of larger rivers. Medians at impact class 1 were used to normalize data set, except EP2 river type: here we used 75-th percentile for LITH, INSEV guilds and relative abundance of *Alburnoides bipunctatus*, presuming that these metrics are underestimated; the box-plots suggest that. We draw boundaries following the differences between impact classes and the values that occur most often. The class boundaries (according to values of normalized data set at the 25-th percentile) and corresponding metric values are in the Table 14.

Table 14 also includes large salmonid-cyprinid rivers of type EP3. Metrics values at the given impact class boundary for this river type were extrapolated from type EP2. We suppose it possible, because medians of metrics at the impact class 2 in EP2 rivers are rather similar to those in EP3 rivers, which are all of impact class 2 (according to variables of priority).

Table 14. Metric values at the given class boundary

Metrics	**CL**	**range**	**1(HR1)**	**2(HR2)**	**3(HR3)**	**4(EP1)**	**5(MP1)**	**6(EP2)**	**7(EP3)**
LITH Perc_nha	1	1-0.85	**>81**	**>81**	**>78**	**>50**	**>46**	**>48**	**>48**
	2	0.85-0.5	**81-48**	**81-48**	**78-46**	**29-50**	**46-27**	**28-48**	**28-48**
	3	0.5-0.1	**48-10**	**48-10**	**46-9**	**29-9**	**27-5**	**28-6**	**28-6**
	4	0-0.1	**<10**	**<10**	**<9**	**<9**	**<5**	**<6**	**<6**
	5	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**
LITH Perc_kgha	1	1-0.85	**>85**	**>79**	**>79**	**>50**	**>22**	**>48**	**>48**
	2	0.85-0.5	**85-50**	**79-47**	**79-47**	**30-50**	**22-13**	**28-48**	**28-48**
	3	0.5-0.1	**50-10**	**47-9**	**47-9**	**30-6**	**13-3**	**28-6**	**28-6**
	4	0-0.1	**<10**	**<9**	**<9**	**<9**	**<3**	**<6**	**<6**
	5	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOLE Perc_nha	1	1-0,9	**<10**	**<10**	**<9**	**<35**	**<48**	**<35**	**<35**
	2	0,9-0,7	**10-31**	**10-31**	**9-31**	**35-49**	**48-60**	**35-50**	**35-50**
	3	0,7-0,4	**31-60**	**31-60**	**31-60**	**49-71**	**60-77**	**50-71**	**50-71**
	4	0-0.4	**>60**	**>60**	**>60**	**>71**	**>77**	**>71**	**>71**
	5	0	**100**	**100**	**100**	**100**	**100**	**100**	**100**
TOLE Perc_kgha	1	1-0,9	**<11**	**<11**	**<11**	**<35**	**<35**	**<35**	**<35**
	2	0,9-0,7	**11-31**	**11-31**	**11-31**	**35-50**	**35-50**	**35-50**	**35-50**
	3	0,7-0,4	**31-60**	**31-60**	**31-60**	**50-71**	**50-70**	**50-71**	**50-71**
	4	0-0.4	**>60**	**>60**	**>60**	**>71**	**>70**	**>71**	**>71**
	5	0	**100**	**100**	**100**	**100**	**100**	**100**	**100**
INSEV Perc_nha	1	1-0.85	**>58**	**>43**	**>29**	**>21**	**>20**	**>21**	**>21**
	2	0.85-0.5	**34-58**	**25-43**	**17-29**	**12-21**	**12-20**	**12-20**	**12-20**
	3	0.5-0.1	**7-34**	**5-25**	**3-17**	**2-12**	**2-12**	**3-12**	**3-12**
	4	0-0.1	**<7**	**<5**	**<3**	**<2**	**<2**	**<3**	**<3**

	5	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**
LITH Perc_sp	1	1-0.85		**>67**	**>62**	**>51**	**>41**	**>51**	**>51**
	2	0.85-0.65		**67-51**	**62-48**	**51-39**	**41-28**	**51-39**	**51-39**
	3	0.65-0.35		**51-27**	**48-26**	**39-21**	**28-16**	**39-21**	**39-21**
	4	0.35-0		**<27**	**<26**	**<21**	**<16**	**<21**	**<21**
	5	0		**0**	**0**	**0**	**0**	**0**	**0**
EURY Perc_sp	1	1-0,9		**<24**	**<24**	**<46**			
	2	0,9-0,7		**24-41**	**24-41**	**46-58**			
	3	0,7-0,4		**41-66**	**41-66**	**58-76**			
	4	0-0.4		**>66**	**>66**	**>76**			
	5	0		**100**	**100**	**100**			
OMNI Perc_sp	1	1-0,9					**<38**	**<38**	**<38**
	2	0,9-0,7					**38-52**	**38-52**	**38-52**
	3	0,7-0,4					**52-72**	**52-72**	**52-72**
	4	0-0.4					**>72**	**>72**	**>72**
	5	0					**100**	**100**	**100**
Native salmonids Perc_nha	1	1-0.6	**>31**	**>21**	**>7**				
	2	0.6-0	**<31**	**<21**	**<7**				
	3	0	**0**	**0**	**0**				
CotGob Perc_nha	1	1-0.75		**>13**	**>13**	**>8**		**>7**	**>7**
	2	0.75-0.15		**3-13**	**3-13**	**1.5-8**		**1-7**	**1-7**
	3	0-0.15		**<3**	**<3**	**<1.5**		**<1**	**<1**
	4	0		**0**	**0**	**0**		**0**	**0**
AlbBip Perc_nha	1	1-0.75					**9**	**9**	**9**
	2	0.75-0.15					**2-9**	**2-9**	**2-9**
	3	0-0.15					**<2**	**<2**	**<2**
	4	0					**0**	**0**	**0**
Presence of diadromous salmonids					+	+		+	+
Presence of asp&barbel									+

Draft multimetric index

Summarizing, multimetric index based on spatially based approach includes 11 metrics, which were proved to respond significantly to changes of the river status. There are two groups of them – responding positively and responding negatively to decline of status (Table 15).

