BARBUS MERIDIONALIS RISSO 1827 (SYN. *BARBUS BALCANICUS*): PROPOSAL FOR MONITORING ELEMENTS FOR CROATIA, IN THE CONTEXT OF NATURA 2000

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ABSTRACT

The action framework at the European Union level for the protection of biodiversity was established based on the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC). One main element of the future implementation of these Directives in Croatia is the establishment of a Natura 2000 network of special protection sites, a network which should rely on a specific monitoring plan at national level for each species of community interest. In this context, the present study proposes a set of monitoring elements for *Barbus meridionalis* for the Croatian Continental Biogeographical Region. The proposal is based on seven main criteria: proximity of national border, high quality populations, habitats which should be ecologically reconstructed, key habitats/sectors with high importance for connectivity, point sources of industrial pollution, areas/sectors influenced by diffuse sources of agricultural pollution, and areas/sectors influenced by habitat modifications.

ZUSAMMENFASSUNG: *Barbus meridionalis* Risso 1827 (Syn. *Barbus balcanicus*) Vorschläge von Monitoringelementen für Kroatien im Natura 2000 Kontext.

Der Aktionsrahmen auf EU-Ebene für den Schutz der Biodiversität wurde auf Grundlage der FFH Richtlinie (92/43/EEC) und der Vogelschutzrichtlinie (79/409/EEC) festgelegt. Ein Hauptelement der zukünftigen Umsetzung dieser Richtlinienin in Kroatien ist die Einrichtung auf nationaler Ebene des Natura 2000 Netzwerks besonders geschützter Gebiete, ein Netzwerk das auf einem spezifischen, auf nationaler Ebene für jede Art von gemeinschaftlichem Interesse angelegten Monitoringplan beruhen muss.

In diesem Kontext beabsichtigte die vorliegende Studie ein Paket von Monitoringelementen für *Barbus meridionalis* für die Kontinentale Biogeographische Region Kroatiens vorzuschlagen. Der Vorschlag beruht auf sieben Hauptkriterien: die Nähe der nationalen Grenze, Populationen von hoher Qualität, Habitate, die ökologisch renaturiert werden müssen, Schlüssel-Habitate/Abschnitte von besonderer Bedeutung für die Konnektivität, für Quellen punktueller industrieller Verschmutzung durch, Bereiche/Abschnitte, die durch diffuse Verschmutzung aus der Landwirtschaft beeinflusst sind sowie Bereiche/Abschnitte, die von Veränderungen der Habitate beeinflusst sind.

REZUMAT: *Barbus meridionalis* Risso 1827 (sin. *Barbus balcanicus*) propuneri de elemente de monitoring pentru Croaţia, în contextul Natura 2000.

Cadrul de acţiune la nivelul Uniunii Europene, pentru protecţia biodiversităţii a fost stabilit pe baza Directivei Habitate (92/43/EEC) şi a Directivei Păsări (79/409/EEC). Un element principal al implementării acestor directive în Croaţia este stabilirea reţelei de arii de protecţie specială Natura 2000, o reţea care trebuie să se bazeze pe monitoringul la nivel naţional pentru fiecare specie de interes comunitar.

În acest context, prezentul studiu are ca finalitate propunerea unui set de elemente de monitoring pentru *Barbus meridionalis* pentru Regiunea Biogeografică Continentală din Croaţia, propunere bazată pe şapte criterii principale: proximitatea graniţelor naţionale, populaţii de calitate ridicată, habitate care trebuie reconstruite din punct de vedere ecologic, habitate/sectoare cheie cu importanţă ridicată pentru conectivitate, surse de poluare industrială punctiforme, arii/sectoare influenţate de surse difuze din agricultură, arii/sectoare influenţate de modificări ale habitatelor.

INTRODUCTION

In the near future (June-July 2013), it is expected that a new country, Croatia, will join the European Union, which will bring new obligations for this country in terms of nature protection and conservation, in a similar manner with all the older E. U. countries.

The primary aims of the European Community administration representatives in the environment field of interest are the protection, conservation and improving of the environment elements and structure quality for a better use of the natural resources and services of the ecosystems, including the aquatic ecosystems. During the past decades the biodiversity was one of the main issues in this respect.

The action frame at the European Community level, to handle the biodiversity issue was established based on the Habitats Directive (92/43/EEC) and Birds Directive (79/409/EEC). These two very important European Directives have as their main objective to conserve the biodiversity in the European Union based on a protected areas network, namely the Natura 2000 net, to protect essential habitats and species characteristic for all the European biogeographic regions: Arctic, Boreal, Atlantic, Continental, Alpine, Pannonian, Mediterranean, Macaronesian, Steppic, Black Sea and Anatolian (Fig. 1).

Croatia has a relatively high biogeographic diversity among the current and future European Union countries, comprising a total of four biogeographic regions: Continental, Alpine, Pannonian and Mediteranean (Fig. 1).

One main element of the future implementation of the Directives is the establishment of an optimum Natura 2000 network in Croatia too, a network which should rely on a specific monitoring plan at the national level for each habitat and species of European conservative concern. The near future joining of Croatia to EU makes this type of monitoring proposal an important element for future management and conservation related plans in this country.

The range of *Barbus meridionalis* includes the Danube, Nistru/Dniester, Odra, Vistula and Vardar watersheds. It is present also in the Croatian national territory, only in the Danube Watershed, and also in its neighboring countries: Slovenia, Hungary, Serbia, Bosnia and Herzegovina and Montenegro. This species can be found also in the proximity of Croatia, in Italy and Macedonia. Until now, distribution data about *Barbus meridionalis* in Croatia were not systematically collected. It often disappeared/was not found in some areas and reappeared in nearby areas. The sporadic presence/knowledge regarding this species in Croatia is known based on the last few decades of studies in Sava, Drava, Kupa and their tributaries basins. In some of the Croatian Danube Basin areas this species is common or very common.

