Testing some European fish-based assessment systems using Slovenian fish data from the Ecoregion Alps

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Abstract. The European Fish Index (EFI), the Fish Index Austria (FIA) and the German fish-based assessment system (FiBS) were tested using Slovenian fish data. Fish were sampled using electric fishing procedure in small and medium sized rivers of the Danube river basin in the Ecoregion Alps. To test the appropriateness of selected indices, correlations between hydromorphological alteration pressure and fish indices were calculated. Hydromorphological alteration pressure was defined using seven Slovenian hydromorphological quality classes. Correlations were positive and statistically significant in all cases but the coefficient of determination (R^2) was very low, not exceeding 0.15. The highest R^2 was calculated using FIA without the biomass knockout criterion. Possible reasons for the low R^2 values including criteria for the hydromorphological alteration classes, fishery management influence and tested fish indices, are discussed. In addition, appropriateness of the inclusion of allochthonous fish species in the fish-based assessment systems is discussed.

Keywords: EFI, Water Framework Directive, hydromorphology, allochthonous species, ecological status, Alps, rivers

Izvleček. TESTIRANJE NEKATERIH EVROPSKIH METOD VREDNOTENJA EKOLOŠKEGA STANJA NA PODLAGI RIB S SLOVENSKIMI PODATKI – S slovenskimi podatki smo testirali Evropski ribji indeks (EFI), Ribji index Avstrija (FIA) in Nemški sistem vrednotenja na podlagi rib (FiBS). Ribe smo vzorčili z elektriko v malih in srednje velikih rekah donavskega porečja ekoregije Alpe. Za preverjanje primernosti izbranih indeksov smo izračunali soodvisnost med razredi hidromorfološke spremenjenosti rek in ribjimi indeksi. Pozitivno in statistično značilno soodvisnost smo ugotovili v vseh primerih, vendar je bil koeficient determinacije (R^2) nizek in v nobenem primeru ni presegal 0,15. Najvišji R^2 je bil izračunan, ko smo uporabili FIA brez izključitvenega sokriterija. Razpravljamo o možnih vzrokih za nizke vrednosti R^2, vključno s kriteriji za razrede hidromorfološke spremenjenosti rek, ribiškim upravljanjem in testiranimi indeksi ter o primernosti upoštevanja tujerodnih vrst v sistemih vrednotenja ekološkega stanja.

Ključne besede: EFI, Vodna direktiva, hidromorfologija, tujerodne vrste, ekološko stanje, Alpe, reke

Introduction

Implementation of the European Union Water Framework Directive (Directive, 2000/60/EC) as the standard framework for water management within the European Union requires ecological assessment and interpretation of the ecological status of rivers using four key biological quality elements. Besides phytoplankton, phytobenthos and macrophytes and benthic invertebrates, a fish-based assessment system should be used as well. Fish are good indicators of ecological niches and operate over a variety of spatial scales (Simon 1999). They have been used to develop community based indices that integrate a number of measures of functional community structure, linking the ecological functions and requirements of different species to the impacts of human pressures on the structure and function of aquatic ecosystems (Noble et al. 2007). Karr (1981) developed the first fish-based method called Index of Biotic Integrity (IBI) to assess human-induced impact on aquatic ecosystems for streams in the mid-western USA. In the past years, the IBI has been modified mostly on the national and regional scales and in some cases on the continental scale. In the Alpine region, France developed »French Fish based Index« (FBI) (Oberdorff et al. 2002), Germany »German fish-based assessment system« (FiBS) (Dussling et al. 2004), Austria »Fish Index Austria« (FIA) (Haunschmid et al. 2006), while for Europe, FAME consortium developed the »European fish index« (EFI) (Pont et al. 2007). In Slovenia, no national fish-based assessment system has so far been developed. In 2006-2007, however, Slovenia participated in the first phase of the intercalibration process of the national boundary values of fish-based assessment systems (Jepsen & Pont 2007). The process has now reached the second phase. In order to fulfil the demands of the WFD, a fish-based assessment method for the ecological status of rivers will be developed and used in Slovenia as well. The main aim of the present article is to test the European Fish Index, the Fish Index Austria, and the »Fischbasiertes Bewertung System« using Slovenian fish data and to evaluate the suitability of using these assessment systems in Slovenia.

