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National Method for evaluation the ecological status of streams based on fishes:

Fish Index of Slovakia

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1. Introduction

This material describes briefly the new National Method for evaluation the ecological status of Slovak streams based on fish communities. Central to this National Method is a multimetric index Fish Index of Slovakia (FIS) that has been developed based on previous activities of experts involved into the implementation of the Water Framework Directive (Hensel, 2001; 2002; 2003; Mužík 2007; Šporka et al., 2007), as well as on further materials and/or publications. Among these, the most important appeared to be the fish database of Slovak streams (V. Mužík), experience from other European countries, and outputs from the FAME Project (Pont et al., 2004). Current calibration of FIS should be, though, considered preliminary, and therefore, it may be a subject of subsequent modifications.

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2. National Method for evaluation the ecological status of streams based on fishes

Over the last years, the attempts to evaluate the ecological status of Slovak streams based on fishes were focused on the application of the European Fish index (EFI; Pont et al., 2004). However, the use of EFI in Slovak streams was associated with the following problems: 1) deficit of such data from Slovak sites that meet FAME specifications; 2) impossibility to set up reference conditions based on recent ichthyological samples (implication from the data deficiency); 3) high diversity of fish fauna concentrated on a small area (over 80 species/less than 49 000 km^2); and 4) low reliability of EFI in the evaluation of Slovak streams.

Since Slovakia did not participate at the FAME Project, no data from Slovak streams have been involved into the Fish Database of European Streams (FIDES). This implied the problems with reliability of EFI in its current application and did not provide a good perspective for future potencial use of EFI in Slovakia. Therefore, the only solution was to develop a new National Method, as well a new multimetric index that would reflect the ecological status of Slovak streams better than EFI.

The development of new National Method, including the Fish Index of Slovakia, required to proceed via the following steps:

1. To revise the former typology of Slovak streams (fish communities)
2. To develop model reference fish communities for each type of stream in Slovakia (see above)

3. To revise the former ecological classification of fishes with regard to specific conditions in Slovakia
4. To select the proper metrics for calculation of FIS
5. To standardise the sampling protocol and the fish database (to comply FIS with EFI+ and intercalibration)
6. To develop a software tool for calculation of FIS
7. To calibrate FIS (setting the boundaries among the 5 classes of ecological status)

Once the steps 1-3 have been done (see Tables 1-3), one of the crucial points in the development of National Method – a proper selection of metrics for calculation of FIS – was to be done. Taking the advantage of the former experience from other European countries, and outputs from the FAME Project, the process of selection (the metrics for FIS) started with the list of metrics used for calculation of EFI (Pont et al., 2004). Each of the ten EFI metrics (see Fig 1) were assessed using the following criteria required to meet the situation in Slovakia:

1. To reduce ambiguity as much as possible
2. To consider the complexity of interactions between anthropogenic disturbances and fish communities
3. Maximum simplicity principle („Occam razor")
4. Applicability of the metrics despite the data deficiency