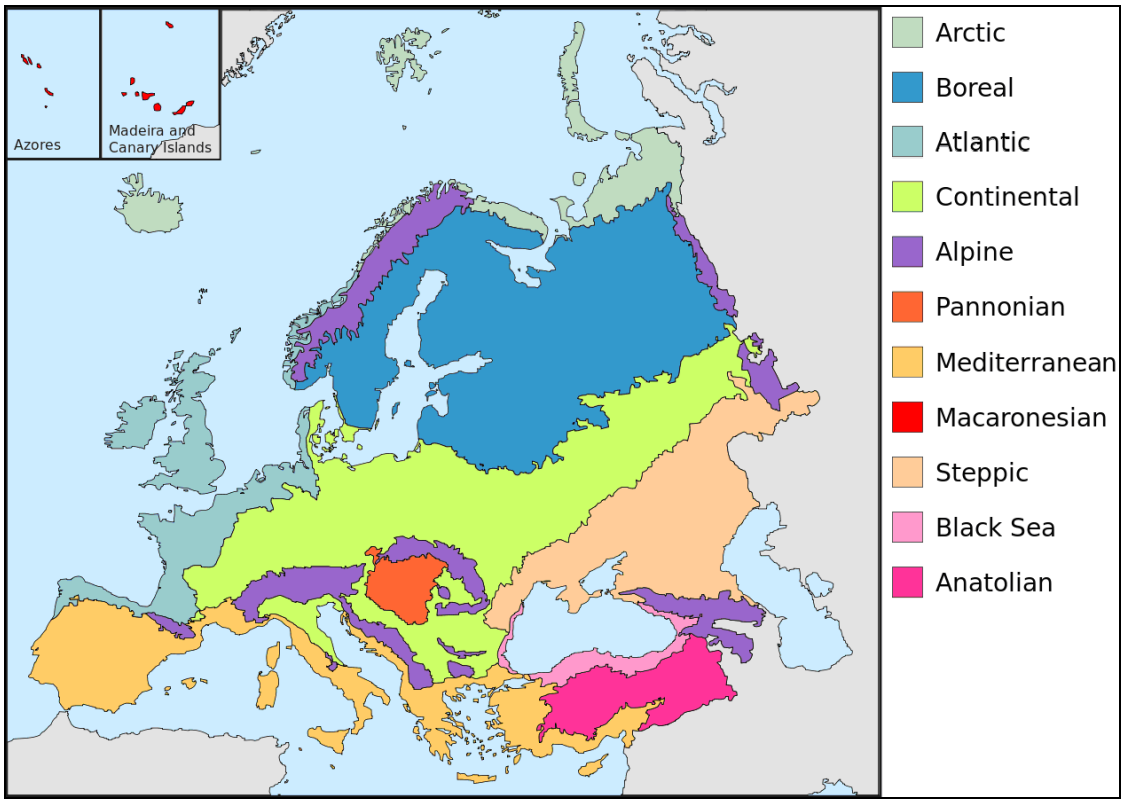

Figure 1: European biogeographic regions;
European Environment Agency - www.eea.eu.in.

There has been no national permanent/long term specific monitoring on the distribution or population, ecologic status of this fish species, not all areas were studied in this respect, including those for the proposal of Natura 2000 sites. Still, it is considered relatively well spread and common on the Croatian territory, in the Danube Basin, mainly in the European Continental Biogeographical Region, in the suitable habitats, with an exception of the Alpine Biogeographical Region, in the Kupa River area, in the very proximity of the Continental Biogeographical Region. There has been no national permanent/long term specific monitoring on distribution or population, ecologic status of this fish species, not all areas were studied in this respect, including those for the proposal of Natura 2000 sites. Still, it is considered relatively well spread and common on the Croatian territory, in the Danube Basin, mainly in the European Continental Biogeographical Region, in the suitable habitats, with an exception of the Alpine Biogeographical Region, in the Kupa River area, in the very proximity of the Continental Biogeographical Region. That is why it was considered needing a monitoring program only for the Continental Biogeographical Region in Croatia.

The range and abundance of this species in the Croatian Continental Biogeographical Region, in suitable habitats, can be considered as relatively high. Assessments have been done so far in the following areas, proposed as pSCI sites: rivers Kupa (15-30% considered proportion of the population in relation to the size of the population at the national level), Korana (2-15%), Dobra (15-30%), Mrežnica (15-30%), Petrinjčica (2%), Bednja (2%), Sutla (2%) and streams in Medvednica (2%) and Papuk (2%) areas.

In the next three years through the Natura 2000 Integration Project (NIP) inventory of freshwater ichthyofauna is expected to be done completely in the areas with present data gaps.

Barbus meridionalis was included in the Habitats Directive (92/43/EC). In the Central and Eastern Europe it is a rather a common species with a high potential as an umbrella species, a similar situation exists in Croatia as well.

In spite of the fact that no exhaustive data about this fish species distribution in the Croatian national territory is available in the present, a relatively common situation in other European countries as well, the present known data represent reliable data for the proposal of a long term monitoring elements proposal for Croatia.

Barbus meridionalis is reophilic, lithophilic and benthopelagic freshwater fish that lives in habitats with water temperature which does not exceed 25˚C in streams up to 500 m above sea level. It is a short-living species which is found in mountainous, hilly and some lowland rivers with suitable habitats. It prefers clear and fast flowing water sectors and hard substrata.

It reaches sexual maturity in the second or third year of life. Reproduction happens is taking place in the spring, sometimes is prolonged till the summer (from May to July). At the time of spawning, it gathers in flocks and moves upstream in search of favourable habitats with gravel and stones. The food of young fish consists mainly of benthic aquatic invertebrates (tendipedes, ephemeropterans, trichopterans, gamarids, oligochetes, etc.) and vegetation debris. There is also information about the fact that the adults feed on fish fries and alevines too.

Barbus meridionalis is listed in Annexes II and IV of the Habitats Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC), in the Annex III of the Berne Convention, and in the Croatian Nature Protection Law (a strictly protected species). In the Croatian territory, it is considered to be a vulnerable (VU) species.

Barbus meridionalis is threatened in general by the decrease of the proper habitats (for spawning, schooling, feeding, sheltering, etc.) quality due to pollution, habitat modification, degradation, destruction, disappearance (channelling, watercourses regulation, remodelling, etc.), flow regulation and water abstraction. Non-indigenous species can have a negative impact on this species. At present, significant fluctuations are noted in the number of this species location and subpopulations are noted.

The conservation measures should target a good conservation status, which should reflect a good balance of the sum of the influences acting on this species that may affect its long-term survival. In this respect specific measures are needed where the local situation requires action: preserving and improving the favorable ecological balance of the natural waters inhabited by this species, protected areas for fish (reserves) of conservative interest, preventing and avoiding of water and sediment flow regulation as much as possible keeping them close to the natural regime, bans of alien/invasive species entry and reproduction, construction of appropriate devices for water recycling, avoiding lotic fragmentations due to different categories of buildings in the river bed, etc. All of these issues cannot be approached on long therm without a functional monitoring system, specific for this species.

RESULTS AND DISCUSSIONS

The main result of this study is intended to be a proposal of a set of monitoring elements for *Barbus meridionalis* for the Croatian Continental Biogeographical Region. The monitoring elements are based on the present distribution data of this species and on the existing main human induced threats in the area of interest. Based on the overlapping of the actual data of distribution of this species on the human induced disturbed/hot spots lotic

sectors, the scale of a monitoring grid can be established and the monitoring frequency in time and space can be revealed and proposed. Any other "theoretical/blind" approach in establishing the spatial and temporal frame of this species monitoring can be in the best case an intellectual exercise, which will more or less fail sooner or later in terms of accuracy of the obtained results, and bring to many important and costly later on adjustments of the initial monitoring system. As far as the lotic systems are dynamic, even in the best approached monitoring proposals, in time, the monitoring systems will require some adjustments.

The proposed *Barbus meridionalis* monitoring sites, at the Croatian national level/Continental Biogeographical Region, were selected based on seven main criteria: ❶ national border proximity areas/sectors coverage; ❷ high quality populations of *Barbus meridionalis* in terms of populational structure/density (ex. protected areas but not only) in characteristic/optimum/good habitats; ❸ habitats which should be ecologically reconstructed to allow *Barbus meridionalis* populations structure improving or natural repopulation; ❹ key habitats/sectors with high importance for connectivity (ex. rivers confluence areas; intermediate lotic sectors between different important populational areas); areas/sectors negatively influenced by human impact, such as: ❺ industrial pollution point sources, ❻ areas/sectors influenced by agricultural pollution diffuse sources, ❼ areas/sectors influenced by habitats modifications (channeling, watercourses regulation, remodeling, etc.).

It should also be stated that the potential future improvement of the *Barbus meridionalis* species distribution data on the Croatian territory, can improve the monitoring proposals situation, the process of improving this specific monitoring system should be a permanent one.