Methods

In 2006, 35 samples were collected in rivers of the Inland water Ecoregion Alps according to Urbanič (2008a). The sampling sites were selected in three bioregions (Carbonate Alps – Danube river basin, Silicate Alps, Pre-Alpine hills – Danube river basin) of the Danube River

basin (Urbanič 2008b), covering small (catchment area 10-100 km^2) and medium-sized (catchment area 100-1.000 km^2) rivers and four Fish zones according to Haunschmid et al. (2006) (Fig. 1). All the samplings were conducted using standardised electric fishing procedures (EN 14011, CEN 2003, Podgornik 2006) by wading 100 m river section during low flow periods. Two-pass catches were performed at all the sites. However, only single-pass catch data were used for the calculation of the European Fish Index (EFI), as requested by the Fame consortium (2004), whereas for Fish Index Austria (FIA) and the German fish-based assessment system (FiBS) data from both catches were used and population estimates for each species at each site were calculated using the Seber Lecren method (Seber & Lecren 1967). All indices were calculated using only autochtonous fish species of the river catchment. Calculations of the EFI, the FIA and the FiBS were performed using an EFI software provided by the FAME consortium (2004), and excel files Fish_Index_Austria_engl.v3.xls and fiBS10 7.4_engl.xls provided for the intercalibration process (Jepsen & Pont 2007), respectively. Besides normalised metrics composing multimetric index, the FIA requires also knockout-criteria (co-criteria), which are defined using fish region index and fish biomass (Haunschmid et al. 2006). In our opinion, the defined biomass knockout values are not always appropriate for Slovenian conditions. Therefore, new (lower) knockout values were defined for some river types (e.g. periodical rivers). In addition to the original FIA, where both co-criteria were used, a modified FIA version was also calculated without using the biomass co-criterium. Altogether, four different index values were calculated for each site: EFI, FIA, FIA without biomass co-criterion and FiBS (Tab. 1). To test the appropriateness of each of the four indices for Slovenian conditions, a coefficient of determination (R^2) was calculated, and a linear regression curve was defined between each of the calculated indices and the hydromorphological (HM) pressure gradient. A VGI (2002) hydromorphological classification of rivers was used as HM pressure, where class 1 represent pristine sites and class 7 hydromorphologicaly severely altered sites. HM pressure was selected, considering that in the Slovenian Ecoregion Alps hydromophological alterations are the dominant pressure (IzVRS, unpublished). As some assumptions (normal distribution, only one source of random variation affecting the variables) have to be made to use a linear regression, which are not valid in our data, correlations were also calculated using Spearman rank correlation coefficient. In addition, the effect of the fish stocking was evaluated. Correlation coefficients between HM pressure and fish indices and pairs of fish indices were calculated using only data from the sites, which were not impacted by stocking. In the latter case, data from 27 sites were used.
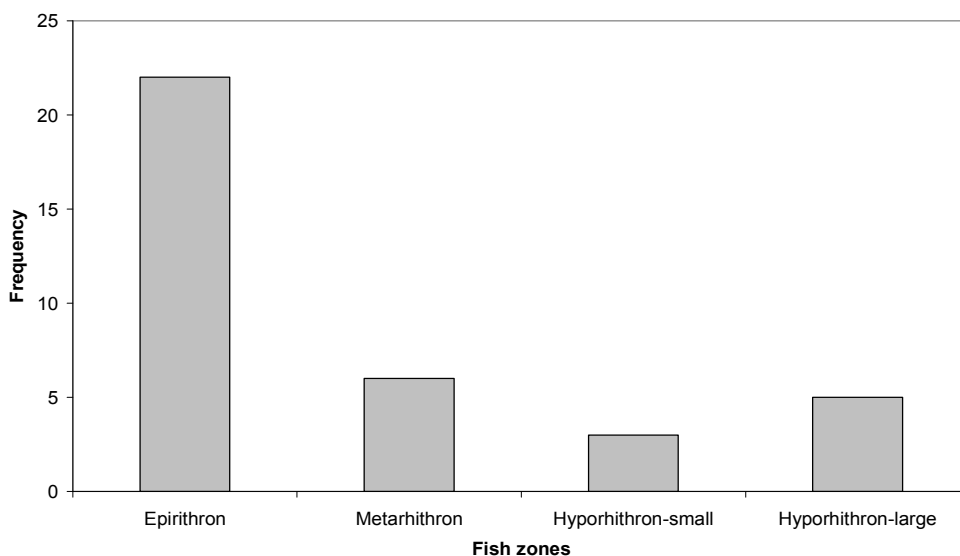
Figure 1. Frequency distribution of sampling sites among Fish Zones.
Slika 1. Frekvenčna razporeditev vzorčnih mest po ribjih pasovih.