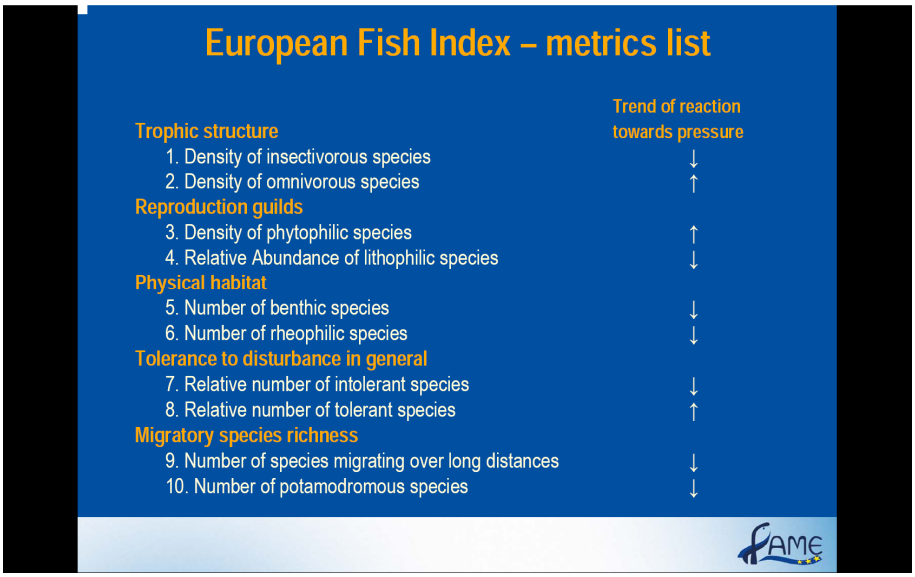


Fig. 1. *Ten metrics used for calculation of EFI (http://fame.boku.ac.at/downloads.htm).*

Therefore, based on the above criteria, the metrics *Relative number of intolerant species* and *Relative number of tolerant species* (metrics 7 and 8, respectively) were first eliminated. The main reason was the potential ambiguity of these metrics when applied at local conditions prevailing at the area not included into the FAME Project, followed by possible duplicity with some other metrics (e.g. rheophily, lithofily).

Similarly, the metric *Density of omnivorous species* (metric 2) was also eliminated from further consideration, because of its potential ambuiguity. Namely, feeding habits of a species may vary from river to river, the diet of each species undergoes changes over ontogeny of individuals, and it also may depend strongly on the prey availability.

Furthermore, the metric *Number of diadromous species* is not relevant for Slovakia any longer, as barriers had been built up in other countries, preventing migrations of diadromous species to the upper stream stretches in Slovakia.

Thus, six from the ten original EFI metrics remained for further consideration:

1. Density of insectivorous species
2. Density of phytophilous species
3. Relative abundance of lithophilous species
4. Number of benthic species
5. Number of rheophilous species
6. Number of potamodrous species

At this point, the criterion concerning the applicability of the metrics despite the data deficiency entered the process. And, because little reliable data on the density of species have been available in Slovakia, this parameter was replaced by the Relative abundance. To follow the maximum simplicity principle, the same sort of replacement was applied in the case of the metrics 4-6. Thus, the first six metrics accepted for calculation FIS became:

1. Relative abundance of insectivorous species
2. Relative abundance of phytophilous species
3. Relative abundance of lithophilous species
4. Relative abundance of benthic species
5. Relative abundance of rheophilous species
6. Relative abundance of potamodrous species

Subsequently, further three metrics were considered. The Relative abundance of piscivorous species is a parameter that provides a signal about how a fish community is balanced. The use of this parameter has a long tradition in Slovak (and/or Czechoslovak) ichthyology (e. g. Balon, 1966). Over the last decades, more and more non-native species have appeared in Slovak streams, and several of them have become invasive (Copp et al., 2005; Kováč et al. 2008). The presence of invasive species is a relevant indicator of anthropogenic disturbancies (e.g. Moyle and Light, 1996; Marchetti et al., 2004; Ribeiro et al., 2007). Finally,

in order to reflect the complexity among the anthropogenic disturbancies and the composition of fish communities, Sheldon's Index of Equitability (Fig. 2) was also considered. As a result, the final list of metrics used for calculation of FIS was completed as follows:

1. Relative abundance of insectivorous species
2. Relative abundance of phytophilous species
3. Relative abundance of lithophilous species
4. Relative abundance of benthic species
5. Relative abundance of rheophilous species
6. Relative abundance of potamodrous species
7. Relative abundance of piscivorous species
8. Relative abundance of invasive species
9. Index of Equitability