Spatial monitoring elements

❶ National border proximity areas of interest coverage

These monitoring sections were selected due to their importance for future international monitoring methods and systems intercalibrations, and for real time data exchange and checking. Also, these sections represent the national limits of the Croatian responsibility for preserving/improving this fish species conservation status. These monitoring stations should be done once every year.

Based on this monitoring criterion, nine monitoring sections (Fig. 2, ❶) were selected/proposed.

Three sampling sections were proposed on Kupa River, which would be monitored once per year, along the 118 km long north-west Croatian - south-east Slovenian border, with around 50 km among them (section 1, road access to Kupa River from Mandli locality; section 2, aproximativelly 50 km downstream; section 3, road access to a bridge over Kupa River from Cerje Vivodinsko or Preseka Ozaljska localities).

Two sampling sections were proposed on Sutla River, which would be monitored once per year, along the Croatian - Slovenian border, with an around of 50 km among them (section 1, road access to Sutla and bridge from Gruškovje locality; section 2, aproximativelly 50 km downstream).

One sampling station should be on Glina River, which would be monitored once per year, on the Croatian - Bosnia-Hertzegovina border (road access and bridge near Katinovac locality).

One station should be on Korana River, which would be monitored once per year, on the Croatian - Bosnia-Hertzegovina border (road access and bridge in proximity of Kosa locality).

One sampling station was proposed in the proximity of the southern Croatian-Bosnia and Herzegovina border on the Una River, in the Stanic Polje locality.

Another sampling station was proposed in the proximity of the southern Croatian-Bosnia and Herzegovina border on the Una River, in the Hrvatska Dubica locality, with road access from the road number 47.

Any human impact from the upstream located countries which can induce qualitative (species disappearance) and quantitative (relative abundance) modifications of the monitored populations, will create a negative future prospects related to this species habitat quality, range and conservation status, long-term viability, situation which should be assessed once a year at a national level.

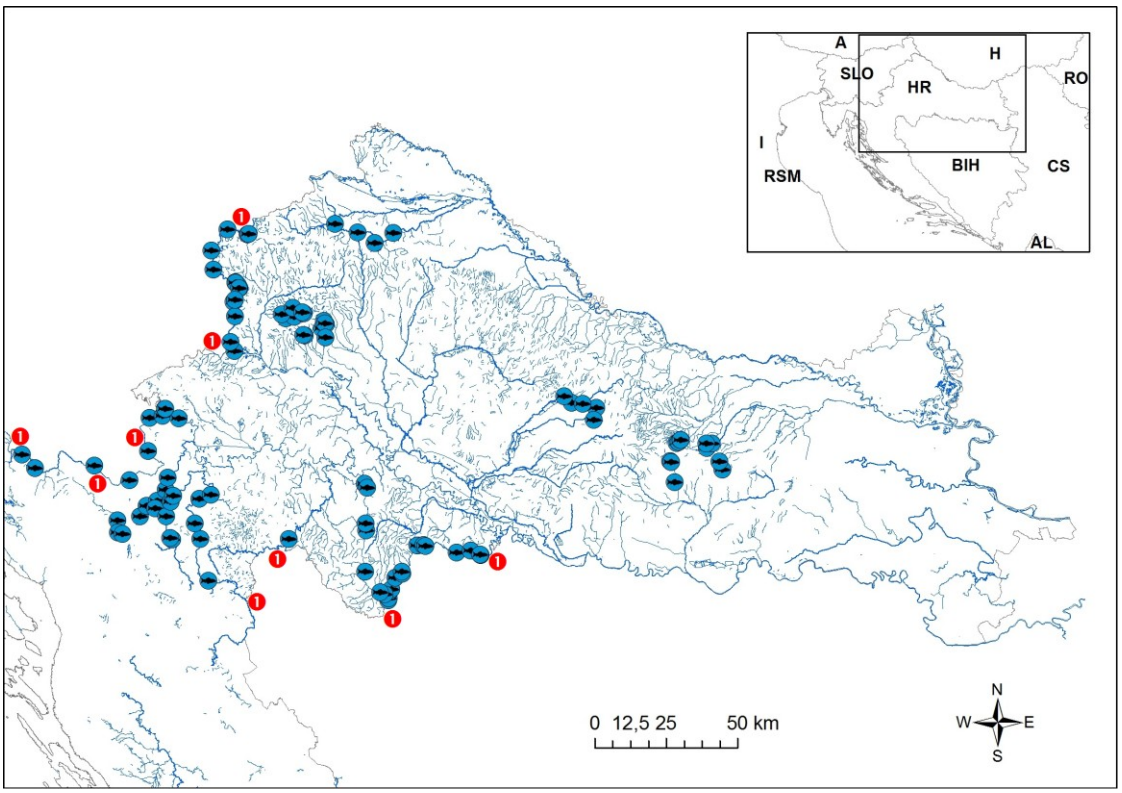

Figure 2: *Barbus meridionalis* proposed monitoring sections (❶),
based on the Croatian national border proximity areas of interest coverage criteria.
Barbus meridionalis distribution, update situation (Duplic, SNIP, 2012).

❷ Excellent quality populations of *Barbus meridionalis* in terms of population structure/density in characteristic/optimum/good habitats.

This second category of monitoring sections were chosen due to their genetic value/importance for keeping a healthy status of this species populations in Croatia and in the neighboring countries, and for the potential of natural repopulation of areas where this species can exist and spread in the future. Based on this monitoring criteria three monitoring sections (Fig. 3; ❷) were selected/proposed.

One sampling section was proposed in the Nature Park Žumberak - Samoborsko gorje, at 30 kilometers south-west of Zagreb, with tributaries of Sava River, sampling activities

are needed once per every six years if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

One sampling section should be in the Nature Park Medvenica, in the vicinity of Zagreb, with tributaries of Sava River, sampling activities are needed once per every six years if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

One sampling section should be in the Nature Park Papuk, with tributaries both of Drava and Sava rivers basins, sampling activities are needed once per six years if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

