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Integrated Assessment of the Status of Fish Fauna Reproduction Areas (Integrated IcRH Index)

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Abstract. Fish fauna reproduction areas (FRA) are natural habitats that ensure sustainable reproduction of fish species populations. In order to preserve them from anthropogenic pressures, it is necessary to monitor the integrity of both biotic and abiotic environmental components. In the monitoring studies carried out in September-November 2020, a pilot approach was applied for integrated assessment of the suitability of streams within the catchments of the Iskar and Vit rivers as FRAs. The studies were performed, adopting the following basic principles for integrated assessment: 1) Applying an ecosystem approach by identifying two main ecosystem components in assessing the status of the FRAs (Biotic Component (1) "Ichthyocenose" (Ic) including 6 criteria for the main biotic metrics; Abiotic Component (2) "Reproduction habitat" (HR) including 5 criteria for the basic hydromorphological and physicochemical quality metrics). 2) Equal weight of the two components in the integrated assessment of the state of the potential FRAs; 3) Application of standardized methodologies and available data in the estimation of the two components and the calculation of the integrated IcRH index. The development of the integrated approach was carried out with data from the river type R 2 Mountain rivers in Ecoregion 12 Pontic province. Its application for assessment to other types of aquatic ecosystems needs to be validated with additional monitoring data. The integrated approach was developed and tested for the river type R 2 Mountain rivers in Ecoregion 12 Pontic province. Its application for other types of surface waters (rivers and lakes) will be further validated with additional data.

Key words: integrated assessment, fish fauna reproduction areas, freshwater protected areas, IcRH Index.

Introduction

FRAs are natural habitats that provide appropriate conditions for the sustainable reproduction of the native fish species. In order to preserve them from anthropogenic pressures, it is necessary to monitor the integrity of both biotic and abiotic environmental components, which provide suitable conditions for reproduction of fish. A detailed literature review on research of the water protected areas (Lowry & Lainsley, 2020) found that the emphasis is on marine protected areas, for which a variety of assessment methods are applied, which is not the case for freshwater protected areas.

A complex of factors, such as: climate change (Orr et al., 2015) human activities

(Vorosmarty et al., 2010), and non-native species (Rahel & Olden, 2008), can compromise the ability of native fish species to reproduce and / or to realize spawning migrations. In order to implement measures for maintaining, conservation or restoration of aquatic ecosystems, should initially be evaluated their ecological status. The approach for condition assessment of surface water bodies using an index of biological integrity (IBI), based on fish community, was developed (Karr, 1981) and then applied to numerous water bodies, after regional modifications of the multi-metric model. Most of developed indices include a complex of population and coenotic metrics of the fish community, as well as some environmental parameters, but not the conservation status. According to WFD, species should be classified in guilds and therefore "sensitive species" and "intolerant species" are the guilds, which better correspond to the higher conservation status.

Specific conservation zones for fish have been established first in marine habitats. In parallel, certain studies have been carried out to develop tools for freshwater biodiversity conservation (Moilanen et al., 2008), and various methods and strategies have been proposed in this area (Suski & Cooke, 2007).

Other studies are focused on the restoration of given spawning habitats, but based on environmental factors only, such as the spawning substrate (Taylor et al., 2019).

In Bulgaria the legislation concerning the protection of water has determined water protection areas transposing requirements of Annex IV of Water Framework Directive 2000/60/EC (Art. 119a, (1), 1-4 of the Bulgarian Water Law, URL 3) According the Approach for defining / updating water protection areas and their environmental objectives (2016) adopted in the period of 2nd Bulgarian

River Basin Management Plans (BG RBMPs 2016 - 2021) the achievement of good quality of surface water bodies identifies with areas designated for the protection of economically significant aquatic species.

Currently, this kind of protected areas are mainly delimited based on presence-absence species data and expert knowledge. Environmental parameters and the overall condition of fish communities are in general overlooked by the existing regulations for the purpose, although the biological condition is largely depending on the quality of the physical habitat features, forming the template within which biological communities develop (Southwood, 1977). This defines habitat assessment as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour et al., 1996).

The aim of the present study was to develop a multimetric algorithm for the recognition of critical for the fish fauna reproduction river sections, which integrates assessments of both fish community and habitat parameters, in order to update the boundaries of existing areas and designate new ones for protection of fish species according to the Bulgarian Water Law (1999).