Table 15. Metrics selected by SBA approach and their response to degradation

<table>
<tr><td rowspan="4">Measurement unit</td><td colspan="8">Metrics</td></tr>
<tr><td colspan="3">Positive response (metric increases)</td><td colspan="5">Negative response (metric decreases)</td></tr>
<tr><td colspan="3">Ecological guilds</td><td colspan="2">Ecological guilds</td><td colspan="3">Sentinel species</td></tr>
<tr><td>Tolerant</td><td>Eurytopic</td><td>Omnivorous</td><td>Lithophilic</td><td>Insectivorous</td><td>Native salmonids</td><td>Cottus gobio</td><td>Alburnoides bipunctatus</td></tr>
<tr><td>Abundance (%)*</td><td>1</td><td colspan="2" rowspan="2"></td><td>5</td><td>8</td><td>9</td><td>10</td><td>11</td></tr>
<tr><td>Biomass (%)**</td><td>2</td><td>6</td><td colspan="4" rowspan="2"></td></tr>
<tr><td>Nb of species (%)</td><td></td><td>3</td><td>4</td><td>7</td></tr>
</table>

*   - relative abundance of individuals
** - relative biomass of individuals

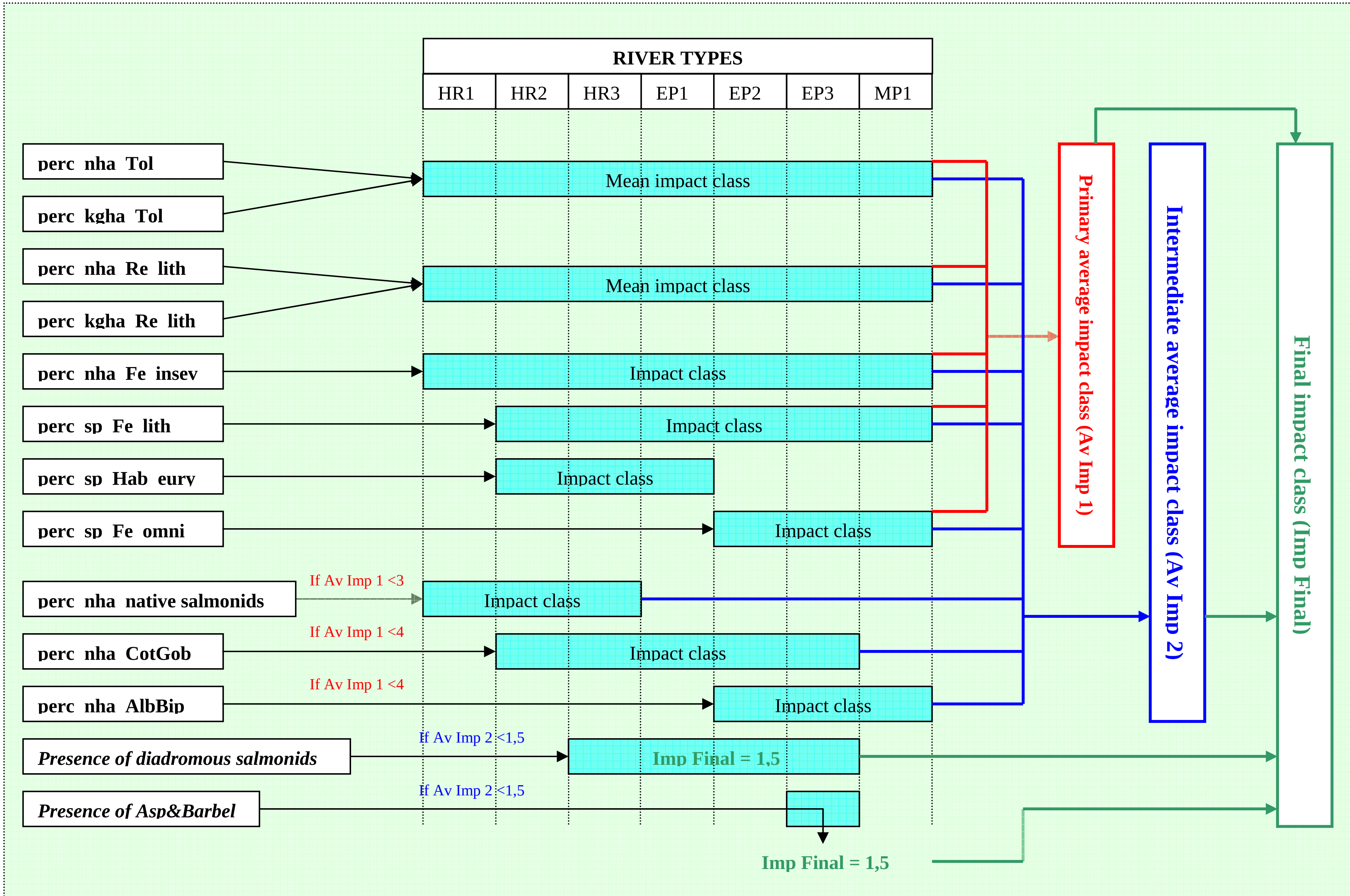
Relative abundance and biomass of individuals of the same ecological guild respond to degradation in the same direction (metrics 1-2 and 5-6). In order to give them equal weights in respect of the rest metrics, the only one - mean impact value for relative abundance and biomass is used (for tolerant and lithophilic ecological guilds).