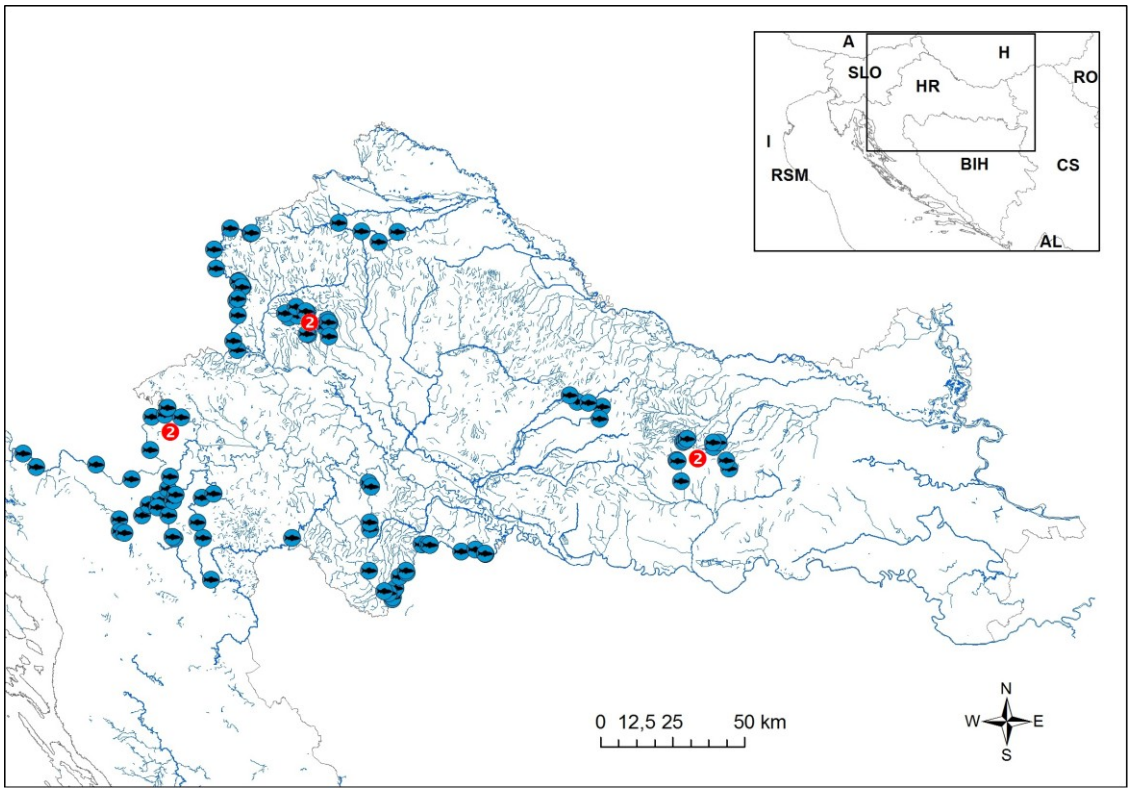

Figure 3: *Barbus meridionalis* proposed monitoring sections ❷, based on the high quality populations of *Barbus meridionalis* in terms of populational structure/density in characteristic/optimum/good habitats.
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

Any human impacts or pressures in these protected areas which can induce qualitative (disappearance of the species) and quantitative (changing in relative abundance, age structure) modifications of the monitored populations, will create negative future prospects related to the species habitat quality, long-term viability, range and conservation status, situation which should be assessed once in every six years period at national level, if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

❸ Lotic sectors/habitats which should be ecologically reconstructed/proposed for ecological reconstruction to allow the *Barbus meridionalis* populations structure improving or natural repopulation. This is the case only if the lack of actual data did not induce some fake gaps in continuity of distribution data/knowledge.

This third category of monitoring sections was chosen due to the gaps in continuity of this species, possibly as a result of human impact, but also due to the gaps in the actual scientific knowledge. Based on this monitoring criteria, six monitoring sections (Fig. 4; ❸) were selected/proposed.

Four sampling sections should be on Kupa River, under an once per six years monitoring, along the 118 km long north-west Croatian - south-east Slovenian border, between each couple of sites where the presence of this fish species is known (and marked in Fig. 4 map). If new scientific data about the presence of the species in these actual gaps on the map become available in the future, these proposals will no longer be taken into consideration.

One sampling station should be on Glina River, which would be monitored once per six years, along the Croatian - Bosnia-Hertzegovina border (road access and bridge near Katinovac locality). One sampling station should be on Korana River, which would be monitored once per six years, along the Croatian - Bosnia-Hertzegovina border (road access and bridge in the relative proximity of Kosa locality).

Any human impact or pressures in these lotic sectors, which cause the absence of the species, create a negative future prospects related to its habitat quality, long-term viability, range and conservation status, situation which should be assessed once in every six year period at the national level.

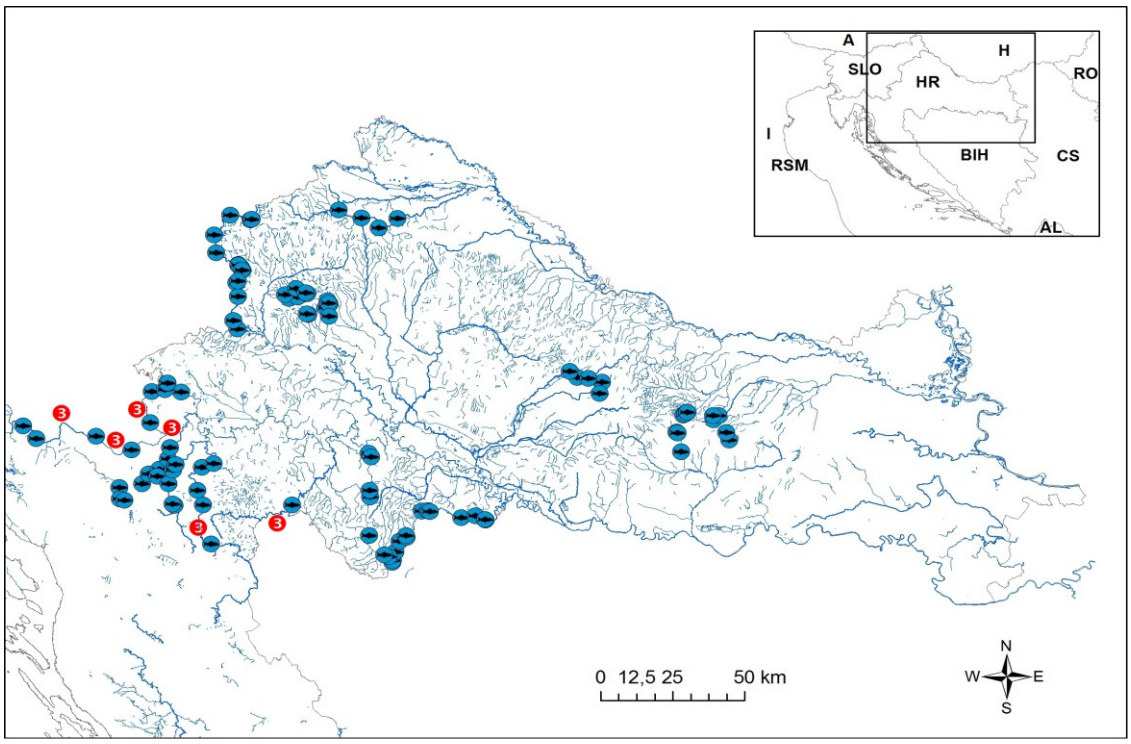

Figure 4: *Barbus meridionalis* proposed monitoring sections (❸), based on the lotic sectors/habitats which should be ecologically reconstructed/proposed for ecological reconstruction to allow *Barbus meridionalis* population structure improving or natural repopulation criteria, potential sectors to be proposed for ecological reconstruction. *Barbus meridionalis* distribution , update situation.

❹ key habitats/sectors with high importance for connectivity (ex. rivers confluence areas; intermediate lotic sectors between different important fish populations' areas).

This fourth category of monitoring sections was chosen due to their potential role as connectivity culloars with importance in the continuity of this species, but they can also represent gaps in the actual scientific knowledge. If these sections will prove to be only gaps in the knowledge, gaps which will be covered by future information, they can be removed from the proposed list of sampling/monitoring sections.

Based on this monitoring criteria five monitoring sections (Fig. 5; ❹) were selected/proposed.

One section, monitored once per six years, on the Dobra River, between the last downstream sampling point where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Kupa River at Karlovec.