Material and Methods

The application of an integrated approach for assessment of biological communities and physical habitats was performed in 23 river monitoring sites, 12 in the Iskar river basin (Fig. 1) and 11 in the Vit river basin (Fig. 2), identified in 10 FRAs according to the second RBMP and 2 new river sections. Most of the monitoring sites are situated on the territory of BG river type R 2 Mountain rivers in Ecoregion 12 and selected for the implementation of the following tasks:
- To ensure validation of the designated areas for the protection

of economically significant aquatic species in the RBMP of DBD (2016 - 2021);

- To perform monitoring and status assessment of the selected river sites with fish populations under protection included in the orders of the Ministry of Agriculture, Food and Forestry according art. 3 & art. 30 of BG Law on Fisheries and Aquaculture in the period 2015 - 2020 (2001);

- To propose additional river sections for the designation of FRAs based on the WFD and NATURA 2000 monitoring data and the performed integrated assessment.

The studies were performed, adopting the following basic principles for integrated assessment:

1) The integrated assessment is based on the definition of an ecosystem (Odum, 1971) and corresponds to the ecosystem approach (Shepherd, 2004) identifying two main components in assessing the status of the FRAs:

- Biotic Component (1) "Ichthyocenosis" (Ic) included 6 criteria for the main biological metrics with an emphasis on fish fauna;

- Abiotic Component (2) "Reproduction habitat" (RH) included 5 criteria for the basic hydromorphological and physicochemical quality metrics.

2) The two components have equal weight in the integrated assessment of the status of the FRAs, assuming that the maximum (reference) number of points for High status =100 points divided equally for the two components ($Ic_{max} = RH_{max} = 50$ points);

3) Application of standardized methodologies and available public data for the estimation of the two components and the calculation of the integrated IcRH index.

Following these principles, 6 criteria for evaluation of the component Ic (Table 1) and 5 criteria for evaluation of the component RH (Table 2) were defined. The classification scale for assessment of the status of FRA was unified with 5 degrees ecological status scale in Annex V of WFD. The maximum number of points for all criteria is determined when the monitoring data confirms reference conditions (without deviation of the natural conditions) or close to them according to the adopted methodologies. The number of points for each criterion is distributed proportionally between the 5 levels as in normalized rating scales.

The calculation of the Index for assessment of ichthyocenosis reproduction habitats (Index IcRH) is performed using the following mathematical relation:

$$\text{Index IcRH} = \sum \text{Ic } 1 - 6 + \sum \text{RH } 1 - 5, \text{ value range: } 6 - 100$$

$$\text{EQR IcRH: } (\sum \text{Ic } 1 - 6 + \sum \text{RH } 1 - 5) / 100, \text{ value range: } 0{,}06 - 1{,}00$$

Classification scale for assessment of the status of FRA (Index IcRH) is presented in Table 3.

The ratio of the two components in the Index for assessment of ichthyocenosis reproduction habitats determines the Coefficient of ichthyocenosis & reproduction habitats Integrity–CoIn of the FRA:

$$\text{CoIn} = \sum \text{Ic } 1 - 6 / \sum \text{RH } 1 - 5$$

The coefficient shows the degree of integrity between the ichthyocenosis and its habitat and its value varies in the following range (Table 4).

Fig. 1. Map of the studied FRAs in the Iskar river basin.

Fig. 2. Map of the studied FRAs in the Vit river basin.

Table 1. Status determination of the component Ichthyocenosis (Ic) - weight 50%, max. Points – 50. Legend: [1] - Classification method TsBRI for assessment of the ecological status of BQE fish fauna (Apostolou et al., 2016). [2] - Refers to identified indicator, sensitive and less tolerant fish species according to the Fish Based Index (Mihov, 2010). [3] - Information system for protected areas from ecological network Natura 2000 (2000). [4] - Adopted methods in Regulation № H-4/14.09.2012 for characterization of the surface waters. *State gazette 22, 5.03.2013, last amend. SG 13, 16.02.2021.* (2012). [5] - Refers to identified indicator, sensitive, less tolerant and introduced fish species according to the Fish Based Index (Mihov, 2010). [6] - BG Executive Agency on Fishery and Aquaculture.