Table 1. Main characteristics of tested fish indexes.
Tabela 1. Glavne značilnosti testiranih ribjih indeksov.

Index	No. metrics	Metrics group	Co-criteria metrics	Score range
European Fish Index (EFI)	10	Trophic level, Reproductivity strategy, Physical habitat, General tolerance, Migratory behaviour		0-1
Fish Index Austria (FIA)	9	Trophic level, Dominance, Physical habitat, Reproduction guilds, Length frequency distribution of dominant and subdominant species	Fish biomass, Fish region index (co-criterion in special cases)	1-5
German fish-based assessment system (FiBS)	6 or 9 multimetrics (number of metrics depends on the river type)	Inventory of species and guilds, Abundance, Age structure, Migration, Fish region, Dominant species		5-1

Results

In all cases, statistically significant relationships were observed between hydromorphological pressure data and the calculated versions of fish indices. Correlations between selected fish indices were statistically significant, but differ considerably (Tab. 2a). High correlation between FIA and FIA_noCO is the result of the fact that only few sites were classified differently in the case of using co-criterion. Moderate correlations were observed between FIA (both versions) and FIBS, and also between EFI and FIBS, whereas correlations between EFI and FIA (both versions) were low. However, coefficients of determination (R^2) are low in all three cases. The highest R^2 value was calculated for FIA when co-criteria were not used, but the R^2 was only 0.14. When co-criteria were used, R^2 was slightly lower. Similar R^2 was observed for FIBS, whereas for the European fish index, R^2 was the lowest and did not exceed 0.1 (Figs. 2-5). Spearman rank correlations showed similar results. Correlations between HM class and fish indices were statisticaly significant but Spearman's rho values were low and varied between 0.37 (HM class-EFI) and 0.43 (HM class-FIA_noCO). On the other hand, correlations between pairs of fish indices were low (Spearman's rho <0.4) between EFI and FIA (also FIA_noCO), modest (Spearman's rho<|0.7|) between EFI and FIBS and FIA_noCO and FIBS, and high (Spearman's rho>|0.7|) among FIA and FIBS and FIA and FIA_noCO. When the sites with fish stocking impact were excluded from the calculation of the correlation coefficients between HM class and fish indices, Spearman's rho values were slightly higher (Tab. 2b). The highest increase in the Spearman's rho was observed among HM class and EFI, which proved to have same correlation coefficient as was recorded between HM class and FIA with a value of 0.47. Moreover, correlations between pairs of fish indices were similar as when all data were used, but modest correlation was observed between FIA and FIBS and high between FIA_noCO and FIBS.

Table 2. Spearman rank correlations between hydromorphological (HM) classes, European Fish Index (EFI), Fish Index Austria (FIA), Fish Index Austria without biomass co-criterion (FIA_noCO) and German fish-based assessment system (FiBS), and level of statistical significance (*- P<0.05, **- P<0.01); a) all sites (N=35) and b) sites without fish stocking influence (N=27).

