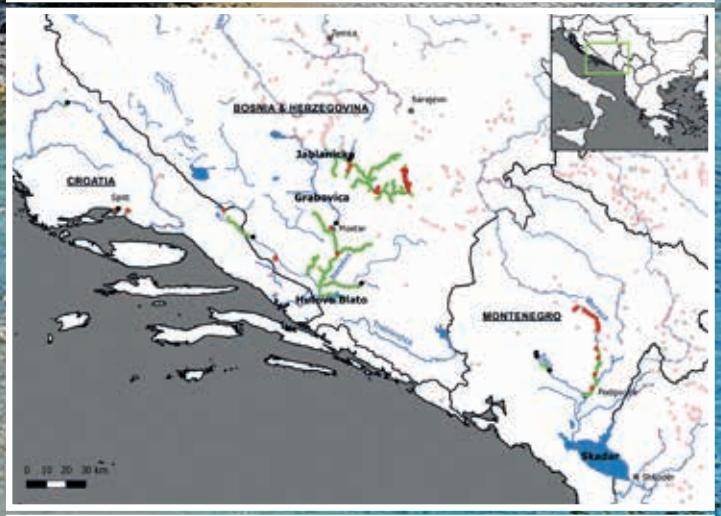
Balkan Rivers

save the blue heart of europe

Endangered Fish Species

Distributions and threats from hydropower development



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Endangered Fish Species

Distributions and threats from hydropower development

euroNATUR RiverWatch UNI GRAZ

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The upper Neretva River (A. Vorauer); marble trout (Salmo marmoratus) & Neretva spined loach (Cobitis narentana) (Perica Mustafić); map of distribution of the endangered softmouth trout (Salmo obtusirostris)

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EXECUTIVE SUMMARY

We reviewed the potential impact of large-scale hydropower expansion on the conservation status and extinction threat of 113 freshwater fish species on the Balkan Peninsula. Each of these species is listed in one of three IUCN threat categories and/or listed in one or more annexes of the European Habitats Directive or Bern Convention. For 81 of these species, GIS-based distribution maps have been overlaid with distributions of existing hydropower facilities (ca. 1,000), those in construction (ca. 180), or those planned (ca. 2,800) to explicitly demonstrate the spatial dimension of potential habitat loss. Based on these plans, we predict that up to **49 freshwater fish species are faced with either the threat of extinction or loss of between 50 and 100% of their Balkan distribution.** Of these, **eleven endemic species are threatened with extinction, seven will become critically endangered, and the number of endangered species will double to twenty-four.** For 68 of 69 endemic species, **habitat losses are estimated between 30 and 100%, resulting in increased levels of endangerment for essentially the entire endemic fauna.** Additionally, the **four migratory sturgeon species would essentially lose their potential for rehabilitation in the lower Danube** if additional dams were constructed there.

Three exemplary hotspots of biodiversity and threat were further described: The Neretva basin in Bosnia-Herzegovina and Croatia with fourteen listed species, the Morača/Skadar system in Montenegro and Albania with eleven listed species, and the Tara/upper Drina system in Montenegro and Bosnia-Herzegovina with nearly 200 kilometers of free-flowing riverine habitat. An additional six rivers of strategic conservation interest (the Sava in Slovenia and Croatia; the Kolpa on the Croatian-Slovenian border; the Una on the Croatian-Bosnian-Herzegovinian border, the Lim in Montenegro; and the Sana in Bosnia-Herzegovina) are described with respect to their length and value in conserving self-sustaining populations of key species, such as the endangered huchen. Several smaller rivers (Cetina River, Croatia; Kalamas River, Greece; Treska River, Republic of Macedonia) are discussed as critical habitat for species, whose global existence is endangered.