Criteria	Number of points on the adapted 5-point scale (unified with the WFD ecological status scale)				
Criterion Ic 1 WFD ecological status of BQE fish fauna[1]	Bad	Poor	Moderate	Good	High
	1	4	8	12	16
[2]**Criterion Ic 2** Age structure of fish species populations	Absence of ichthyofauna	1 age group / single individuals	2 age groups	3 age groups	> 3 age groups
	1	4	8	12	16
[2]**Criterion Ic 3** Presence of protected fish species (Directive 92/43/EEC, Natura 2000, IUCN, Red Book of Europe and Bulgaria, BG Law for the Biological Diversity)	Absence of protected fish species	1 species - reductant protected according 2 documents	1 species - eudominant or 2 species with less presence protected in 2 documents	2 species in eudominants protected in 2 documents or the 2nd species – in 1 document	2 species or more in eudominants and 1 of them – protected in 3 documents
			If only the genus *Salmo sp.* is presented in the zone ER the assessment is carried out on the basis of Criterion Ic 2		
	1	2	3	5	6
[3]**Criterion Ic 4** Conservation status (CS) and fish species populations density (PD)	Absence of protected fish species / no data available	Unfavorable –bad CS / Very rare-available PD	Unfavorable-inadequate CS / Rare PD	Favorable CS & Common PD	All species in FCS & Common PD
	2	3	4	5	6
[4]**Criterion Ic 5** WFD BQE ecological status (BQE PB, MP, Minv, PP - if applicable)	Bad	Poor	Moderate	Good	High
	1	2	3	5	6
[5]**Criterion Ic6 Restocking** carried out during the last 5	>3 times in the last 5 years	3 times in the last 5 years	2 times in the last 5 years	Ones in the last 5 years	No restocking has been carried out in the last 5 years.

	Bad (min)	Poor (max)	Moderate (max)	Good (max)	High (max)
years: official data by the competent authorities[6]	- 5	- 4	- 2	- 1	0
Status assessment of the component Ichtyocenosis (Ic) / Total number of points	Bad (min)	Poor (max)	Moderate (max)	Good (max)	High (max)
Ic 1 (points)	1	4	8	12	16
Ic 2 (points)	1	4	8	12	16
Ic 3 (points)	1	2	3	5	6
Ic 4 (points)	2	3	4	5	6
Ic 5 (points)	1	2	3	5	6
Ic 6 (points)	- 5	- 4	- 2	- 1	0
Ic value ($\sum$ Ic 1 - 6)	1 - 9	10 - 20	21 - 31	32 - 42	43 - 50

Table 2. Status determination of the component Reproduction habitat (RH) – weight 50%, max. Points – 50. Legend: [1] - Standard EN 14614: 2020 Water quality - Guidance standard for assessing the hydromorphological features of rivers (2020). [2] - Standard EN 15843 : 2010 Water Quality – Guidance standard on determining the degree of modification of river hydromorphology (2010). [3] - An approach for assessing the impact of migration barriers, riverbed condition and effectiveness of proposed measures in 2nd RBMP of EARBD, Final report on public procurement (Vasilev et al., 2017). [4] - Adopted methods in Regulation № H-4 / 14.09.2012 for characterization of the surface waters. *State gazette 22, 5.03.2013, last amend. SG 13, 16.02.2021. (2012).* [5] - Adopted methodology and standards in Regulation for EQS of priority substances and some other pollutants. (2010). *SG 88, 9.11.2010, last amend. and suppl. SG 97, 11.12.2015. (2010).* [6] - In case of "moderate or worse" status according to criterion RH 4 and / or "bad" according to criterion RH 5, an additional analysis is performed for the sources of pollution on the territory of FRA. If the pollution cause poor or bad status of the biological elements, the number of points for the RH component is reduced: when IC is in poor status - RH is reduced by 1/3 (1/3 $\sum$ RH) and when IC is in bad status - RH is reduced by 1/2 (1/2 $\sum$ RH) of the total number of points. In case the total value of RH is a decimal number, it is rounded according to the standard mathematical rule.

Criteria	Number of points on the adapted 5-point scale (unified with the WFD ecological status scale)				
Criterion RH 1. Hydromorphological status in the monitoring transect[1,2]	Very heavily modified status	Heavily modified status	Moderate modified status	Good status (slight modification changes)	The status is close to the natural
	1	4	8	11	12
Criterion RH 2. Hydromorphological status of the habitat in the FRA (Barbour et all., 1996a)	Bad	Poor	Moderate	Good	The status is close to the natural
	2	4	8	10	12