The algorithm of impact assessment is in Figure 2.

There are three steps:

1. *Primary average impact class* is calculated according to impact classes of metrics representing ecological guilds (average of sum of impact classes).
2. If *Primary average impact* is less than 3, than all three metrics, related to sentinel species (relative abundance of native salmonids, *Cottus gobio* and *Alburnoides bipunctatus*; depending on river type) are also included into calculation of *Intermediate average impact class*. If *Primary average impact* is greater than 3, than metric representing relative density of native salmonids is skipped from further evaluation of the status of salmonid rivers (HR1-HR3 types), and P*rimary average impact = Final impact class* (because salmonids are absent at the impact class greater than 2). If *Primary average impact* is greater than 4, the same is valid for relative abundances of *Cottus gobio* and *Alburnoides bipunctatus* (those species are absent at the impact class greater than 3) in the appropriate river types.
3. There are two additional metrics, indicating river connectivity (*presence of diadromous salmonids* for river types HR3, EP1, EP2 and EP3) and exploitation pressure (*presence of asp&barbel*, sentinels for river type EP3). The latter two metrics are important when average impact class derived at the step 2 is < 1,5: if *Intermediate average impact* is less than 1,5, but diadromous salmonids are absent in the appropriate river types, the *Final impact class* is being equated to 1,5 (rounded overall impact class = 2). The same is valid for presence of asp&barbel – sentinel species for EP3 river type. If diadromous salmonids and sentinels are present, or if *Intermediate average impact* class is equal or greater than 1,5, than *Intermediate average impact = Final impact class.*

Fig. 1. Algorithm of impact assessment



Annex I

Results of Spearman correlation and Fisher's LSD test per river type

HR1 type	Connectivity segment	Hydrological regime_site	Morphological condition_site	Nutrients organic_input	5 impact classes	3 impact classes	Fishers's LSD test, 5 impact classes	Fishers's LSD test, 3 impact classes
Perc_kgha_Hab_b	-0,374	-0,042	-0,086	0,169	0,042	-0,495		
Kg_ha_Hab_b	-0,230	-0,026	-0,209	0,087	-0,045	-0,446		
Perc_nha_Hab_b	-0,252	-0,067	-0,084	0,126	-0,025	-0,397		
N_ha_Hab_b	-0,265	-0,128	-0,197	0,052	-0,053	-0,475		
N_sp_Hab_b	-0,273	-0,051	-0,223	-0,045	-0,081	-0,475		
Perc_sp_Hab_b	-0,025	-0,436	-0,215	-0,039	-0,248	-0,439		
Perc_kgha_Hab_eury	-0,061	0,456	0,169	0,139	0,333	*0,397*	*	*
Perc_nha_Hab_eury	-0,013	0,442	0,237	0,082	0,249	0,497	*	*
Perc_sp_Hab_eury	0,004	0,411	0,240	0,094	0,235	0,489	*	*
Perc_kgha_Fe_insev	0,109	-0,262	-0,091	-0,450	-0,505	-0,131	*	
Kg_ha_Fe_insev	0,103	-0,198	-0,279	-0,394	-0,488	-0,156		
Perc_nha_Fe_insev	0,016	-0,248	-0,139	-0,356	-0,494	-0,139	*	
N_ha_Fe_insev	-0,018	-0,233	-0,265	-0,329	-0,468	-0,197		
Perc_kgha_Intol	0,114	-0,266	-0,103	-0,435	-0,499	-0,131		
Kg_ha_Intol	0,103	-0,213	-0,315	-0,370	-0,487	-0,172		
Perc_nha_Intol	-0,015	-0,252	-0,178	-0,317	-0,476	-0,172		
N_ha_Intol	-0,048	-0,235	-0,344	-0,266	-0,429	-0,262		
N_sp_Intol	-0,103	-0,146	-0,107	-0,321	-0,256	-0,270		
Perc_sp_Intol	0,053	-0,256	-0,018	-0,404	-0,356	-0,177		
Perc_kgha_Re_lith	0,135	-0,369	-0,127	-0,353	-0,426	-0,299	*	
Kg_ha_Re_lith	-0,014	-0,245	-0,518	-0,146	-0,344	-0,422		
Perc_nha_Re_lith	-0,032	-0,342	-0,220	-0,292	-0,444	-0,444	*	
N_ha_Re_lith	-0,156	-0,332	-0,408	0,091	-0,131	-0,471		
N_sp_Re_lith	-0,283	0,028	-0,246	-0,202	-0,110	-0,461		
Perc_sp_Re_lith	-0,045	-0,357	-0,243	-0,308	-0,452	-0,479	*	*
Perc_sp_Re_phyt	-0,021	0,100	0,311	0,266	0,165	0,512		
Perc_kgha_Mi_potad	0,102	-0,257	-0,178	-0,366	-0,491	-0,148	*	
Kg_ha_Mi_potad	0,124	-0,252	-0,384	-0,356	-0,513	-0,222	*	
Perc_nha_Mi_potad	0,079	-0,255	-0,309	-0,319	-0,505	-0,230	*	
N_ha_Mi_potad	-0,003	-0,280	-0,449	-0,298	-0,493	-0,349	*	*
N_sp_Mi_potad	-0,155	-0,164	-0,188	-0,256	-0,441	-0,319	*	*
Perc_sp_Mi_potad	0,008	-0,289	-0,164	-0,344	-0,439	-0,309	*	*
Perc_kgha_Hab_rh	0,136	-0,406	-0,088	-0,258	-0,341	-0,333	*	*
Kg_ha_Hab_rh	-0,054	-0,208	-0,472	-0,133	-0,320	-0,454		
Perc_nha_Hab_rh	0,017	-0,317	-0,160	-0,214	-0,263	-0,460	*	*
N_ha_Hab_rh	-0,186	-0,192	-0,312	0,016	-0,091	-0,512		
N_sp_Hab_rh	-0,266	0,012	-0,219	-0,139	-0,053	-0,474		
Perc_sp_Hab_rh	0,021	-0,325	-0,198	-0,217	-0,323	-0,472	*	*
Perc_kgha_Tol	-0,040	0,415	0,115	0,078	0,284	*0,351*	*	*
Perc_nha_Tol	-0,003	0,322	0,182	0,160	0,255	0,447	*	*
Perc_sp_Tol	0,051	0,328	0,203	0,064	0,273	0,452	*	*
Perc_kgha_Hab_wc	0,360	-0,011	0,064	-0,193	-0,097	0,446		
Perc_sp_Hab_wc	0,025	0,436	0,215	0,039	0,248	0,439		