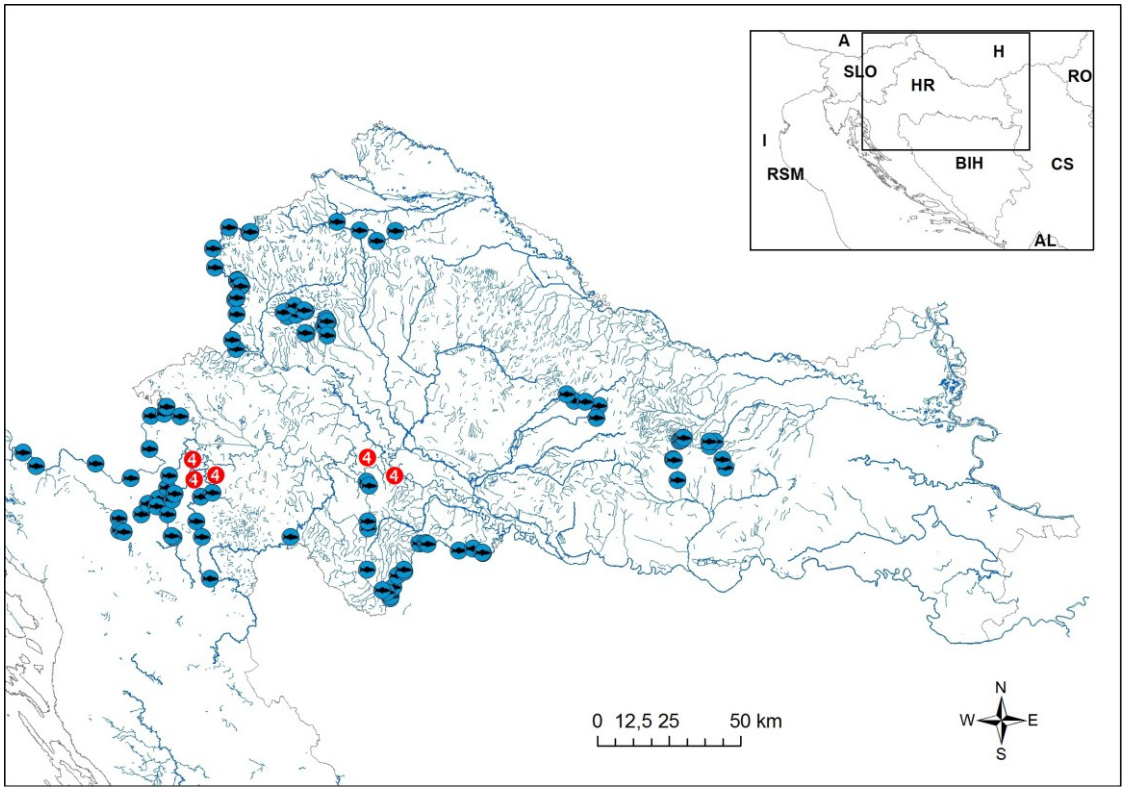

Figure 5: *Barbus meridionalis* proposed monitoring sections ❹,
based on key habitats/sectors with high importance for connectivity.
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

One section, monitored once per six years, on the Mrežnica River, between the last downstream sampling point, where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Korana River.

One section, monitored once per six years, on the Korana River, between the downstream last sampling point, where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Kupa River at Karlovec.

One section, monitored once per six years, on the Glina River, between the last downstream sampling point, where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Kupa River.

One section, monitored once per six years, on the Kupa River, between the last downstream sampling point where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Sava River at Sisak.

Any human impact in these lotic sectors which can cause the absence or at least accidental presence of *Barbus meridionalis*, will create negative future prospects about this species conservation status and range, situation which should be assessed once per six years at national level.

❺ industrial/waste water pollution point sources areas (Fig. 6)

Kupa River needs once per year monitoring of a section downstream of the Karlovac locality, where partially treated waste water is released.

Kupa River needs a once per year of monitoring section downstream the Karlovac locality, which release partially treated waste water.

Also in the area of Kupa with Sava confluence at Sisak locality, a negative impact from industry (chemical, metal, leather, textile and food) brings a supplementary reason for monitoring this area.

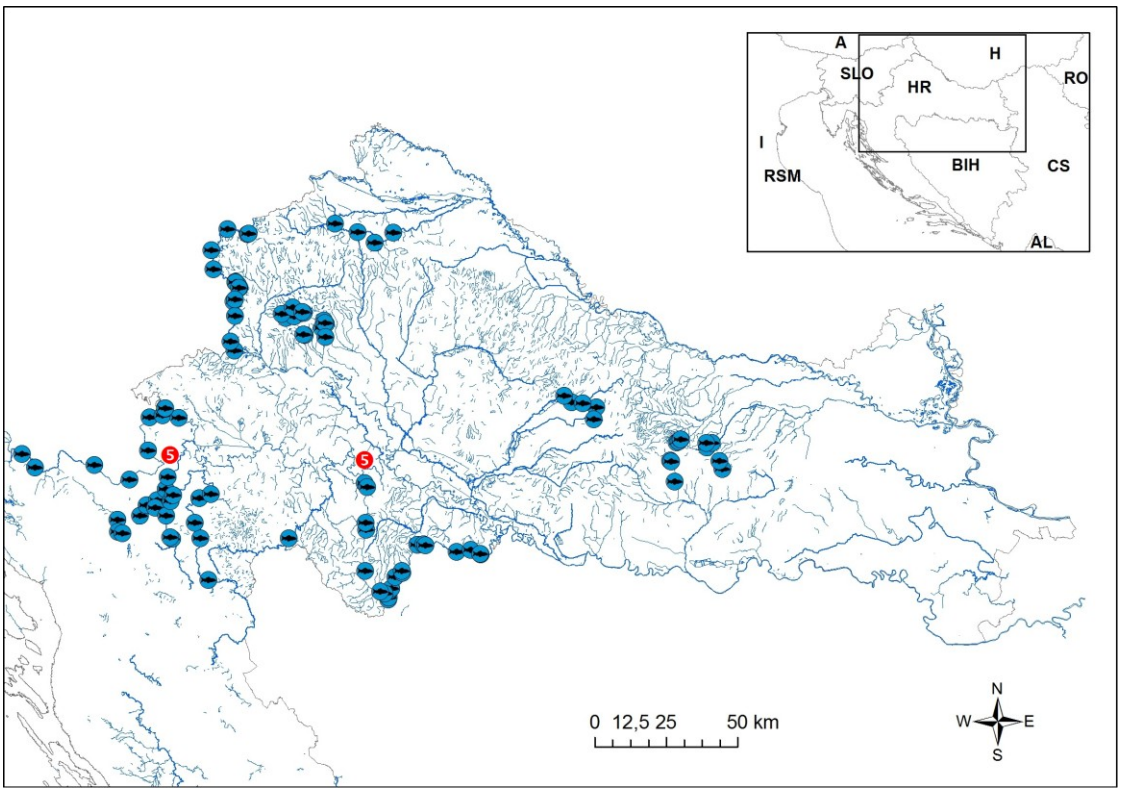

Figure 6: *Barbus meridionalis* proposed monitoring sections ❺,
based on the industrial/waste water pollution point sources data criteria;
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

❻ areas/sectors influenced by agricultural pollution diffuse sources (Fig. 7)

The following Sava River tributary was approached regarding the agricultural pollution diffuse sources, which need monitoring sectors.

The Sutla River, due to the proximity of large corn fields' cultivation, has high heavy metals concentrations values in the water due to K_2O, Co, Cu sulphate and Ti used in chemicals fertilizers, needs a monitoring section in this river between the localities Ključ Brdovečki and Drenje Brdovečko. In this section were also constantly found high values for enterococci numbers (coming from the farms situated in this basin), N total, P total and humic substances (including U complexes) from chemical fertilizers.