	Very strong impact	Strong impact	Moderate impact	Weak impact	The status is close to the natural
Criterion RH 3. Impact from existing migration bariers[3]	2	8	14	18	20
	Bad / Moderate & Bad Ic	Poor / Moderate & Poor Ic	Moderate/ Unknown & Moderate Ic	Good	High
Criterion RH 4. WB ecological status in FRA (physicochemical substances and specific pollutants[4]).	0	0	1	2	3
	Bad & Bad Ic	Bad & Poor Ic	Unknown / Bad & Moderate Ic	Good / Good or worse Ic	Good / High Ic
Criterion RH 5. WB chemical status in FRA (Annex V of WFD and Directive 2013/39/EU)[5]	0	0	1	2	3
[6]Status assessment of the component Reproduction habitat (RH) / Total number of points	**Bad (min)**	**Poor (max)**	**Moderate (max)**	**Good (max)**	**High (max)**
RH 1 (points)	1	4	8	11	12
RH 2 (points)	2	4	8	10	12
RH 3 (points)	2	8	14	18	20
RH 4 (points)	0	0	1	2	3
RH 5 (points)	0	0	1	2	3
RH value (∑ RH 1 - 5)	**(3)[5] 5 - 8**	**9 - 16**	**17 - 32**	**33 - 43**	**44 - 50**

Table 3. Classification scale for assessment of the status of FRA (Index IcRH).

Classification scale for assessment of the status of FRA Index IcRH	Status	**Bad**	**Poor**	**Moderate**	**Good**	**High**
	Ic	1 (min)	20 (max)	31 (max)	42 (max)	50 (max)
	RH	3 (min)	16 (max)	32 (max)	43 (max)	50 (max)
	Index IcRH	4 - 17	18 - 36	37 - 63	64 - 85	86 - 100
	EQR IcRH	0.04 - 0.17	0.18 - 0.36	0.37 - 0.63	0.64 - 0.85	0.86 - 1.00

Table 4. Range of the values of the coefficient of degree of integrity between the ichthyocenosis and its habitat.

CoIn	Degree of integrity	Measures
CoIn ≈ 1	The status of ichthyocenosis in FRA corresponds to the habitats capacity for reproduction. In high, good and moderate status of IcRH and CoIn ≈ 1 the habitat has a good to moderate capacity for determination of FRA. In case of poor and bad status of IcRH, the capacity for reproduction of the fish fauna is low or absent and it is not appropriate to determine FRA.	When the status of IcRH is high and good a surveillance monitoring of the abiotic criteria (RH 1 - 5) is planned. In moderate status, obligatory measures are applied for improvement for the indicated abiotic criteria. The recommended monitoring frequency for assessment of the effect of applied measures is 2 times during the 6 years RBMP period.

CoIn > 1	The status of the ichthyocenosis exceeds the capacity of the habitats for its reproduction, which may due to the formation of local fish fauna communities, isolated from each other and disproportionately distributed in the FRA.	Measures for monitoring and if necessary re-stocking are recommended in case of adverse events and destructuring of fish populations, when they could not recover naturally. If it is economically efficient - removal of migration barriers is appropriate.
CoIn < 1	The status of the ichthyocenosis does not reach the capacity of the habitats for reproduction of the fish fauna due to specific factors: poaching, fish diseases, unidentified pressures etc.	Specific measures depending on the identified reasons / pressures for deterioration of fish fauna status.

Results and Discussion

The summarized results from the conducted study in the FRAs in the Iskar and Vit river basins for the two components Ichthyocenosis (Ic) and Habitat for reproduction (RH), the assessment by the IcRH index, as well as the values of the Coefficient of Integrity (CoIn) are presented in Table 5 and Table 6.

In the calculation of the Component Ichthyocenosis (Ic) a corrective effect of Criterion Ic2 Age structure of fish species populations is observed, which partially reduced the value for Criterion Ic1 Assessment of the ecological status of ichthyofauna (Index TsBRI, Apostolou et al., 2016, URL10). This effect is analyzed and verified in the process of validation of the TsBRI method for the other BG surface water types that have not participated in the EU process of intercalibration. The most significant difference is observed in the assessments of Criterion Ic1 Ecological status

and Criterion Ic4 Conservation status: 92% FRA are in good and high ecological status and 100% FRA are in less than good conservation status. The reasons for this essential difference are the significantly larger territorial scope of the conservation status assessment and the timeliness of the data used (due to the limited number of national monitoring points for conservation status assessment, they are often absent in the surveyed FRAs). Therefore, when calculating Component Ic, a possibility was ensured to adjust the assessment of the Criterion Ic4 Conservation status in connection with the actual data from monitoring of fish fauna in the studied FRAs. The Criterion Ic6 Re-stocking according to official data is applied only with the species of river trout (*Salmo trutta fario L.*). During the last 5 years, permanent stocking has been carried out in the catchment of the Beli Vit River and the assessments of the fish fauna show a positive effect on its ecological status.