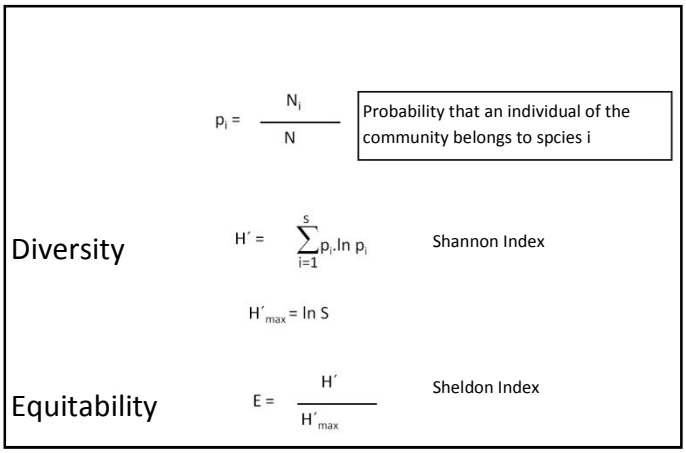


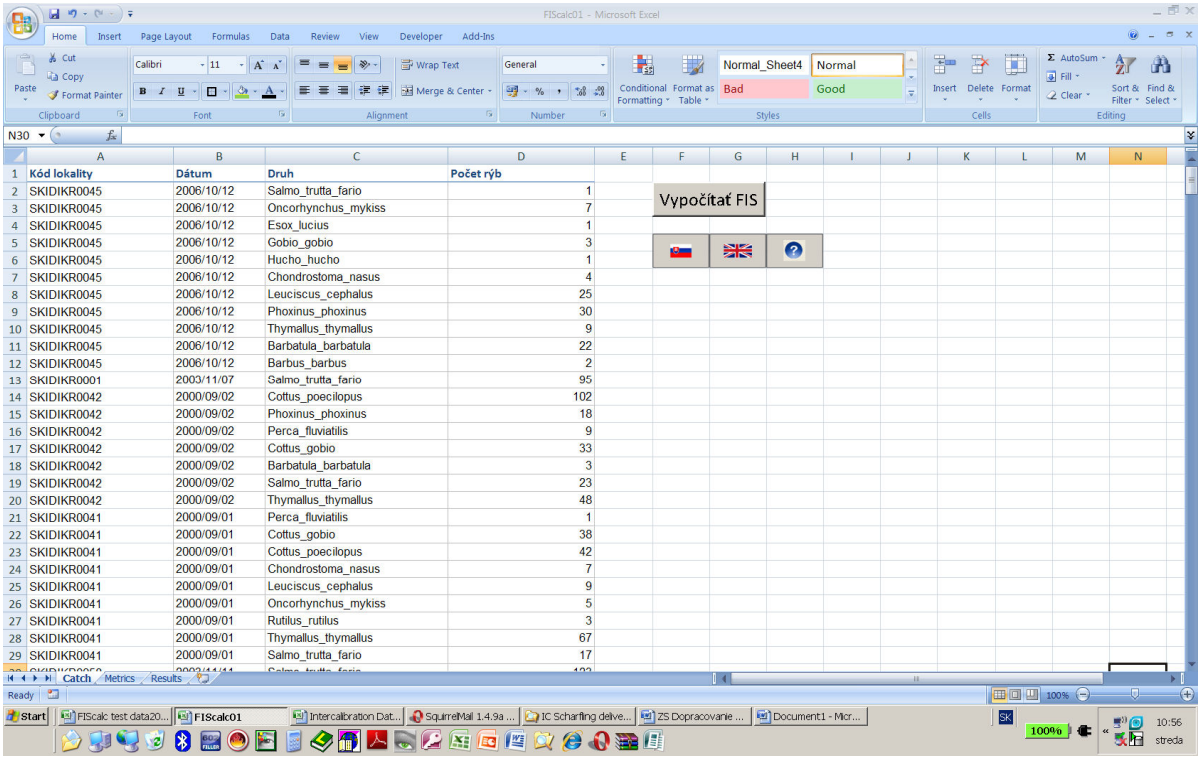
Fig.2. *Formulas for calculation the Index of Equitability.*

3. How to calculate FIS

The Fish Index of Slovakia is calculated using the software tool FIScalc that has been developed especially for this purpose. FIScalc works within the Microsoft Excel package (Fig. 3). The values of the metrics 1-8 are obtained by calculation of the Ecological Quality Ratio (EQR) that compares the values observed at the monitored site with the reference values for the appropriate stream type (see Table 2), using the formula

$$EQR = \frac{mv - la}{ha - la}$$

Where mv = metric value, la = lower anchor and ha = high anchor.