Tabela 2. Spearmanovi korelacijski koeficienti med hidromorfološkimi (HM) razredi, Evropskim ribjim indeksom (EFI), Ribjim indeksom Avstrija (FIA), Ribjim indeksom Avstrija brez sokriterija biomase (FIA_noCO), in Nemškim sistemom vrednotenja na podlagi rib (FiBS) ter stopnja statistične značilnosti (*- P<0,05, **- P<0,01); a) vsa vzorčna mesta (N=35), b) vzorčna mesta brez vpliva vlaganja rib (N=27).

a)

Index	HM_class	EFI	FIA	FIA_noCO
EFI	0.367*			
FIA	0.406*	0.373*		
FIA_noCO	0.425**	0.333*	0.939**	
FIBS	-0.403*	-0.561**	-0.720**	-0.590**

b)

Index	HM_class	EFI	FIA	FIA_noCO
EFI	0.469**			
FIA	0.474**	0.344*		
FIA_noCO	0.459**	0.379*	0.942**	
FIBS	-0.422*	-0.643**	-0.567**	-0.702**

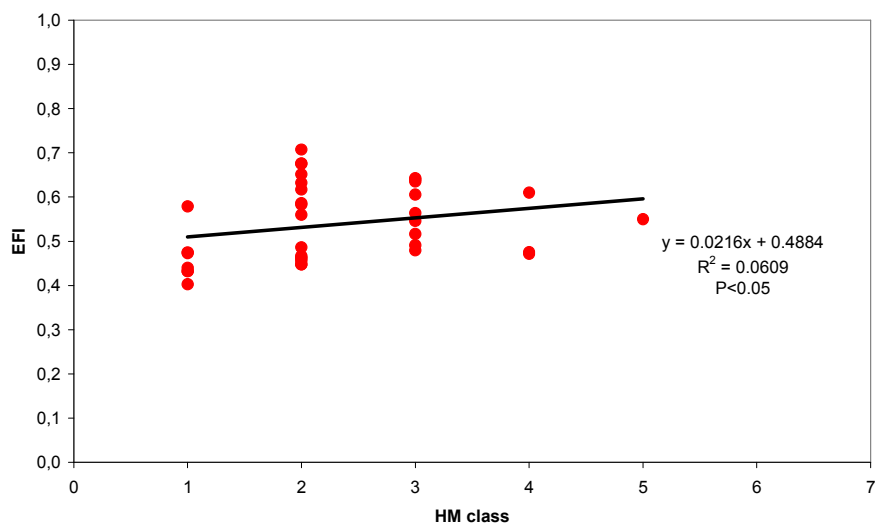$$y = 0.0216x + 0.4884$$
$$R^2 = 0.0609$$
$$P<0.05$$

Figure 2. Relationship between hydromorphological (HM) class and European Fish Index (EFI).
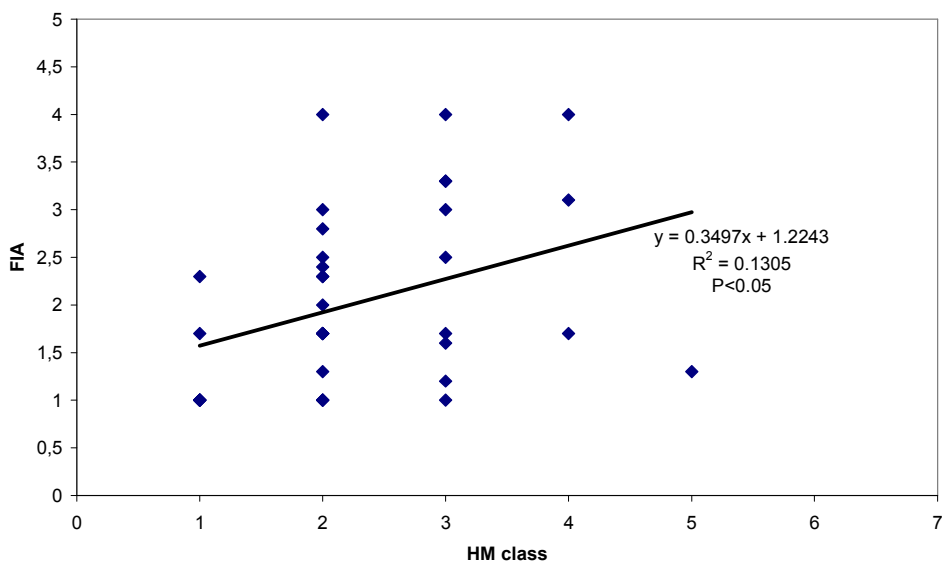**Slika 2.** Odnos med hidromorfološkimi (HM) razredi in Evropskim ribjim indeksom (EFI).