Table 5. Summarized results from the integrated status assessment[1] of Component Ic in FRAs in the Iskar and Vit river basins. Legend: [1] - Status assessment color (unified to WFD ecological status): High Good Moderate Poor Bad

№	FRA names	Ic 1 Ts BRI	Ic 2 Age str-re	Ic 3 Prot. species	Ic 4 Cons. status	Ic 5 BQE status	Ic 6 Resto king	Ic	RH	IcRH	CoIn
1	BG1FSWIS300R019 GABROVNITSA	16	12	5	4	5	0	42	36	78	1.17
2	BG1FSWIS300R1018 ISKRETSKA	12	8	3	4	3	0	30	41	71	0.84
3	BG1FSWIS300R1017	16	16	6	2	5	0	45	43	88	1.05

№	FRA names										IcRH
	BATULIJSKA										
4	BG1FSWIS700R1107 BISTRITSA VITOSHKA	4	4	2	3	3	0	16	19	35	0.84
5	Iskar River after the inflow of Beli Iskar River into Cherni Iskar River	12	16	6	2	5	-1	40	38	78	1.05
6	Beli Iskar River before the inflow into Cherni Iskar River	16	12	6	3	5	-1	41	38	79	1.08
7	BG1FSWIS900R1103 LEVI ISKAR	16	12	6	3	6	0	43	29	72	1.48
8	BG1FSWIS900R1203 CHERNI ISKAR	16	8	6	3	5	0	38	42	80	0.90
9	BG1FSWVT800L1004 SOPOT DAM (Toplya river)	12	16	6	4	1	0	39	42	81	0.92
10	BG1FSWVT900R1001 BELI VIT	16	16	6	4	5	-5	41	28	69	1.48
11	BG1FSWVT900R1101 RIBARITSA	12	4	5	3	5	-2	29	26	55	1.12
12	BG1FSWVT900R1002 CHERNI VIT	12	8	4	4	5	0	33	29	62	1.14

Table 6. Summarized results from the integrated status assessment[1] of the Component RH in FRAs in the Iskar and Vit river basins. Legend: [1] - Status assessment color (unified to WFD ecological status): High Good Moderate Poor Bad

№	FRA names	RH 1 HM status	RH 2 Habitat status	RH 3 River contin.	RH 4 Ecol. status	RH 5 Chem. status	RH	Ic	IcRH	CoIn
1	BG1FSWIS300R019 GABROVNITSA	11	8	12	2	3	36	42	78	1.17
2	BG1FSWIS300R1018 ISKRETSKA	12	9	16	1	3	41	30	71	0.84
3	BG1FSWIS300R1017 BATULIJSKA	12	7	20	1	3	43	45	88	1.05
4	BG1FSWIS700R1107 BISTRITSA VITOSHKA	4	3	8	1	3	19	16	35	0.84
5	Iskar River after the inflow of Beli Iskar River into Cherni Iskar River	12	9	12	2	3	38	40	78	1.05
6	Beli Iskar River before the inflow into Cherni Iskar River	12	9	12	2	3	38	41	79	1.08

#										
7	BG1FSWIS900R1103 LEVI ISKAR	11	7	6	2	3	29	43	72	1.48
8	BG1FSWIS900R1203 CHERNI ISKAR	12	9	16	2	3	42	38	80	0.90
9	BG1FSWVT800L1004 SOPOT DAM (Toplya river)	11	7	20	1	3	42	39	51	0.92
10	BG1FSWVT900R1001 BELI VIT	11	7	6	1	3	28	41	69	1.48
11	BG1FSWVT900R1101 RIBARITSA	10	6	6	1	3	26	29	55	1.12
12	BG1FSWVT900R1002 CHERNI VIT	12	9	4	1	3	29	33	62	1.14

There is a clear correlation between the values of the components Ichthyocenosis (Ic) and Habitat for reproduction (RH) with Criterion RH 3 Impact from existing migration barriers (to the greatest extent) and Criterion RH 2 "Hydromorphological status of the habitat in the FRA". For river type R 2 "Mountain rivers", the impact on river continuity and runoff as a result of established migration barriers is of major importance for the hydromorphological state of biotopes. The fact that this river type is represented by relatively short sections enhances the limiting effect of this impact. Criterion RH 2 is also secondarily affected by the disturbed river continuity, taking into account negative changes in some of the parameters that form it. CoIn > 1 values have usually been found in FRAs with lower Criterion RH 3 values, indicating that, as a result of physically limited migration, fish fauna form local communities.