Kód lokality	Dátum	Druh	Počet rýb
SKIDIKR0045	2006/10/12	Salmo_trutta_fario	1
SKIDIKR0045	2006/10/12	Oncorhynchus_mykiss	7
SKIDIKR0045	2006/10/12	Esox_lucius	1
SKIDIKR0045	2006/10/12	Gobio_gobio	3
SKIDIKR0045	2006/10/12	Hucho_hucho	1
SKIDIKR0045	2006/10/12	Chondrostoma_nasus	4
SKIDIKR0045	2006/10/12	Leuciscus_cephalus	25
SKIDIKR0045	2006/10/12	Phoxinus_phoxinus	30
SKIDIKR0045	2006/10/12	Thymallus_thymallus	9
SKIDIKR0045	2006/10/12	Barbatula_barbatula	22
SKIDIKR0045	2006/10/12	Barbus_barbus	2
SKIDIKR0001	2003/11/07	Salmo_trutta_fario	95
SKIDIKR0042	2000/09/02	Cottus_poecilopus	102
SKIDIKR0042	2000/09/02	Phoxinus_phoxinus	18
SKIDIKR0042	2000/09/02	Perca_fluviatilis	9
SKIDIKR0042	2000/09/02	Cottus_gobio	33
SKIDIKR0042	2000/09/02	Barbatula_barbatula	3
SKIDIKR0042	2000/09/02	Salmo_trutta_fario	23
SKIDIKR0042	2000/09/02	Thymallus_thymallus	48
SKIDIKR0041	2000/09/01	Perca_fluviatilis	1
SKIDIKR0041	2000/09/01	Cottus_gobio	38
SKIDIKR0041	2000/09/01	Cottus_poecilopus	42
SKIDIKR0041	2000/09/01	Chondrostoma_nasus	7
SKIDIKR0041	2000/09/01	Leuciscus_cephalus	9
SKIDIKR0041	2000/09/01	Oncorhynchus_mykiss	5
SKIDIKR0041	2000/09/01	Rutilus_rutilus	3
SKIDIKR0041	2000/09/01	Thymallus_thymallus	67
SKIDIKR0041	2000/09/01	Salmo_trutta_fario	17

Fig. 3. *Software tool FIScalc1.1.*

Should the value of a metric (calculated as EQR) exceed 1.0 (i.e. if the observed relative density of a metric is higher than the expected value in the reference community), then such a metric enters the calculation of FIS with 1.0. This is because if the the relative density of a metric that contributes to indication of the ecological status of a fish community exceeds the expected relative density, then such a metric indicates a high status (class 1), which cannot be further improved. Therefore, the values of the metrics 1-8 always fall within the interval 0 – 1, whis is also the case of the metric 9 (Index of Equitability). Finally, the FIS is calculated as a mean value of the metrics 1-9.

4. FIS calibration (setting the boundaries among the 5 classes of ecological status)

Due to the data deficiency, for the beginning, expert judgement was applied to calibrate the boundaries among the 5 classes of ecological status based on the assessment of fish communities. At this time, high or good ecological status (class 1 and/or 2) is accepted only if the fish community achieves at least 70 % EQR of the model reference communnity, i.e. if FIS ≥ 0.7. The boundaries for the other classes of ecological quality were also proposed as an expert judgement (Fig. 4).

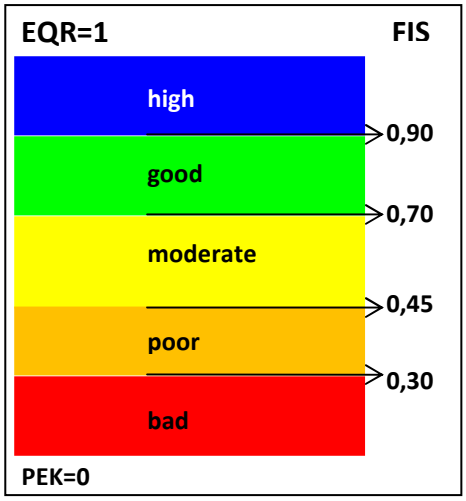


Fig. 4. *Boundaries among the 5 classes of ecological status based on the calculation of FIS.*

In 2009, approximately 200 new sites are supposed to be sampled and the current calibration of FIS will be further validated and tested, and therefore, it may be a subject of subsequent modifications.