Introduction

Background

The **Balkan Peninsula** is a sub-region of the Mediterranean region, and as such, in **the center of the world's original 25 designated biodiversity hotspots** (Myers 2000). **For freshwater biodiversity, the Balkan region is the most important hotspot** for both mollusks and fishes **in Europe** (Freyhof 2012). It also harbors Europe's highest concentration of endemic fish species (Freyhof & Brooks 2011), whereby both species diversity and endemism can be further allocated into natural biogeographic units within the region (Oikonomou et al. 2014). Stretching from Slovenia to northern Greece (see Fig 1), the Balkan region contains 35,000 km of rivers (catchments > 500 km^2), 80% of which are categorized to be either in pristine (ca. 30%) or good (ca. 50%) hydromorphological condition (Schwarz 2012). This is in stark contrast to the state of rivers in the rest of continental Europe, where, for example, a country like Austria reported only 6% of its river kilometers in pristine condition and 15% in good condition (Muhar et al. 1998). Despite the fact that the Balkan region has some of Europe's most pristine rivers and is a global hotspot of biodiversity, the region is the target of one of the most ambitious hydropower expansion plans in the world, with currently up to 2,800 projects planned, over one third of which are located in protected areas, such as national parks (Schwarz 2017). As a building block for the ***Save-the-Blue-Heart-of-Europe*** campaign, this report aims to provide an exhaustive list of endangered freshwater fishes, their distributions and their level of vulnerability to hydropower expansion. The report builds upon a similar species-specific study on the vulnerability of Danube salmon (*Hucho hucho*) to hydropower expansion in the region (Freyhof et al. 2015) as well as a broader evaluation of endangered mollusks and fishes (Freyhof 2012).

Project scope

Geographically, the study considers the same region covered in Freyhof (2012) and Schwarz (2012), an area of ca. 450,000 km^2 from Slovenia to northern Greece, including river basins south (i.e. right tributaries) of the Danube from Hungary to Bulgaria as well as Aegean Sea drainages of estern Turkey (see Fig 1., as well as http://www.balkanrivers.net/en/map).

Fig. 1. *Area of investigation from Slovenia south to northern Greece and east along the Danube River including all right tributaries of the Danube along the Bulgarian border to the Black Sea, as well as the Aegean Sea coast along southern Greece and Turkey up to Istanbul.*

Taxonomically, obligate freshwater fishes including anadromous and catadromous species are considered, with an emphasis on riverine fishes, including lacustrine species that either require rivers for spawning, or whose habitats could be threatened by water level changes of lakes or springs due to hydropower development (N = 113 species). Each of these species is listed in an IUCN Red List threat category, namely (Critically Endangered (CR), Endangered (E), or Vulnerable (VU)) and/or appear in one or more Annexes of the European Habitats Directive (i.e. Annex II, IV, V), or the Bern Convention (Appendices II, III) as they are subject to various levels of protection by European Member States (Table 1). Of the species on this list, 101 species (90%) are considered at least moderately sensitive to hydropower development. For 81 of these species, we have created a GIS-based distribution map based on available data from both scientific literature as well as local expert contributions (primarily academic scientists or government officials). These maps are overlaid with the most up-to-date shape file of existing or planned hydropower facilities (Schwarz 2017). For each species, we provide a brief description of their conservation status, unique biological features and vulnerability to hydropower development at various levels, including the immediate threat to their Balkan distribution, or, where relevant, their global existence stemming from planned hydropower

expansion. While a comprehensive description and summary of each species is beyond the scope of this study, we do provide an up-to-date reference list for more detailed information (see also bibliography of Oikonomou et al. 2014). Additionally, we take a closer look at three hotspots with respect to fish biodiversity or ecosystem quality and immediate endangerment due to one or more planned hydropower facilities.