Total in 10 of the studied FRAs (83%) the values of the integrated index IcRH determine good or higher status (1 FRA – in High status; 7 designated FRAs and 2 additional river sections – in Good status). The status of 1 FRA is moderate (BG1FSWVT900R1101 RIBARITSA) and it was proposed for inclusion in the boundaries of FRA Beli Vit as its tributary and feeding habitat for the young individuals of *Salmo trutta fario L.* with

measures to ensure greater runoff and restore the connectivity of the river. The status of 1 FRA is poor (BG1FSWIS700R1107 BISTRITSA VITOSHKA) and it was proposed for exclusion of the list of designated FRAs. The analysis of the hydromorphological conditions in the last two FRAs in moderate and poor status derives from significant fragmentation, disturbed river continuity, runoff regulation, riverbed correction and other local physical changes leading to compromise of the river sections.

The values of the component ichthyocenosis (Ic) in most cases corresponds to and exceeds the capacity of the habitats for its reproduction (values of RH), as in 42% of the zones this is happening due to the formation of local fish communities, isolated from each other and disproportionately distributed in the FRA.

The achieved results ensured the validation of the designated areas for protection of economically significant aquatic species in the RBMP of DBD (2016 - 2021). Determination of a common FRA including all defined FRAs in the RBMP together with two new river sections have been identified as a measure necessary to protect fish species populations in the upper part of the Iskar river basin. Their hydraulic connectivity, common river type (R 2 Mountain rivers) and the established good

integrated status (IcRH) ensure appropriate conditions for successful reproduction of the fish fauna in a large river area for which protection is required. The absence of fish species populations in the designated FRA of the Vitoshka Bistritsa River before the inflow into Iskar River caused by significant hydromorphological pressure from migration barriers is the reason for determination of a poor integrated status and exclusion of this river section as a protected area.

In some tributaries of Beli Vit River a disturbed river connectivity and significantly reduced runoff because of the pressure from water abstraction was established (mouth of the Stara Ribaritsa River) which determine moderate IcRH status. During the study it was found that these river sections are successfully used by young individuals of the species Salmo trutta fario L. as a habitat for feeding and protection, although they develop in small and isolated populations. This fact led to the conclusion that the disturbed river habitats also have to be included in the boundaries of the FRA when they provide appropriate conditions for young individuals of fish populations until they reach breeding age.

For all river sections where the assessment of the RH component found deviations from the good status, measures to improve the river connectivity and the condition of the hydromorphological elements were determined. The integrated assessment has allowed these measures to focus on improving the condition of fish fauna where deviations have been identified or are expected, as well as to make changes to the monitoring carried out to provide reliable data.

The results from the integrated assessment (Index IcRH) were summarized in the information passports, containing specific data for the surveyed FRAs and measures necessary to be taken to protect them.

Conclusion

Based on the definition of the ecosystem (Odum, 1971) as a main functional unit in the ecology, the presented index for integrated assessment of the fish faun reproduction areas (FRA) apply principles of the Ecosystem approach (Shepherd, 2004) introducing a mechanism for monitoring and conservation of the ecosystem structure and functioning. Integrating the assessments of WFD status of biological and abiotic quality elements in aquatic ecosystems (Annex V, WFD) with the assessments of the conservation status of fish fauna (Directive 92/43/EEC, Natura 2000, etc.) the IcHR index uses a wide range of criteria (11) related to 2 main components: (1)Biotic Component „Ichthyocenosis" (Ic) including 6 criteria with emphasis on fish fauna; (2) Abiotic Component "Reproduction habitat" (RH) with 5 criteria, including basic hydromorphological and physicochemical quality metrics. Application of standardized methodologies and available public data for the calculation of the integrated IcRH index and determination of the status of the FRAs ensure representativeness and confidence of the obtained results. The integrated index is developed and applied with data from the river type R 2 Mountain rivers in Ecoregion 12 Pontic province and it needs to be further validated with additional monitoring data for application to other types of aquatic ecosystems.

their collaboration for the successful implementation of the project.

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