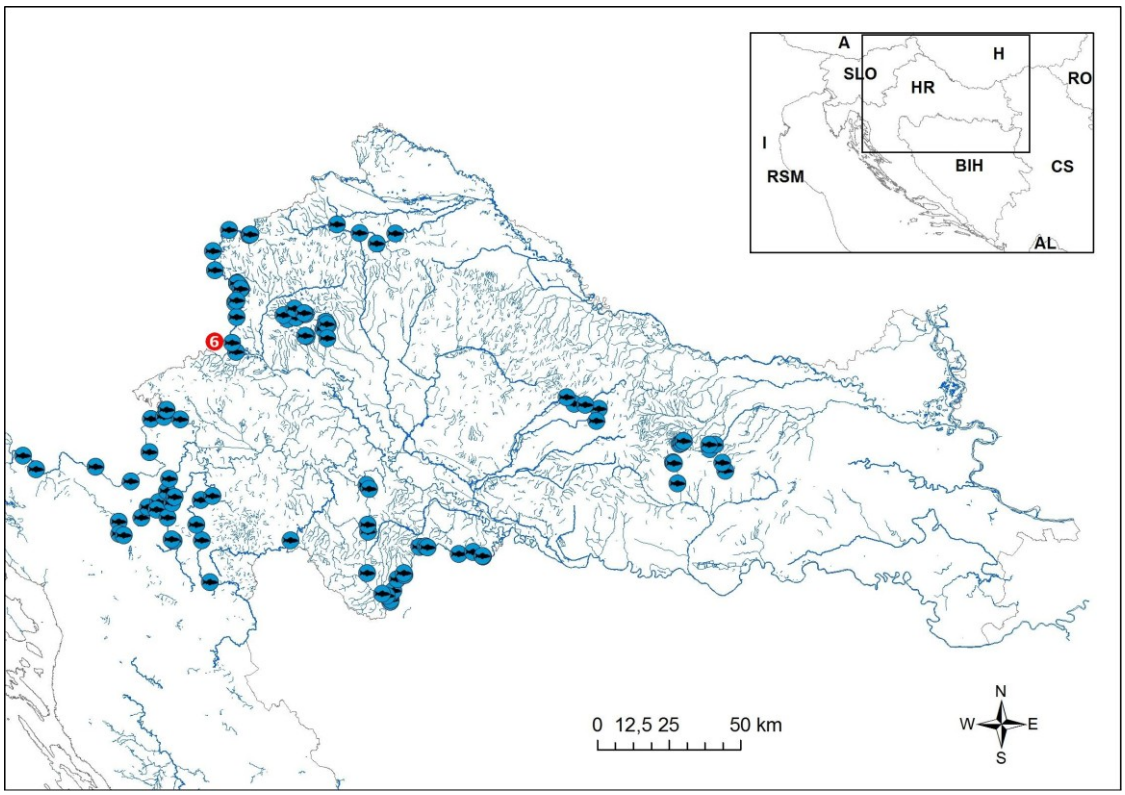

Figure 7: *Barbus meridionalis* proposed monitoring sections ❻, based on areas/sectors influenced by agricultural pollution diffuse sources data criteria.
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

❼ areas/sectors influenced by habitat modifications (dams, channeling, watercourses regulation, remodeling, etc.) (Fig. 8).

Kupa (15-30% considered proportion of this fish species population in relation to the size of the population at the state level), needs monitoring in the following areas: upstream and downstream of Ozalj Dam on Kupa River; Kupa-Kupa natural channel.

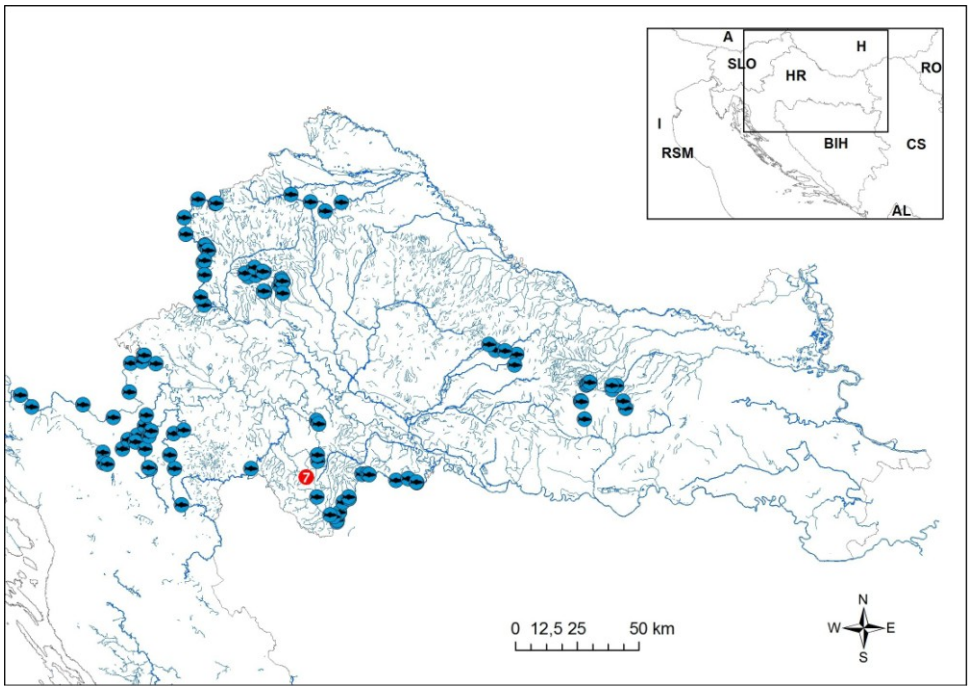

Figure 8: *Barbus meridionalis* proposed monitoring sections (❼), based on the habitats modifications criteria. *Barbus meridionalis* distribution , update situation (Duplić, SNIP, 2012).

❽ geographically extreme sections (Fig. 9) in the most-upstream and most-downstream rivers sections, in this species range and in the near outer proximities of these extremes.

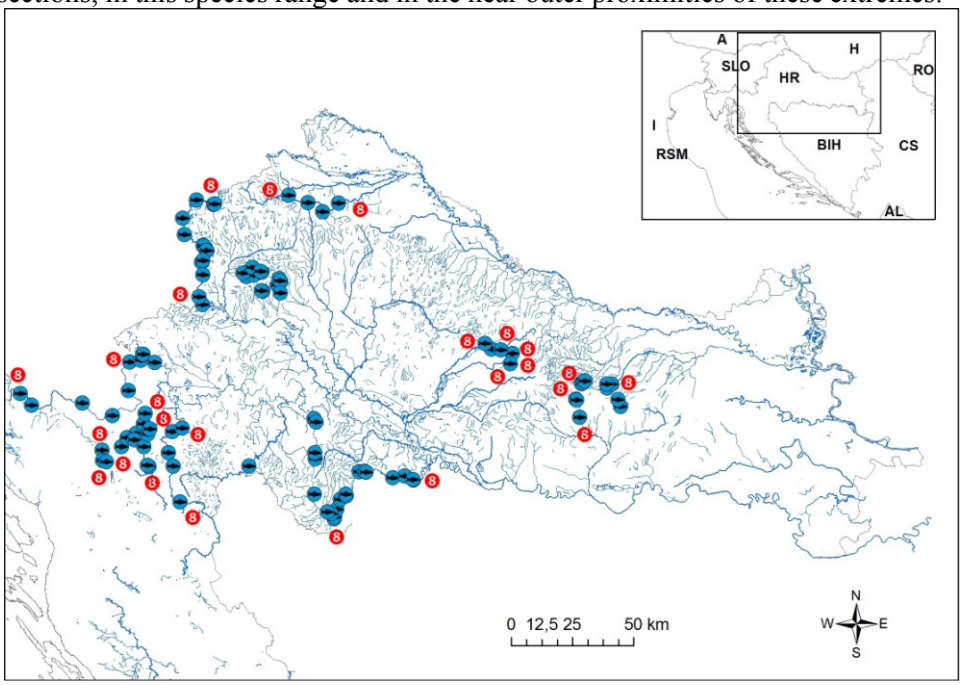

Figure 9: *Barbus meridionalis* proposed monitoring sections (❽), based on the geographically extreme monitoring sections. *Barbus meridionalis* distribution , update situation (Duplić, 2012).