Figure 3. Relationship between hydromorphological (HM) classes and Fish Index Austria (FIA).
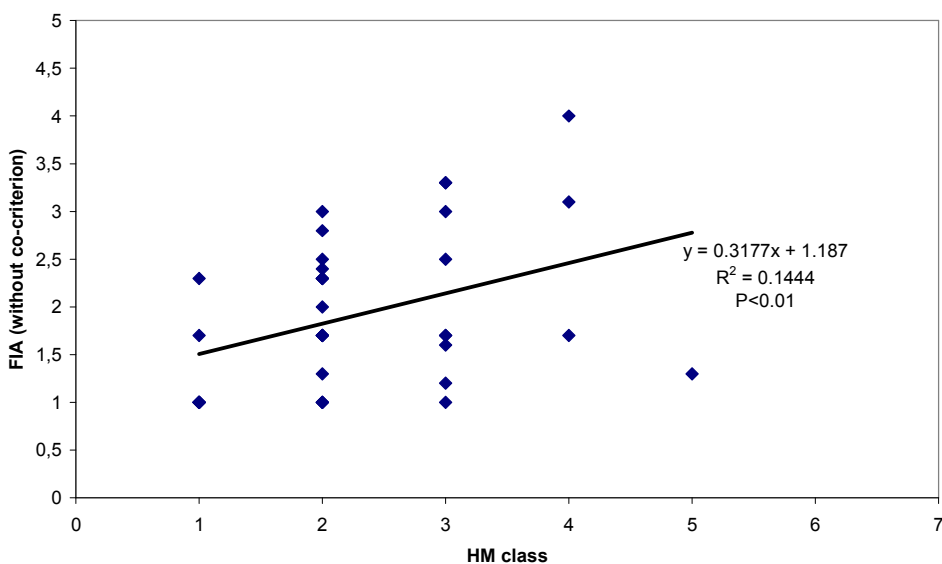**Slika 3.** Odnos med hidromorfološkimi (HM) razredi in Ribjim indeksom Avstrija (FIA).

Figure 4. Relationship between hydromorphological (HM) classes and Fish Index Austria (FIA) without using biomass co-criterium.
Slika 4. Odnos med hidromorfološkimi (HM) razredi in Ribjim indeksom Avstrija (FIA) brez upoštevanja sokriterija biomase.
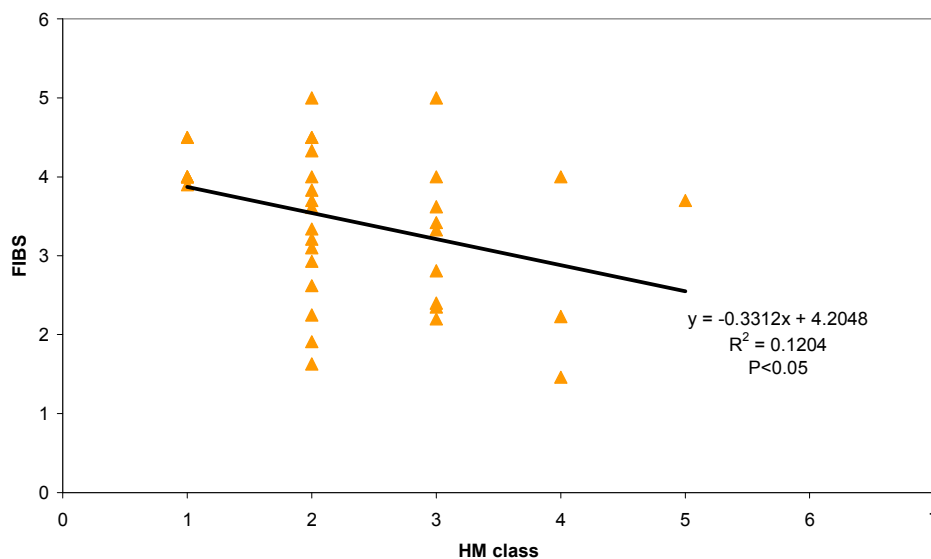
Figure 5. Relationship between hydromorphological (HM) classes and German fish-based assessment system (FiBS).
Slika 5. Odnos med hidromorfološkimi (HM) razredi in Nemškim sistemom vrednotenja na podlagi rib (FiBS).