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Karpaty	Atlantická provincia	Popradský okres	horská zóna	nad 800 m n. m	horný tok Poprad a prítoky Popradu a Dunajca nad 800 m n. m.	1
			podhorská zóna	do 800 m n. m.	stredný tok Popradu, ako aj Dunajec a ich prítoky do 800 m n. m.	2
				do 500 m n. m.	spodný tok Popradu po sútok s Valaskou vodou do 500 m n. m.	3
	Pontokaspická provincia	Hornovážsky prechodný okres	horská zóna	nad 800 m n. m.	pramene a prítoky Váhu nad 800 m n. m.	4
			podhorská zóna	do 800 m n. m.	prítoky Váhu do 800 m n. m.	5
					horný tok Váhu po sútok s Oravou	6
		Potiský okres	horská zóna	nad 400/500/600 m n. m.	Laborec, Topľa a Ondava nad 400, Slaná, Bodva a Rimava nad 500, Hornád a Torysa nad 600 m n. m., vrátane ich prítokov	7
			podhorská zóna	do 400/500/600 m n. m.	prítoky Laborca, Tople, Ondavy do 400 Slanej, Bodvy a Rimavy do 500, Hornádu a Torysy do 600 m n. m.	8
					Laborec, Topľa a Ondava do 400, Torysa a Hornád do 700 m n. m.	9
			nížinná z.	do 200 m n. m.	Hornád, Bodva, Rimava, Slaná a ich prítoky do 200 m n. m.	10
		Podunajský okres	horská zóna	nad 500/600/700 m n. m.	prítoky Váhu Nitry a Ipľa nad 500, Turca a Hronu nad 600 a Oravy nad 700 m n. m.	11
			podhorská zóna	do 500/600/700 m .n. m.	prítoky Váhu Nitry a Ipľa do 500, Turca a Hronu do 600 a Oravy do 700 m n. m.	12
					Váh od VDŽ po sútok s Oravou (r. km 430), Orava, Turiec od ústia po Antonský potok (64,6), Hron od Zvolena po Hámor (265)	13
					Váh od Klanečnice (r. km 142) po VDŽ (255), Hron od Rudna n/Hr. (113) po Zvolen (174), Ipeľ od Kalinova (159) po Ipeľský potok (187)	14
			nížinná z.	do 200 m n. m.	Ipeľ a jeho prítoky	15
Panónska panva	Pontokaspická provincia	Podunajský okres	podhorská	do 300 m n. m.	malé toky Panónskej panvy	16
			nížinná zóna	do 200 m n. m.	prítoky Dunaja, Moravy, M. Dunaja, Váhu, Nitry, Žitavy a Hronu	17
					Morava	18
					Malý Dunaj, dolný tok Váhu, Nitry, Žitavy, Hronu a Ipľa	19
					Dunaj r. km 1789,5 – 1880,2	20
					Dunaj r. km 1708,2 – 1789,5	21
		Potiský okres	nížinná zóna	v Panoniku (do cca 200 až 300 m n.	malé toky povodia Tisy v Panoniku	22
					Bodrog, Latorica, Uh, Tisa, spodný tok Laborca po Strážske (r. km 57,9), Ondavy po Ondavku (r. km 57,6) a Tople po Soľ (r. km 29)	23

Tab. 1.*Typology of streams in Slovakia (K. Hensel) for the purposes of evaluation the ecological status based on fish communities.*