Evaluation of the conservation status

First a complete systematic survey of this species range on the national territory should be done and the range should be continuously compared with the future monitoring data.

These fish species population quantitative and qualitative elements, selected in the upper monitoring sections can be based on some specific fish biotic index criteria. The selected combination of metrics was designed to reflect insights of assemblage and population comparable perspectives. Each metric value should be compared with the values estimated from other similar sites. It should be considered that when the biotic integrity (based on the following metrics) decreases, the population, habitat and lotic ecosystem quality decreases as well.

The proposed categories of metrics are: I species richness and composition (1 total number of fish species; 2 proportion of benthic fish species; 3 proportion of water column species; 4 proportion of individuals of intolerant species; 5 proportion of individuals of typically tolerant species), II trophic composition (1 proportion of individuals of omnivorous feeders; 2 proportion of individuals as insectivorous feeders); III fish abundance and condition (1 numbers of individuals in the sample, 2 introduced species will be assigned to each metric species, on zoogeographic basis).

Ratings of 5 to 1 should be assigned to each metric according to whether its assessed value approximates deviates somewhat or strongly from the value expected by the best expert judgement at a comparable site that is relatively similar, but also relatively undisturbed.

The total obtained score for each site should represent all the nine-metrics sum and the scores can be interpreted with the following interval comparison: 45-43-excelent, this score reflects excellent, comparable to pristine conditions, exceptional assemblage of fish species; 42-36-very good, this score shows a decreased species richness, intolerant species in particular, sensitive species present; 35-31-good, this score describes fair intolerant and sensitive species absent, skewed trophic structure; 30-24-fair, this score reflects some expected species absent or rare, omnivorous and tolerant species dominant; 23-17-fairly poor score shows few species and individuals present, tolerant species dominant; 16-10-poor, this scores describes very few species and individuals present, tolerant species dominant; 9-1-very poor, this score reflects extremely low number of species and individuals present, tolerant species or no fish.

A real assessment of any fish species population conservation status can be done only in the ichthyocenosys assessment context!

Any other simplified monitoring/assessment approaches will have a lower and/or uncertain quality of the obtained results!

The use of these integrated ichthyologic metrics allows the possibility to assess both the conservation status of the target population/populations in the local specific ichthyologic assemblage context and of the fish habitat as well!

At every six years period, supplementary sampling stations should be done in all the upstream and/or downstream extreme (concerning the geographical position) areas in order to highlight the potential territorial expansion of the species.

The reduction in the species range can be highlighted through the usual presence or absence of the species in the monitoring stations.

Evaluation Grid

A 50/50 km grid was applied on the Danube Basin map of Croatia (Fig. 10).

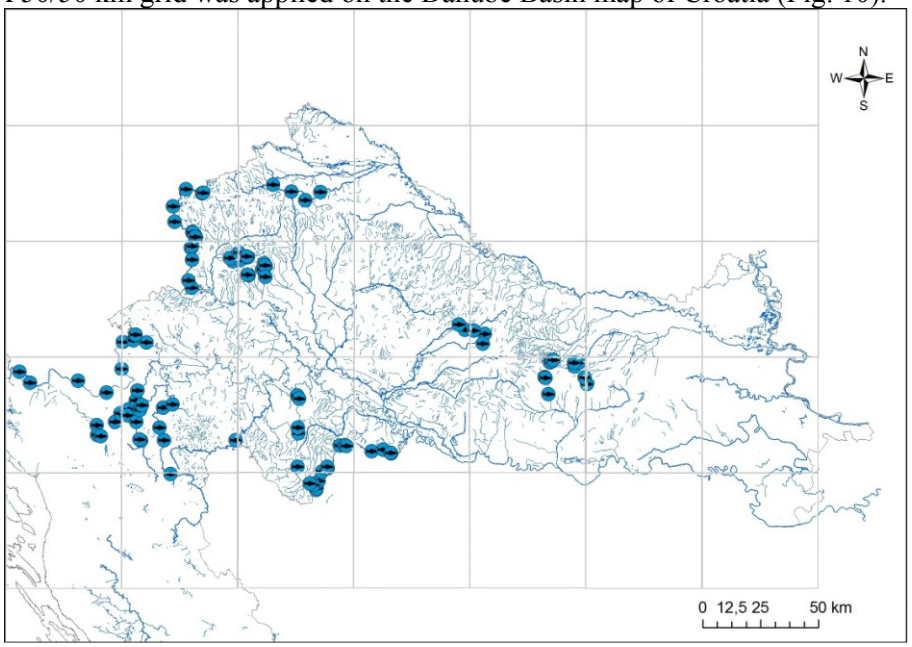

Figure 10: 50/50 km (grey) grid, used as a base for *Barbus meridionalis* monitoring areas.
Barbus meridionalis distribution, update situation (Duplić, 2012).

The minimum number of monitoring areas - 12, for *Barbus meridionalis* should have at least one monitoring section in every 50/50 km plot (✵), plots are proposed based on the eight selected criteria, (Fig. 11).

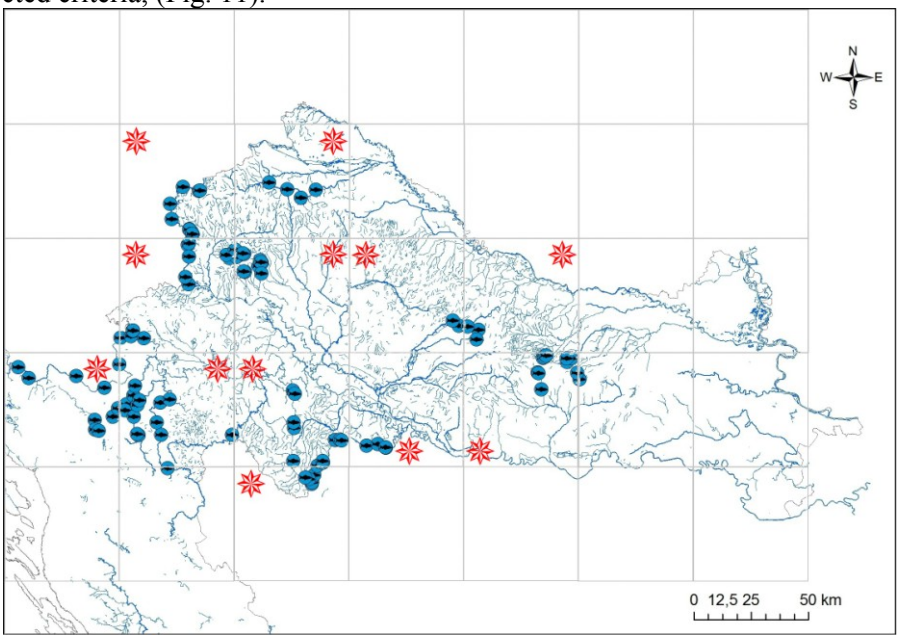

Figure 11: The minimum 12 sampling stations for *Barbus meridionalis*
should be in the marked 50/50 km plots (✵).
Barbus meridionalis distribution, update situation (Duplić, 2012).