Legislation

The International Union for Conservation of Nature (IUCN) is not a legislative body, but an umbrella organization with its headquarters in Switzerland and nearly 1,400 government and non-governmental organizations as members. One of their most visible tasks is the maintenance of the IUCN Red List of Threatened Species – on which some of this report is based. Based on a set of objective criteria, IUCN assessments are done by independent scientists on a volunteer basis. The listings are peer-reviewed and updated when new information becomes available, and assessors submit an updated assessment. We have checked the IUCN status of all species listed in this report and further noted whether assessments are in need of an update (Table 1). For a few species which either have not been assessed or their status clearly needs changing, we provide recommendations. IUCN assessments are primarily for the global status of a species, although regional assessments are also possible. This means that for those species with very broad distributions or some distribution outside the Balkan region, their global status may not reflect their level of endangerment in the Balkans. In summary, although the IUCN Red List status of a species has no direct legal meaning, it does represent the best scientific and politically independent assessment of a species' conservation status at the global level.

The Bern Convention is a legally binding instrument, ratified in 1982, focused on European nature protection, for both members and some non-members of the Council of Europe (https://www.coe.int/en/web/bern-convention). It includes annexes of species, with varying levels of protection. This agreement is relevant to the protection of listed species in the Balkans in that **NGOs as well as private citizens may issue complaints concerning the lack of implementation.** For each species, we note if it is listed under Appendix II (Strictly Protected Fauna) or Appendix III (Protected Fauna) of the Bern Convention. **Additionally, we include species that stem from taxonomic splitting, as these automatically assume the protection assignment of the parent species (see list in Freyhof & Brooks 2011).**

The European Habitats Directive (92/43/EEC) together with the European Birds Directive (2009/147/EC), is the backbone of legally binding European species protection and conservation. The relevant appendices for this report are Appendix II (species of community interest, for which protection areas must be assigned), Appendix IV (strictly protected species), and Appendix V (species whose exploitation is compatible with a favorable conservation status). For all 113 species reviewed, we list their assignment to one or more of these appendices, whereby **similar to the Bern Convention, daughter species assume the assignment of their parental species (see list in Freyhof & Brooks 2011).**

For clarity, we note that our species list and assignments to various Annexes of the European Habitats Directive and the Bern Convention are based on the list compiled by Freyhof & Brooks (2011), and also reflect the most recent nomenclatural changes found in the Catalog of Fishes (Eschmeyer et al. 2018, ver. Jan 13, 2018).

Hydropower Sensitivity

For each species, an assessment of its sensitivity to hydropower is given dependent on its tolerance for impoundment, its sensitivity to invasive species (which invariably accompanies impoundments), and its need for fast or moderately flowing water and clean gravel for one or more phases of its life-history or its general sensitivity to hydrological disturbance (e.g. for karst species). These assessments, where applicable, follow those of Freyhof (2012), comments by Kottelat & Freyhof (2007) as well as recent literature. The assessment of Balkan Dam Threat is made based on the loss of habitat that would occur if all or most of the planned hydropower schemes in the distribution range of the species were to be built. If the species would lose most or all of its global distribution and would be in immediate danger of extinction, the threat assessment would be “Very High”. If a species would lose 50% or more of its Balkan distribution range, it would be assessed as “High”, even if part of its range existed outside the Balkans. A moderate threat would be assigned to those species that would lose at least one third of their range, and low or low-to-moderate assignments were essentially given to either species that are generally less sensitive to hydropower development or, species whose ranges outside the Balkans are very large and thus their global status would be little affected by what happens in the Balkans. In this way, we define in general terms what the hydropower expansion plan on the Balkan Peninsula means for the survival of each of the assessed species at the global level.