Discussion

Fish indices

The European Fish Index (EFI) was developed to support the European Union member states in fulfilling the demands of the Water Framework Directive. Although different pressures were considered at the index building, the EFI response to physical pressure is significant but weaker (Pont et al. 2007). Our results (Tab. 1) support this statement. Although the correlation between the hydromorphological pressure gradient and the EFI was positive and statistically significant, the coefficient of determination was very low (R^2=0.06, P<0.05). On the other hand, the Fish Index Austria (FIA) and German fish-based assessment system (FiBS) were developed mainly to assess the impact of hydromorphological alterations on fish assemblages (Dussling et al. 2004, Haunschmid et al. 2006). Especially in the Alps, hydromorphology is the prevailing pressure. Our results of the statistical analyses show that the FIA and FiBS respond better to HM alterations in comparison to the EFI. Besides the positive and statistically significant (P<0.05) correlation between the hydromorphological

gradient and the FIA, also the coefficient of determination was higher. However, R^2 values were still low (R^2=0.13 and R^2=0.12, P<0.05). When we removed the effect of the co-criteria in the FIA, the statistical significance was higher but the coefficient of determination was only slightly higher (R^2=0.14, P<0.01). A reason for the low explanatory power of the FIA and the FiBS might be in the defined hydromorphological classes. VGI (2002) evaluate HM alterations mainly according to the changes in the structure of the river and less considering the effect of the alterations on the fish assemblages. Moreover, the field work was done in the 1990s and 15 years later there might be structural changes at some of the sites. The second influence could be due to fishery management. Some sites were selected on the river sections where active fishery management is present (Bertok et al. 2003). However, when data from stocked sites were excluded prior the calculation of the correlation coefficients, no substantial increase in the correlation between HM class and fish indices was observed, although Spearman's rho between HM class and EFI increased more than 0.1. The impact of stocked sites on correlation coefficient was observed also when fish indices were correlated. Correlation between FIA and FIBS was lower than when all data were used but higher between FIA_noCO and FIBS. The fish stocking affects the fish communities but the influence on the results of the fish-based assessment systems depends on the fish index. Therefore, at such sites, it might not be suitable to assess ecological quality of the water body due to the fact that fish assemblages do not reflect only ecological conditions but are in many cases mainly a result of the fishery management impact. A relatively low explanation power lies also in the tested indices. For some river types we already found that the biomass co-criterion defined in the FIA is not appropriate. We ascertained that type specific biomass co-criterion works better. Therefore, new values were applied in some cases. However, information was not available for all river types. In the river sections where only one species is present – usually brown trout (epirhithron zone), only age structure and the biomass co-criterion in the FIA might influence the result. But we have found that at hydromorphologically altered sites these criteria are usually not sufficient. Therefore in these river sections the FIA and FiBS might not reflect the actual ecological situation. In our study, more than 50% of sites belonged to the epirithral zone (Fig. 1). However, not all the epirhithral sites were represented with only one species. According to the results of the relationships between tested fish indices and the hydromorphological pressure it would be necessary to develop new fish index using Slovenian pressure and fish data or at least modify one of the indices that were tested and performed well. Nevertheless, as none of the tested indices includes fish species endemic to the Adriatic river basin substantial changes should be made at least for some Slovenian rivers. In addition to this for some river types (e.g. karst rivers) new reference conditions and dose-response relationships should be established.