* - significant differences

HR2 type	Connectivity segment	Hydrological regime_site	Morphological condition_site	Nutrients organic_input	5 impact classes	3 impact classes	Fishers's LSD test, 5 impact classes	Fishers's LSD test, 3 impact classes
Perc_kgha_Hab_eury	0,420	0,352	0,351	0,234	0,469	0,423	*	*
Kg_ha_Hab_eury	0,348	0,162	0,203	0,399	0,496	0,275		
Perc_nha_Hab_eury	0,429	0,298	0,243	0,132	0,386	0,327		
N_ha_Hab_eury	0,411	0,141	0,132	0,301	0,473	0,227	*	
N_sp_Hab_eury	0,217	0,155	0,264	0,431	0,460	0,219		
Perc_sp_Hab_eury	0,372	0,442	0,442	0,345	0,618	0,465	*	*
Perc_kgha_Fe_insev	-0,321	-0,444	-0,451	-0,660	-0,682	-0,486	*	
Kg_ha_Fe_insev	-0,321	-0,676	-0,612	-0,337	-0,670	-0,543		
Perc_nha_Fe_insev	-0,359	-0,332	-0,354	-0,631	-0,554	-0,692	*	
N_ha_Fe_insev	-0,321	-0,544	-0,515	-0,452	-0,575	-0,635		
N_sp_Fe_insev	-0,338	-0,581	-0,532	-0,472	-0,610	-0,597	*	
Perc_sp_Fe_insev	-0,129	-0,290	-0,405	-0,490	-0,425	-0,327	*	
Perc_kgha_Intol	-0,300	-0,443	-0,451	-0,637	-0,642	-0,525	*	
Kg_ha_Intol	-0,260	-0,667	-0,621	-0,327	-0,517	-0,664		
Perc_nha_Intol	-0,338	-0,311	-0,329	-0,606	-0,642	-0,455	*	
N_ha_Intol	-0,155	-0,501	-0,544	-0,416	-0,482	-0,573		
N_sp_Intol	-0,114	-0,551	-0,515	-0,482	-0,554	-0,474		
Perc_sp_Intol	-0,191	-0,303	-0,331	-0,642	-0,523	-0,321	*	
Perc_kgha_Re_lith	-0,375	-0,492	-0,500	-0,530	-0,746	-0,578	*	
Kg_ha_Re_lith	-0,314	-0,670	-0,649	-0,156	-0,448	-0,735		
Perc_nha_Re_lith	-0,390	-0,558	-0,516	-0,496	-0,755	-0,591	*	
N_ha_Re_lith	-0,236	-0,471	-0,452	-0,079	-0,293	-0,535		
N_sp_Re_lith	-0,259	-0,703	-0,542	-0,177	-0,574	-0,625		
Perc_sp_Re_lith	-0,319	-0,628	-0,517	-0,457	-0,703	-0,527	*	
N_ha_Fe_omni	0,399	0,081	0,062	0,335	0,374	0,145		
Perc_sp_Fe_omni	0,280	0,144	0,084	0,304	0,334	0,088		
Perc_kgha_Re_phyt	0,078	0,365	0,414	0,172	0,304	0,347		
Kg_ha_Re_phyt	0,112	0,303	0,339	0,254	0,333	0,305		
N_ha_Re_phyt	0,218	0,220	0,253	0,288	0,370	0,289		
N_sp_Re_phyt	0,226	0,321	0,369	0,305	0,411	0,386		
Perc_kgha_Mi_potad	-0,196	-0,509	-0,550	-0,400	-0,495	-0,522	*	*
Kg_ha_Mi_potad	-0,157	-0,659	-0,642	-0,224	-0,427	-0,601	*	*
Perc_nha_Mi_potad	-0,189	-0,426	-0,447	-0,296	-0,381	-0,421	*	*
N_ha_Mi_potad	-0,101	-0,609	-0,645	-0,245	-0,413	-0,571	*	*
N_sp_Mi_potad	-0,007	-0,568	-0,410	-0,150	-0,304	-0,338		
Perc_sp_Mi_potad	-0,100	-0,396	-0,246	-0,298	-0,334	-0,189		
Perc_kgha_Hab_rh	-0,453	-0,352	-0,330	-0,237	-0,475	-0,427	*	
Kg_ha_Hab_rh	-0,391	-0,537	-0,412	0,120	-0,200	-0,530		
Perc_nha_Hab_rh	-0,437	-0,333	-0,283	-0,144	-0,409	-0,368	*	
N_sp_Hab_rh	-0,366	-0,679	-0,516	-0,040	-0,520	-0,643		
Perc_sp_Hab_rh	-0,401	-0,505	-0,476	-0,274	-0,593	-0,524	*	
Perc_kgha_Tol	0,441	0,205	0,178	0,338	0,406	0,242	*	
Kg_ha_Tol	0,393	0,119	0,122	0,421	0,441	0,192		
Perc_nha_Tol	0,450	0,287	0,167	0,190	0,417	0,240	*	
N_ha_Tol	0,424	0,142	0,112	0,304	0,401	0,200		
N_sp_Tol	0,289	0,118	0,147	0,341	0,383	0,133		
Perc_sp_Tol	0,396	0,321	0,208	0,248	0,475	0,263	*	
Kg_ha_Hab_wc	0,078	-0,409	-0,444	0,091	-0,047	-0,396		