Distribution Data

The data and general knowledge behind each species distribution in this report is of varying quality. While certain government agencies or research groups have already spent a great deal of time collecting new data on the distribution of their freshwater fauna, for others it is a work in progress. There is also varying public access and levels of cooperation concerning faunal distribution data, and species with very limited distributions are obviously easier to map, than those distributed across large river basins, like the Danube or across many different jurisdictional borders. Finally, the habitat demands and behavior of each species have tremendous influence on our ability to map them accurately; some species may be widely distributed, but occur only very rarely within this distribution, others undergo relatively long migrations, and yet others can colonize headwater stream habitats if the conditions are suitable, but data will rarely be available at this scale. In our efforts, we aim to be as transparent as possible concerning the accuracy or confidence surrounding each species or drainage. That being said, there is generally higher confidence for the data from Slovenia, Croatia and Greece and thus relatively high confidence there for most if not all of the species presented. For species with relatively broad ranges, there is more uncertainty, especially if they have become increasingly rare – such sparse or fragmented distributions were mapped by marking for example the entire Danube River (e.g. *Pelecus cultratus*) but not implying that the entire river is prime habitat for the species. The distributions presented for Albania and Serbia are relatively good for most, but not necessarily all species. The data situation in Bosnia-Herzegovina, Montenegro and Republic of Republic of Macedonia is less satisfying, but improving steadily in all three countries. For the Neretva River and its tributaries, there is recent ongoing work that has helped tremendously, so we believe that the information presented there is relatively accurate but not necessarily exhaustive for each of the species presented. Additionally, as we write, there is new data being collected, and, some populations are disappearing. Thus, distribution data is much more dynamic than one might think. For this reason, and in an attempt to adhere to normal academic procedures, this entire report has been sent out to several regional experts for review, to ask for improvements concerning local or up-to-date information. Lastly, the distribution data presented in this report is not meant to replace project-specific environmental assessment requirements. Rather, we provide distribution data at a sufficient scale to make large-scale predictions of species loss and to serve as background information for large-scale conservation planning.

Hydropower impacts

Environmental Impacts of Hydropower

Hydropower is a blanket term referring to a variety of technologies that exploit the kinetic energy of falling water for transformation into electrical energy. This report will not attempt to address all environmental impacts associated with the construction and operation of hydropower facilities. However, it is acknowledged that dams in general represent one of the major anthropogenic disturbances of our freshwater and nutrient cycles globally (Van Cappellen & Maavara 2016). While no form of energy development is benign concerning the environment, hydropower clearly has the most significant ecological impacts compared to other major forms of renewable energy, and is especially risky in certain geographical settings (Gibson et al. 2017). Numerous studies reveal large-scale trends of fish species loss and reduced abundance due to the loss of habitat, habitat fragmentation and disruption of the hydrological regime (Dynesius & Nilsson 1994; Nilsson et al. 2005; Liermann et al. 2012; Carvajal-Quintero et al. 2017). Increasingly, the spread of invasive species is a major problem (Piria et al. 2017;Todd et al. 2017), and this can be up to 300 times more likely in man-made reservoirs than natural lakes (Johnson et al. 2008). However, different types of facilities have very different impacts on biodiversity and eco-system function, and each river and its biotic community respond differently to both short- and long-term effects of hydropower construction and operation. There is also the issue of scale, at both the site and landscape level. It may perhaps help frame the discussion to recognize some of the more surprising or extreme potential impacts of large-scale hydropower development. These start with the production of greenhouse emissions, first brought to light by Rudd et al. (1993), reviewed by Vincent et al. (2000) and subsequently supported by over 200 studies (Deemer et al. 2016), to the rarely discussed triggering of earthquakes, now supported for up to 90 different sites globally (Tuan et al. 2017). While not confirmed, there is mounting evidence that the earthquake in Sichuan, China that claimed 80,000 lives was triggered by the filling of the Zipingpu reservoir (Gupta 2011, cited from Tuan et al. 2017). Regardless of the rarity of such events, it is imperative to properly communicate the landscape-scale and transboundary dimensions of the current exploitation plan on the Balkan Peninsula, and to predict its negative consequences on the environment throughout the region. To help do that, and focus primarily on fish biodiversity, we will first summarize the different technologies that are involved as well as the site-specific or species-specific consequences that each type of facility or operational scheme produces.

In the next section, we will briefly consider four basic types of hydropower schemes, which can also be combined, and their most obvious impacts on the aquatic fauna, followed by a section on fish passage. There are also a variety of alternative or lower-impact technologies on the market, but they are still extremely rare in comparison to traditional forms of hydropower exploitation, and to our knowledge, they comprise few of the current exploitation plans on the Balkan Peninsula.