	Karpaty															Panónska panva							
	Popradský okres			Hornovážsky okres			Potiský okres				Podunajský okres					Podunajský okres						Potiský okres	
species / typ toku	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Abramis ballerus										0,01							0,05	7,2	0,5	1	2	0,03	2
Abramis brama			0,1						0,05	0,1			0,1	1		0,5	2	17,2	1	11	4	1,1	9
Abramis sapa										0,01							0,1	0,18	0,5	1	2	0,05	1,5
Acipenser ruthenus																		0,01	0,5	2	0,6		0,5
Alburnoides bipunctatus		0,3	2,2				3,2	11,2	7,5	15	0,1	6	1,5	15	5	8	1,5	0,01		0,05		3,5	1,5
Alburnus alburnus		1,1	7,8			0,1	0,2	0,6	2,1	10	0,2	5	1,2	1,5	9,1	1	20	10,9	13	19,5	1,5	14	10
Aspius aspius			0,2						0,05	0,1					0,2		1	0,65	0,1	0,5	1	0,1	1
Barbatula barbatula	8	11,6	4,9	1	5,7	11,5	10	4,7	4,5	4	2,6	4	3,5	4,8	0,2	8	0,7	0,01	0,8	0,04	2,2	1,4	0,1
Barbus barbus		3,7	23			0,2	0,5	2,4	6,5	11		5	5	0,4	2,2	1,5	1	0,48	4,4	10	6	7	5
Barbus peloponnesius		13,3	21				3	23,6	25,5	12		1	0,2	0,6	2,6	0,5	0,3		0,5			0,4	4
Blicca bjoerkna									0,01	0,05		0,1	0,1	0,5	1,3	0,5	4	20,2	3	1,5	2	2,2	4
Carassius carassius									0,02	0,01					0,3		2,4	0,2	0,8	0,08	5	0,07	2
Chondrostoma nasus		5,7	14		0,1	1	2	5,4	16	20		9	30	0,8	7,7	4	2,4	0,14	9	5	4	7	3,5
Cobitis taenia							2	0,01	0,3	0,1	0,1	0,4	0,1	0,4	7	6	4,8	0,53	2,5	0,02	4	0,8	0,7
Cottus gobio	3	2,6	0,6	2	7,5	4	4	0,4	0,2		3	4	2,3	10		3,5	1,4			0,5	8		
Cottus poecilopus	38,5	5,1	0,2	84	40	11,5	12	0,02	0,2		56	8	0,1	0,2									
Cyprinus carpio									0,02	0			0,1				1,2	0,75	1	0,1	5	0,05	3
Esox lucius			0,1						0,03	0,1		0,01	6,2	1	2,9	1	2	1,73	2	0,5	0,4	0,5	3
Eudontomyzon danfordi							0,5	0,3	0,05	0												0,08	
Eudontomyzon mariae	0,5	0,5	0,5																				
Eudontomyzon vladykovi				0,1	0,1	0,3					2	4	0,1	3,8	0,05	0,1	0,05		0,1	0,5	0,4		
Gobio albipinnatus										0,1		1,2	1,5	2	3,4	0,5	5	1,16	8,5	1	5	1,5	1,5
Gobio gobio		2,3	1,5		1,5	5	0,3	3,3	2,3	2,5	0,1	6	1,5	2	13	10	8	0,03	11	0,05	0,1	5,5	2,6
Gobio kesslerii							0,2	0,3	1,2	1,4		1,1	1	1	2	0,5	0,5		1	0,01	0,05	3	1
Gobio uranoscopus							0,1	0,06	0,9	0,01		0,01	0,05	0,05						0,04		0,01	