* - significant differences

HR3 type	**Connectivity segment**	**Hydrological regime_site**	**Morphological condition_site**	**Nutrients organic_input**	**5 impact classes**	**3 impact classes**	**Fishers's LSD test, 5 impact classes**	**Fishers's LSD test, 3 impact classes**
N_sp_Hab_b	0,186	0,246	0,045	0,181	0,426	0,279		
Perc_kgha_Hab_eury	0,370	0,441	*0,386*	0,214	0,559	0,401	*	*
Kg_ha_Hab_eury	0,366	0,429	0,282	0,281	0,432	0,514	*	*
Perc_nha_Hab_eury	0,412	*0,393*	0,231	0,327	0,524	0,539	*	
N_ha_Hab_eury	0,403	0,480	0,172	0,412	0,482	0,568	*	*
N_sp_Hab_eury	0,289	0,565	0,266	0,465	0,624	0,519	*	*
Perc_sp_Hab_eury	0,393	0,625	0,326	0,482	0,625	0,588	*	
Perc_kgha_Fe_insev	-0,299	-0,745	-0,232	-0,567	-0,601	-0,523	*	*
Kg_ha_Fe_insev	-0,231	-0,605	-0,127	-0,403	-0,411	-0,325		
Perc_nha_Fe_insev	-0,258	-0,642	-0,181	-0,515	-0,558	-0,434	*	
N_ha_Fe_insev	-0,233	-0,537	-0,164	*-0,389*	-0,405	-0,313		
N_sp_Fe_insev	-0,265	-0,621	-0,413	-0,555	-0,596	-0,502	*	*
Perc_sp_Fe_insev	-0,026	-0,321	-0,193	-0,275	-0,361	-0,273		
Perc_kgha_Intol	-0,302	-0,739	-0,232	-0,566	-0,597	-0,511	*	*
Kg_ha_Intol	-0,238	-0,591	-0,126	*-0,393*	-0,404	-0,301		
Perc_nha_Intol	-0,274	-0,607	-0,195	-0,502	-0,556	-0,410	*	*
N_ha_Intol	-0,242	-0,496	-0,178	-0,376	-0,418	-0,245		
N_sp_Intol	-0,286	-0,552	-0,270	-0,473	-0,470	*-0,358*		
Perc_sp_Intol	-0,340	-0,689	-0,310	-0,612	-0,701	-0,487	*	*
Perc_kgha_Re_lith	-0,404	-0,616	-0,321	*-0,380*	-0,602	-0,516	*	*
Perc_nha_Re_lith	-0,411	-0,465	-0,209	-0,439	-0,543	-0,592	*	*
Perc_sp_Re_lith	-0,364	-0,634	-0,220	-0,509	-0,575	-0,540	*	
N_sp_native	0,091	0,310	0,088	0,304	0,443	0,271		
Perc_kgha_Fe_omni	0,062	0,311	0,230	0,261	*0,382*	0,297	*	*
Kg_ha_Fe_omni	0,100	0,314	0,252	0,258	0,280	0,400		
Perc_nha_Fe_omni	0,346	0,324	0,276	0,332	0,435	0,455	*	*
N_ha_Fe_omni	0,371	0,343	0,189	0,433	*0,379*	0,490		
N_sp_Fe_omni	0,152	0,480	0,217	0,486	0,497	0,407	*	*
Perc_sp_Fe_omni	0,147	0,498	0,236	0,505	0,461	*0,395*	*	*
Perc_kgha_Hab_rh	-0,361	-0,510	-0,352	-0,260	-0,564	-0,478	*	*
Perc_nha_Hab_rh	-0,408	-0,417	-0,221	-0,337	-0,523	-0,547	*	*
N_sp_Hab_rh	-0,327	*-0,380*	-0,214	-0,223	-0,194	*-0,380*		
Perc_sp_Hab_rh	*-0,398*	-0,639	-0,314	-0,498	-0,617	-0,599		*
Perc_nha_Lon_sl	-0,281	-0,527	-0,307	-0,369	-0,419	*-0,389*		
Perc_kgha_Tol	0,322	0,465	0,272	0,432	0,623	*0,395*	*	*
Kg_ha_Tol	0,326	0,456	0,273	0,433	0,523	0,455		
Perc_nha_Tol	0,455	0,370	0,218	*0,389*	0,535	0,513	*	*
N_ha_Tol	0,423	0,456	0,185	0,513	0,510	0,549		
N_sp_Tol	0,345	0,585	0,123	0,572	0,559	0,521		*
Perc_sp_Tol	0,374	0,563	0,089	0,542	0,453	0,489	*	*