Types of facilities

Hydropower schemes: 1) storage 2) run-of-the-river; 3) diversion run-of-the-river, and 4) pump-storage

1) Storage hydropower: Most of the world's largest hydropower dams are storage facilities. As such, they dramatically alter the landscape, across several hundred if not several thousand square kilometers. Many of these large dams also serve other goals, namely drinking water supply, irrigation and flood control, and a large number of dams may serve exclusively non-energy needs, but we limit our discussion to dams that are primarily built for energy production. The environmental problems resulting from large storage hydropower plants are numerous. For now, **we emphasize three issues that are more specifically relevant for storage hydropower** compared to run-of-the river facilities. First, **most facilities involve "hydropeaking"**, i.e., the varying release of water through the turbines to meet peak-load electricity demand. Hydropeaking is recognized as one of the most pervasive impacts on downstream environments at distances of up to hundreds of kilometers for the very largest facilities (Poff et al. 1997; Wohl 2012; Holzapfel et al. 2017). The ecological consequences are that young fish become stranded (Halleraker et al. 2003; Nagrodski et al. 2012; Harby & Noack 2013), spawning sites or activity may be disrupted (Tiffan et al. 2010), and biological productivity is heavily impacted (Kennedy et al. 2016). Second, **large impoundments almost always become dominated by non-native species,** and their spread is **one of the most wide-ranging threats to the rich endemic fish fauna of southern Europe** (Freyhof 2012; Marr et al. 2010). Third, **most of the dams for such facilities, even in the Balkans, are too high to accommodate any fish passage facility** (Fig. 2).

Fig. 2. *Left, the 228 meter high Mratinje Dam on the Piva River, Montenegro; Right, the 113.5 meter high Krichim Dam on the Vacha River, Bulgaria.*

2) Run-of-the-river ROR: The entire width of a river is dammed and turbine stocks are integrated directly into or beside the facility. Most often there is no storage of water, so electrical generation is directly related to river flow. For larger dams, or chains of dams, however, short-term (hours or days) storage can be used to exploit varying prices that follow varying demand. **The general problems** that run-of-the-river plant operations create (all of these problems are also relevant for storage facilities) usually **involve fish passage both upstream and downstream, interruption of sediment transport, sedimentation and flushing of the reservoir, altered ground water levels and the promotion of invasive species.** If the facility is large, or there is a long chain of smaller facilities, **short-term storage and varied release, termed "hydro-filibration"** (see Greimel et al. 2016) also **can be a problem,** but is markedly less than hydropeaking for storage facilities. **The smaller the facility, the less likely all of these negative impacts will occur, while larger facilities will often exhibit all of these consequences at some level.** From an ecological perspective, the least problematic sites for hydropower exploitation are those with the highest gradients, where fishes may not even exist, or fish passage is not an issue. Not surprisingly, ecological disturbance is minimized where the natural fall of water is used with the least amount of river engineering or manipulation of the natural hydrological or sediment regimes**. When sites are sub-optimal** in terms of gradient, or urbanization, like most remaining unexploited sites in Central Europe, **even ROR schemes may involve extraordinary encroachments.** In such

sites, **the riverbed downstream from the dam will be dredged and channelized to help create a higher drop,** while upstream, **levees and drainage systems are needed to protect settlements or agricultural lands** from the elevated water level. These engineering measures degrade natural habitats, fragment or isolate fish populations, create cyclical problems concerning flood control, drainage, and reservoir capacity and can dramatically alter ground water levels. **Closed chains of ROR facilities, foreseen for many Balkan rivers, transform rivers into a series of highly engineered pools that must be routinely flushed to transport fine sediments. Reservoirs in such systems are not lakes.** Lakes do not fill with fine sediments over periods of months or a few years and thus do not need to be regularly flushed (Fig. 3 and 4). When flushing takes place, **the consequences can be catastrophic for life below the dam, sometimes for a few hundred meters, or for many kilometers** depending on the volume of fine sediment being transported and flow levels (Zarfl et al. 2015; Bauligao et al. 2016; Grimardias et al. 2017).