Gymnocephalus baloni															0,1		0,1	0,03	0,1	2	2,5		0,5
Gymnocephalus cernuus						0,1			0,01	0,1		0,3	1	1	0,8	0,5	1,8	1,66	2,4	8	2,2	0,3	5
Gymnocephalus schraetser										0,01					0,1			0,01	0,5	2	3		1
Hucho hucho					0,1	0,5						0,5	0,4	0,3					0,1	0,05	0,05		
Lampetra planeri	0,5	2,7	1																				
Leucaspius delineatus																	2	0,21				0,01	0,2
Leuciscus cephalus		20	17,8		7	9	5	32,9	21,9	14	1,8	17	5	24	25	20	5,3	0,61	11,5	2	6	22	8
Leuciscus idus									0,04	0,2							0,5	1,18	1	5	2	1	0,2
Leuciscus leuciscus		0,5	1,6			0,3	0,1	0,2	0,3	1	0,1	2,3	2,4	2,7	1,5	3	0,2	0,64	0,5	1	3,9	9	1,3
Lota lota					0,1	0,2	0,5	0	0,05	0,01	0,5	0,6	1,2	0,6	0,3	2	0,2	0,3	0,2	0,5	1,7	0,5	0,1
Misgurnus fossilis										0,01							3	0,01	1	0,01	0,2	1	1,5
Pelecus cultratus																			0,5	1,5	0,2	0,01	0,5
Perca fluviatilis		0,1	0,1			0,1		0,01	0,1	0,1		1,7	0,8	0,1	0,3	2	3,1	3,9	1	5	2	0,5	3
Phoxinus phoxinus	19,5	17,8	1,4	0,6	17	38	10	9	7,3	3	21	11	1,5	13		25	0,1		0,05	0		3	
Proterorhinus marmoratus																	2	1,56	1	1,5	8		
Rhodeus sericeus								0,1	0,1	0,6		0,7	0,1	0,1	3	0,6	4,1	6,95	8	0,01	0,7	7,5	2
Rutlus pigus																			2	1	0,2		3
Rutilus rutilus		0,1	0,2		0,1	1			0,1	0,2			1	0,9	3,8	0,1	5	13,1	2,5	7	2,5	3	7
Sabanejewia balcanica							1	1	0,4	0,1		0,4	0,1	0,6	1	0,2	0,02	0,01	1	0,05	0,5		0,5
Salmo trutta fario	23	9,6	0,3	12	15	13	45	4,4	1,2		9	6	2	9			0,01			0		0,05	
Sander lucioperca			0,1						0,03	0,1		0,02	0,05	0,05			2	1,49	1	5	4	0,1	1,5
Sander volgensis														0,3	0,05		0,01	0,01	0,5	1	2		0,5
Scardinius erythrophthalmus			0,1						0,01	1,5							2	5,41	1	1,6	3	1	4
Silurus glanis										0,5				0,5	4		2	1,31	1	1	1		1
Tinca tinca									0,05	0,01		0,01	0,3	0,3	0,2	1	1	0,25	0,2	0,05	0,1	0,7	1
Thymallus thymallus	7	3	1	0,3	5,8	4	0,2	0,05	0,2		3,5	4	28										
Umbra krameri																	5,5		0,05			2	1
Vimba vimba			0,3			0,2		0,03	0,5	1		0,6	1	0,5	0,4		1,7	0,01	1	0,2	0,2	0,05	0,3
Zingel streber							0,2	0,01	0,2	0,9		0,05	0,5	0,7	1,5			0,01	1	0,1	0,6		0,3
Zingel zingel								0,01	0,1	0,2			0,1	0,3	1			0,05	0,7	0,05	0,2		0,7