* - significant differences

EP1 type	**Hydrological regime_site**	**Morphological condition_site**	**Nutrients organic_input**	**5 impact classes**	**3 impact classes**	**Fishers's LSD test, 5 impact classes**	**Fishers's LSD test, 3 impact classes**
N_ha_Hab_eury	0,308	0,252	0,178	0,356	0,288	*	
Perc_sp_Hab_eury	0,293	0,444	0,031	0,374	0,325	*	*
Perc_kgha_Fe_insev	-0,131	-0,163	-0,454	-0,355	-0,304		
Kg_ha_Fe_insev	-0,195	-0,178	-0,517	-0,424	-0,350	*	
Perc_nha_Fe_insev	-0,117	-0,241	-0,426	-0,419	-0,521	*	*
N_ha_Fe_insev	-0,122	-0,245	-0,437	-0,409	-0,433	*	
N_sp_Fe_insev	-0,363	-0,538	-0,196	-0,510	-0,499	*	*
Perc_kgha_Intol	-0,022	-0,053	-0,433	-0,272	-0,194		
Kg_ha_Intol	-0,096	-0,074	-0,503	-0,350	-0,257		
Perc_nha_Intol	-0,050	-0,170	-0,437	-0,384	-0,449	*	*
N_ha_Intol	0,092	-0,008	-0,388	-0,230	-0,197		
N_sp_Intol	-0,240	-0,380	-0,274	-0,456	-0,389	*	*
Perc_sp_Intol	-0,271	-0,202	-0,371	-0,396	-0,174	*	*
Perc_kgha_Re_lith	-0,231	-0,191	-0,335	-0,405	-0,226	*	
Kg_ha_Re_lith	-0,245	-0,232	-0,264	-0,408	-0,314	*	
Perc_nha_Re_lith	-0,277	-0,181	-0,457	-0,451	-0,366	*	*
N_sp_Re_lith	-0,281	-0,579	0,055	-0,395	-0,495		*
Perc_sp_Re_lith	-0,447	-0,496	-0,038	-0,435	-0,320	*	*
Perc_sp_Fe_omni	0,393	0,092	0,388	0,420	0,260	*	*
Perc_kgha_Hab_rh	-0,262	-0,203	-0,301	-0,387	-0,241	*	
Kg_ha_Hab_rh	-0,257	-0,255	-0,212	-0,379	-0,319		
Perc_nha_Hab_rh	-0,338	-0,226	-0,311	-0,404	-0,392	*	*
N_sp_Hab_rh	-0,199	-0,561	0,078	-0,345	-0,494		*
Perc_sp_Hab_rh	-0,336	-0,469	0,021	-0,356	-0,340	*	*
Perc_kgha_Tol	0,437	0,195	0,313	0,426	0,290	*	*
Perc_nha_Tol	0,248	0,090	0,246	0,299	0,270	*	
Perc_sp_Tol	0,471	0,423	0,150	0,520	0,489	*	*