Allochthonous species

In the Alpine region many rivers are stocked with rainbow trout (*Oncorhynchus mykiss*). Moreover, in some river sections, the rainbow trout reproduces naturally. The opinions on the suitability of using allochthonous species in the assessment systems differ. In the German fish index (FiBS) (Dussling et al. 2004), rainbow trout is treated equally as autochthonous species. In the Austrian FIA, rainbow trout is included in the computation of the index as far as biomass is concerned (Haunschmid et al. 2006, Jepsen & Pont 2007). Also in our study, the rainbow trout was a common or even dominant species at many sampling sites. In the river sections where rainbow trouts naturally reproduce, they might be used for the assessment of the hydromorphological pressure, and also other abiotic pressures. But as ecological status of a water body should be assessed as a deviation from the natural or the so-called reference conditions (Directive 2000/60/EC), allochthonous species can not be regarded equally as autochthonous fish species, since they represent a deviation in the structure of the ecosystem from the reference conditions. Therefore, allochthonous species will not be used as indistinguishable from the native fish species in assessment of the ecological status in Slovenia.

Povzetek

Države članice Evropske unije so obvezane vrednotiti ekološko stanje površinskih voda v skladu z Vodno direktivo. Eden od bioloških elementov za vrednotenje ekološkega stanja so tudi ribe. V Evropi je bilo razvitih že več ribjih indeksov, ki omogočajo vrednotenje ekološkega stanja v skladu z Vodno direktivo. Namen te raziskave je testirati ustreznost nekaterih ribjih indeksov za slovenske razmere. Testirali smo tri ribje indekse: Evropski ribji indeks (EFI), ki je bil razvit na podlagi podatkov iz velikega dela Evrope, Ribji indeks Avstrija (FIA) in Nemški sistem vrednotenja na podlagi rib (FiBS). FIA smo izračunali tudi brez upoštevanja dodatnega izključitvenega kriterija. Ribe smo vzorčili na 35 vzorčnih mestih v majhnih in srednje velikih rekah donavskega porečja ekoregije Alpe, ki smo jih uvrstili v 4 ribje pasove. Izlov rib smo opravili z metodo elektro ribolova. S pridobljenimi podatki smo za vsako vzorčno mesto izračunali vrednosti indeksov. Za preverjanje primernosti izbranih indeksov smo izračunali soodvisnost med razredi hidromorfološke spremenjenosti rek in ribjimi indeksi. Podatke o razredu hidromorfološke spremenjenosti vzorčnih mest smo povzeli po nacionalni hidromorfološki klasifikaciji. Za vse biotske indekse smo ugotovili soodvisnost z visoko stopnjo statistične značilnosti, vendar je bil koeficient determinacije (R^2) v vseh primerih nizek. Najvišji R^2 (ca. 0,15) je bil izračunan, ko smo uporabili FIA brez izključitvenega sokriterija. Možni razlogi za nizko soodvisnost so lahko v uporabljeni hidromorfološki klasifikaciji, ki v nekaterih primerih ne ustreza povsem trenutnim razmeram. Pomembnejši vzrok je ribiško upravljanje. Z

vlaganjem rib v reke prisotna združba rib na teh mestih ni več odraz obremenitve, ampak predvsem vpliva upravljanja. Na takih odsekih uporaba ribjih indeksov ni primerna. Obravnavana je tudi primernost upoštevanja tujerodnih vrst v sistemih vrednotenja ekološkega stanja. V testiranih sistemih vrednotenja so tujerodne vrste obravnavane enako kot avtohtone vrste, ali pa so upoštevane le pri izračunu nekaterih metrik. V sistemu vrednotenja, ki ga razvijamo v Sloveniji, tujerodne vrste pri vrednotenju ekološkega stanja ne bodo obravnavane enakovredno avtohtonim vrstam.

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