Tab. 2. *Model reference communities for the 23 stream types in Slovakia (K. Hensel).*

	Ekologická charakteristika							
Druh	Bentický	Reofilný	Litofilný	Fytofilný	Insektivorný	Piscivorný	Potamodromný	Inváz ny
Abramis ballerus	0	1	1	0	0	0	0	0
Abramis brama	1	0	0	0	0	0	1	0
Abramis sapa	1	1	1	0	0	0	0	0
Acipenser ruthenus	1	1	0	0	0	0	1	0
Alburnoides bipunctatus	0	1	1	0	1	0	0	0
Alburnus alburnus	0	0	0	0	0	0	0	0
Ameiurus melas	1	0	1	0	0	0	0	1
Ameiurus nebulosus	1	0	0	1	0	0	0	0
Anguilla anguilla	1	0	0	0	0	0	0	0
Aspius aspius	0	0	1	0	0	1	1	0
Barbatula barbatula	1	1	1	0	0	0	0	0
Barbus barbus	1	1	1	0	0	0	1	0
Barbus peloponnesius	1	1	1	0	0	0	0	0
Blicca bjoerkna	1	0	0	0	0	0	0	0
Carassius auratus	1	0	0	1	0	0	0	0
Carassius carassius	1	0	0	1	0	0	0	0
Chondrostoma nasus	1	1	1	0	0	0	1	0
Cobitis taenia	1	0	0	1	0	0	0	0
Cottus gobio	1	1	1	0	1	0	0	0
Cottus poecilopus	1	1	1	0	1	0	0	0
Ctenopharyngodon idella	0	0	0	0	0	0	0	0
Cyprinus carpio	1	0	0	1	0	0	0	0
Esox lucius	0	0	0	1	0	1	0	0
Eudontomyzon danfordi	0	0	0	0	0	0	0	0
Eudontomyzon mariae	1	1	1	0	0	0	1	0
Eudontomyzon vladykovi	0	0	0	0	0	0	0	0
Gasterosteus aculeatus	0	0	0	0	0	0	0	1
Gobio albipinnatus	1	1	1	0	0	0	0	0
Gobio gobio	1	1	0	0	0	0	0	0
Gobio kesslerii	1	1	1	0	0	0	0	0
Gobio uranoscopus	1	1	1	0	0	0	0	0
Gymnocephalus baloni	1	1	0	0	0	0	0	0
Gymnocephalus cernuus	1	0	0	0	0	0	0	0
Gymnocephalus schraetser	1	1	1	0	0	0	0	0
Hucho hucho	0	1	1	0	0	1	1	0
Hypophthalmichthys molitrix	0	0	0	0	0	0	0	0
Lampetra planeri	1	1	1	0	0	0	1	0
Lepomis gibbosus	0	0	0	0	1	0	0	1
Leucaspius delineatus	0	0	0	1	0	0	0	0
Leuciscus cephalus	0	1	1	0	0	0	1	0
Leuciscus idus	0	1	0	0	0	0	1	0
Leuciscus leuciscus	0	1	1	0	0	0	0	0
Lota lota	1	0	1	0	0	0	1	0
Micropterus salmoides	0	0	0	1	0	0	0	0
Misgurnus fossilis	1	0	0	1	0	0	0	0
Neogobius fluviatilis	1	0	1	0	0	0	0	1
Neogobius gymnotrachelus	1	0	0	0	0	0	0	1
Neogobius kessleri	1	0	1	0	0	0	0	1
Neogobius melanostomus	0	0	0	0	0	0	0	1
Oncorhynchus mykiss	0	0	0	0	0	0	0	0
Pelecus cultratus	0	0	0	0	0	0	1	0
Perca fluviatilis	0	0	0	0	0	0	0	0
Perccottus glenii	0	0	0	0	0	0	0	1
Phoxinus phoxinus	0	1	1	0	0	0	0	0
Proterorhinus marmoratus	1	0	1	0	0	0	0	0
Pseudorasbora parva	0	0	0	0	0	0	0	1
Rhodeus sericeus	0	0	0	0	0	0	0	0
Rutilus meidingeri	0	0	0	0	0	0	0	0
Rutilus pigus	1	1	0	0	0	0	0	0
Rutilus rutilus	0	0	0	0	0	0	0	0
Sabanejewia balcanica	1	1	0	1	0	0	0	0
Salmo trutta fario	0	1	1	0	1	0	0	0
Salvelinus fontinalis	0	1	1	0	1	0	0	0
Sander lucioperca	0	0	0	0	0	1	0	0
Sander volgensis	1	0	0	0	0	0	0	0
Scardinius erythrophthalmus	0	0	0	1	0	0	0	0
Silurus glanis	1	0	0	1	0	1	0	0
Thymallus thymallus	0	1	1	0	1	0	1	0
Tinca tinca	1	0	0	1	0	0	0	0
Umbra krameri	1	0	0	1	0	0	0	0
Vimba vimba	1	1	1	0	0	0	1	0
Zingel streber	1	1	1	0	0	0	0	0
Zingel zingel	1	1	1	0	0	0	0	0

Tab. 3. *Ecological characteristics of fishes used for calculation of metrics from the Fish Index of Slovakia (V. Kováč, V. Mužík, I. Stráňai and J. Koščo).*