* - significant differences

EP2 type	**Connectivity segment**	**Hydrological regime_site**	**Morphological condition_site**	**Nutrients organic_input**	**5 impact classes**	**3 impact classes**	**Fishers's LSD test, 5 impact classes**	**Fishers's LSD test, 3 impact classes**
Perc_nha_Hab_b	-0,418	-0,294	-0,221	-0,010	-0,090	-0,489		
Perc_kgha_Hab_eury	0,343	0,215	0,179	0,058	0,155	0,387		
Perc_nha_Hab_eury	0,402	0,298	0,146	0,064	0,254	0,361	*	*
Perc_sp_Hab_eury	0,408	0,394	0,150	0,089	0,339	0,396	*	*
Perc_kgha_Fe_insev	-0,302	-0,307	0,130	-0,246	-0,326	-0,297		
Perc_nha_Fe_insev	-0,365	-0,329	-0,004	-0,145	-0,359	-0,294	*	
N_sp_Fe_insev	-0,437	-0,446	-0,126	-0,252	-0,480	-0,325	*	
Perc_sp_Fe_insev	-0,294	-0,377	-0,161	-0,382	-0,515	-0,159	*	
Perc_kgha_Intol	-0,321	-0,249	0,104	-0,240	-0,400	-0,347	*	
Perc_nha_Intol	-0,380	-0,301	-0,021	-0,126	-0,293	-0,335		
N_sp_Intol	-0,444	-0,333	-0,141	-0,268	-0,417	-0,440	*	*
Perc_sp_Intol	-0,338	-0,367	0,071	-0,230	-0,413	-0,383	*	*
Perc_kgha_Re_lith	-0,349	-0,239	-0,163	-0,114	-0,195	-0,423	*	*
Perc_nha_Re_lith	-0,393	-0,316	-0,113	-0,147	-0,308	-0,380	*	*
N_sp_Re_lith	-0,428	-0,358	-0,181	-0,233	-0,398	-0,431	*	*
Perc_sp_Re_lith	-0,309	-0,458	-0,029	-0,125	-0,352	-0,362	*	*
Perc_kgha_Mi_long	-0,266	-0,385	-0,114	-0,126	-0,157	-0,464		
Kg_ha_Mi_long	-0,266	-0,390	-0,114	-0,113	-0,159	-0,464		
Perc_nha_Mi_long	-0,266	-0,375	-0,114	-0,122	-0,159	-0,464		
N_ha_Mi_long	-0,266	-0,366	-0,114	-0,081	-0,147	-0,465		
N_sp_Mi_long	-0,268	-0,356	-0,115	-0,170	-0,231	-0,468		
Perc_sp_Mi_long	-0,266	-0,354	-0,114	-0,144	-0,200	-0,465		
Perc_kgha_Fe_omni	0,346	0,553	0,154	0,252	0,428	0,374	*	*
Perc_nha_Fe_omni	0,419	0,365	0,163	0,167	0,346	0,417	*	*
Perc_sp_Fe_omni	0,460	0,315	0,196	0,160	0,401	0,323	*	*
Perc_kgha_Hab_rh	-0,346	-0,225	-0,179	-0,047	-0,147	-0,387		*
Perc_nha_Hab_rh	-0,402	-0,298	-0,138	-0,057	-0,246	-0,358	*	*
N_sp_Hab_rh	-0,419	-0,300	-0,202	-0,193	-0,354	-0,412	*	*
Perc_sp_Hab_rh	-0,402	-0,389	-0,134	-0,068	-0,328	-0,393		*
N_sp_Lon_sl	-0,429	-0,148	-0,198	-0,039	-0,149	-0,391		
Perc_kgha_Tol	0,315	0,298	0,204	0,142	0,289	0,406	*	*
Perc_nha_Tol	0,414	0,289	0,171	0,068	0,230	0,388	*	*
Perc_sp_Tol	0,380	0,323	0,192	0,064	0,304	0,364		
Perc_kgha_Hab_wc	0,310	0,221	0,229	-0,031	0,054	0,386		
Perc_nha_Hab_wc	0,410	0,288	0,213	0,012	0,086	0,492		
N_sp_Hab_wc	-0,251	-0,286	-0,193	-0,317	-0,390	-0,284		

* - significant differences

MP1 type	Connectivity segment	Hydrological regime_site	Morphological condition_site	Nutrients organic_input	5 impact lasses	3 impact classes	Fishers's LSD test, 5 impact classes	Fishers's LSD test, 3 impact classes
Perc_kgha_Hab_b	0,289	-0,230	-0,406	-0,373	-0,189	-0,388		
Kg_ha_Hab_b	0,271	-0,344	-0,422	-0,422	-0,283	-0,426		
Perc_nha_Hab_b	0,184	-0,211	-0,416	-0,241	-0,187	-0,389		*
N_ha_Hab_b	0,245	-0,228	-0,424	-0,298	-0,217	-0,384		*
N_sp_Hab_b	0,199	-0,373	-0,499	-0,255	-0,282	-0,409		*
Perc_nha_Hab_eury	0,174	0,385	0,516	0,271	0,474	0,486	*	*
Perc_sp_Hab_eury	0,035	0,429	0,558	0,170	0,407	0,429	*	*
Kg_ha_Fe_insev	-0,138	-0,335	-0,265	-0,294	-0,406	-0,291		
Perc_nha_Fe_insev	-0,147	-0,299	-0,328	-0,380	-0,450	-0,394	*	
N_sp_Fe_insev	-0,067	-0,501	-0,298	-0,411	-0,436	-0,391		*
Perc_kgha_Re_lith	-0,071	-0,439	-0,497	-0,209	-0,420	-0,381	*	
Kg_ha_Re_lith	-0,025	-0,543	-0,430	-0,418	-0,505	-0,393		
Perc_nha_Re_lith	-0,207	-0,413	-0,472	-0,353	-0,527	-0,460	*	*
N_ha_Re_lith	-0,071	-0,385	-0,434	-0,466	-0,512	-0,468		
N_sp_Re_lith	-0,074	-0,473	-0,495	-0,355	-0,492	-0,519	*	*
Perc_sp_Re_lith	-0,261	-0,420	-0,401	-0,252	-0,514	-0,522	*	*
N_sp_native	0,212	-0,348	-0,385	-0,358	-0,284	-0,379	*	
Perc_kgha_Fe_omni	0,066	0,459	0,381	0,274	0,345	0,307		
Perc_nha_Fe_omni	0,184	0,369	0,528	0,259	0,486	0,480	*	*
Perc_sp_Fe_omni	0,306	0,389	0,381	0,314	0,555	0,497	*	*
Perc_kgha_Fe_pisc	-0,121	-0,389	-0,146	-0,439	-0,382	-0,298		
Kg_ha_Fe_pisc	-0,042	-0,452	-0,205	-0,493	-0,402	-0,336		
Perc_nha_Fe_pisc	-0,130	-0,381	-0,134	-0,382	-0,373	-0,288		
N_ha_Fe_pisc	-0,092	-0,494	-0,250	-0,457	-0,451	-0,364		
N_sp_Fe_pisc	-0,096	-0,374	-0,229	-0,411	-0,395	-0,409		
Kg_ha_Hab_rh	-0,010	-0,392	-0,354	-0,250	-0,356	-0,297		
Perc_nha_Hab_rh	-0,168	-0,390	-0,500	-0,281	-0,480	-0,484	*	*
N_ha_Hab_rh	0,065	-0,327	-0,413	-0,443	-0,420	-0,422		
N_sp_Hab_rh	0,015	-0,428	-0,511	-0,288	-0,424	-0,487		*
Perc_sp_Hab_rh	-0,166	-0,350	-0,487	-0,139	-0,415	-0,490	*	*
Perc_kgha_Tol	0,119	0,505	0,470	0,170	0,412	0,357	*	
Perc_nha_Tol	0,258	0,356	0,518	0,200	0,486	0,508	*	*
Perc_sp_Tol	0,327	0,354	0,471	0,186	0,506	0,588	*	*
Perc_kgha_Hab_wc	-0,350	0,241	0,406	0,384	0,169	0,383		
Perc_nha_Hab_wc	-0,185	0,206	0,418	0,229	0,177	0,379		