The 12 minimum sampling/monitoring areas, one in each 50/50 km plots, were selected in those points/areas where as many as possible monitoring sections, proposed based on the eight criteria) overlapping; thus each of these 12 minimum sampling areas correspond to as many criteria as possible, with the lowest possible costs, effort and time.

Depending on available funding, time and local/national working team potential the number of the monitoring stations can be multiplied with 2, 3, 4, 5, etc., for every 50/50 km plot.

1. From a **qualitative** point of view, the data on the presence of the monitored fish species in each of the 12 50/50 km plots, present a first level of information regarding the species conservation status in Croatian Danube Basin, in terms of future prospects, suitable habitats, populations, as well as area and range. The presence of the species in all 12 50/50 km plots will reveal an excellent conservation status in the Croatian national territory, in 11 very good conservation status, in 10 good conservation status, in 9 fair conservation status, in 8 fairly poor conservation status, in 7 poor conservation status and in 6 or less a very poor conservation status.

2. The second level needed is also a **qualitative** approach, in respect to: age structure, presence/absence of 0+ age individuals, presence/absence of 1+ age individuals, presence/absence of 2+ age individuals, presence/absence of 3+ age individuals, presence/absence of 4+ age individuals, presence/absence of 5+ age individuals. Every plot of 50/50 km is evaluated based on the presence/absence of the age classes. A plot with all 6 age classes will be evaluated as being in an excellent conservation status; 5 age classes presence will reflect a very good conservation status, 4 classes mean a good conservation status, 3 classes fair conservation status, 2 classes fairly poor conservation status, 1 class poor conservation status. This approach should be made independently for each 50\50 km plot, and in the end an average value for all the plots will represent a mean national conservation status.

3. The third level is also a **qualitative** approach, in respect of species composition; only *Barbus meridionalis* presence will represent a poor conservation status; *Barbus meridionalis* + another (indigenous) species represents a fairly poor status of conservation, *Barbus meridionalis* + two fish (indigenous) species represent a fair conservation status, *Barbus meridionalis* + three fish (indigenous) species represent a good conservation status, *Barbus meridionalis* + four fish (indigenous) species represent a very good conservation species, *Barbus meridionalis* + five or more (indigenous) fish species represent an excellent conservation status. This approach should be made independently for each 50\50 km plot and in the end an average value for all the plots, will indicate the mean national conservation status.

4. The fourth needed level is the **integrated** approach. For every monitoring section, results should be obtain in terms of the following IBI (Bănăduc and Bănăduc, 2002) scores (45-43-excellent, 42-36-very good, 35-31-good, 30-24-fair, 23-17-fairly poor, 16-10-poor, 9-1-very poor), which will reveal at quantitative level the conservation status of the *Barbus meridionalis* population in the ichthyocenosys assessment context. This approach is made independently for each 50\50 km plot and in the end an average value for all the plots, will indicate the mean national conservation status.

5. Finally, an average value from the previous 4 steps at national level should be estimated for every plot, and finally for all the plots, and this will be the obtained national conservation status for *Barbus meridionalis*, as a result of the monitoring activities programme.

CONCLUSIONS

The proposed *Barbus meridionalis* monitoring sites, at the Croatian national level, were selected based on eight main criteria: (1) national border proximity areas/sectors coverage; (2) high quality populations of *Barbus meridionalis* in terms of population structure/density (ex. Protected areas, but not only) in characteristic/optimum/good habitats; (3) habitats which should be ecologically reconstructed to allow *Barbus meridionalis* populations structure improving or natural repopulation; (4) key habitats/sectors with high importance for connectivity (ex. Rivers confluence areas; intermediate lotic sectors between different important populational areas); areas/sectors negatively influenced by human impact such as: (5) industrial pollution point sources, (6) areas/sectors influenced by agricultural pollution diffuse sources, (7) areas/sectors influenced by habitat modifications (physico-chemical, watercourse regulation, remodeling, etc.); (8) geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes. These criteria based monitoring site selection represent a significant sum of various influences which can affect this fish species distribution, conservation status, survival and abundance of its populations.

It was considered that these criteria elements exist currently in Croatia and can influence the future conservation status of this fish species. The monitoring sites selections were based on these criteria and the monitoring sections were identified one by one on the maps, based on the existent fish related bibliography.

It should be stated that the potential future improvement of *Barbus meridionalis* distribution data on the Croatian territory, can improve the monitoring sites present situation, the process of improving this specific monitoring system being a permanent and flexible one.

The biological and ecological monitoring in this respect cannot be replaced by the physico-chemical monitoring, even in the monitoring sites selected for the human impact analysis; but some physico-chemical criteria of the species habitat quality should be included in the monitoring, if the fish monitoring stations will overlap with the national Croatian integrated monitoring stations in the future.

Species conservation status components

The ***future prospects*** as one of the four components of this fish species conservation status are highlighted using the following criteria for monitoring site selection: national border proximity; habitats which should be ecologically reconstruct; and areas/sectors negatively influenced by human impact. Thus, also the trends regarding the human induced pressures and threats towards this species can be highlighted.

The ***habitat*** of the species is the second component of its conservation status, related to the area and quality of the suitable habitats. Thus, also the trends regarding the occurrence areas of this species, increasing versus decreasing areas situations, increasing versus decreasing habitat quality situations can be highlighted. For these purposes, monitoring sites criteria based on selection was also done, involving criteria like: national border proximity areas/sectors coverage; high quality populations; habitats which should be ecologically reconstructed; key habitats/sectors with high importance for connectivity; areas/sectors negatively influenced by human impact. Also in this respect some specific metrics were selected: I presence/absence; II age structure, presence/absence of 0+ age individuals, presence/absence of 1+ age individuals, presence/absence of 2+ age individuals, presence/absence of 3+ age individuals, presence/absence of 4+ age individuals, presence/absence of 5+ age individuals; III species composition; IV relative abundance in the local ichthyofauna context.

The ***population*** is the third component of the conservation status for this species. It is assessed based on population size and population structure in terms of reproduction and age structure. To cover this component, respectively the favorable reference populations which are considered as able to ensure the long-term viability of the species, the following metrics were selected: I presence/absence; II age structure, presence/absence of 0+ age individuals, presence/absence of 1+ age individuals, presence/absence of 2+ age individuals, presence/absence of 3+ age individuals, presence/absence of 4+ age individuals, presence/absence of 5+ age individuals; II species composition; IV relative abundance in the local ichtyofauna context.

The fourth component of the species conservation status is the ***range***, which represents the spatial limits within which this species permanently occurs. The trend of the range increasing or decreasing dynamics can be spotted based on the following criteria, which were used for the selection of some monitoring sites: national border proximity areas/sectors coverage; key habitats/sectors with high importance for connectivity; geographically extreme monitoring sections in the upstream-most and downstream-most sections of rivers, in this species range and in the near outer proximities of these extremes.

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