* - significant differences

Annex II

Fish species & guilds in the rivers of ER 15

Species	Fides occurrence	Tolerance	Habitat_feeding	Habitat_rheo	Reproduction	Feeding	Migration	Longevity
Abramis brama	1	**TOLE**	B	**EURY**		**OMNI**	POTAD	LL
Acipenser sturio			B	RH	LITH	OMNI	LONG	LL
Alburnoides bipunctatus	1	INTOL	WC	RH	LITH	INSV		SL
Alburnus alburnus	1	**TOLE**	WC	**EURY**		**OMNI**		SL
Alosa alosa		INTOL	WC	RH			LONG	
Alosa fallax			WC	RH			LONG	LL
Anguilla anguilla	1	**TOLE**	B	EURY			LONG	
Aspius aspius	1		WC	EURY	LITH	PISC	POTAD	
Barbatula barbatula	1		B	RH	LITH			
Barbus barbus	1		B	RH	LITH		POTAD	LL
Blicca bjoerkna	1	**TOLE**	B	**EURY**		**OMNI**		
Carassius carassius	1	**TOLE**	B	LI	PHYT	OMNI		
Carassius gibelio	1	**TOLE**	B	**EURY**	PHYT	**OMNI**		LL
Chondrostoma nasus	1		B	RH	LITH		POTAD	
Cobitis taenia	1		B	EURY	PHYT			SL
Cottus gobio	1	INTOL	B	RH	LITH	INSV		SL
Cyprinus carpio	1	**TOLE**	B	**EURY**	PHYT	**OMNI**		LL
Esox lucius	1		WC	EURY	PHYT	PISC		LL
Gasterosteus aculeatus	1	**TOLE**	WC	**EURY**		**OMNI**		SL
Gobio gobio	1		B	RH				SL
Gymnocephalus cernuus	1		B	EURY				
Lampetra fluviatilis	1	INTOL	B	RH	LITH		LONG	
Lampetra planeri	1	INTOL	B	RH	LITH		POTAD	
Leucaspius delineatus	1		WC	LI	PHYT	OMNI		SL
Leuciscus cephalus	1		WC	RH	LITH	OMNI	POTAD	
Leuciscus idus	1		WC	RH		OMNI	POTAD	
Leuciscus leuciscus	1		WC	RH	LITH	OMNI		
Lota lota	1		B	EURY	LITH	PISC	POTAD	LL
Misgurnus fossilis	1		B	LI	PHYT			
Perca fluviatilis	1	**TOLE**	WC	EURY				
Perccottus glenii	1			LI		OMNI		
Petromyzon marinus	1	INTOL	B	RH	LITH		LONG	
Phoxinus phoxinus	1		WC	RH	LITH			SL
Pungitius pungitius	1	**TOLE**	WC	LI		**OMNI**		SL
Rhodeus sericeus	1	INTOL	WC	LI				SL
Rutilus rutilus	1	**TOLE**	WC	**EURY**		**OMNI**		
Sabanejewia aurata			B	LI	PHYT	OMNI		
Salmo salar	1	INTOL	WC	RH	LITH	INSV	LONG	
Salmo trutta	1	INTOL	WC	RH	LITH	INSV	LONG	
Salmo trutta fario	1	INTOL	WC	RH	LITH	INSV	POTAD	
Sander lucioperca	1		WC	EURY		PISC		LL
Scardinius erythrophthalmus	1		WC	LI	PHYT	OMNI		
Silurus glanis	1		B	EURY	PHYT	PISC		LL
Thymallus thymallus	1	INTOL	WC	RH	LITH	INSV	POTAD	
Tinca tinca	1	**TOLE**	B	LI	PHYT	**OMNI**		LL
Vimba vimba	1		B	RH	LITH		POTAD	