Fig. 3. *Example of a run-of-the-river reservoir being flushed on the Mur River north of Graz.*

Even fish above the dam are often left stranded. Frequent flushing means a high frequency of lower level disturbance below the dam, but less chance for most organisms to build sustainable populations in the reservoir, even those species tolerant of reservoirs. Longer periods between flushing

Fig. 4. *Several hours later at the same reservoir, just upstream from the dam. Large amounts of sediment can still be seen along the sides of the reservoir. All artificial reservoirs are faced with this problem to varying degrees.*

may allow reservoir-adapted communities both above and below dams to develop, but when flushing eventually takes place, it is usually much more catastrophic as larger loads of fine sediment must be moved. Downstream from the dam, life can be exterminated for many kilometers in some cases. Where possible, coordinating such events with natural floods may be advantageous for downstream environments, but impacts are dependent on channel morphology and available habitat complexity or downstream floodplains and thus are difficult to generalize. **Fig. 5 and 6 show a recently flushed reservoir on the Neretva River, Bosnia-Herzegovina, where 2 million fish were reportedly killed.** When very small ROR facilities are built, with the utmost care and foresight concerning site-choice, and state-of-art technology concerning fish migration and riparian habitats, and there are no fluctuating releases, ecosystem damage can be minimized. **However, current plans of hydropower expansion on the Balkan Peninsula do not envision such small-scale development; plans either involve very large dams without regard to strategic placement, or entire rivers are slated for chains of smaller dams.** The latter type of development, even when state-of-art fish passes are installed, would invariably result in cumulative mortality and stress for both upstream and downstream movement and migration, a large-scale loss of riverine habitat, and large-scale alterations in bed-load dynamics and sediment flushing.

Fig. 5. *In January 2017, the 30 km-long Jablanićko Reservoir on the Neretva River was flushed and two million fish were reportedly killed (https://www.fokus.ba/vijesti/bih/pozder-zbog-unistavanja-jablanickog-jezera-rukovodstvo-epbih-mora-dati-ostavke/617366/).*

Fig. 6. *Aerial view of the Jablanićko Reservoir in early February 2017 after flushing.*

3) Run-of-the-river, with diversion RORD: This type of scheme uses the same principles as ROR plants, but the power station is placed many kilometers downstream (or even in another catchment) and the bulk of the water does not flow through or over the dam but rather is diverted to the powerhouse via a diversion channel or pipe. The motivation is economic but also logistic; the dam can often be considerably smaller, as the "drop" or so-called "head" is not created at the dam itself but rather across the landscape, as the diversion ends at a powerhouse that can be tens or even hundreds of meters lower than the site of the dam. This type of hydropower plant is often touted as the most environmentally friendly because the dams are smaller and thus the problems outlined above can be reduced. The ultimate version of this concept is no dam at all, but rather an instream structure or screen (e.g. a Tyrolean weir) that allows the water to fall through the riverbed into a diversion canal. While most RORD dams can generate some if not all of the problems of non-diversion facilities, quantitatively, problems should be reduced compared to a non-diversion scheme. However, this is usually not the issue. **Rather, the main point of contention with such schemes is how much water is being diverted.** If all water is diverted, then obviously all life downstream is eliminated for the stretch of riverbed between the diversion and the powerhouse. If the plant operators are very generous with the residual flow, then the severity of environmental impacts can be reduced. Currently, all newly constructed RORD hydropower plants in the EU must release some "residual flow" below the dam or other type of diversion device. There is a vast technical literature on residual flows and implementing the law in some cases can be complex, **but to simplify and generalize, abiding by EU law usually requires the operator to leave approximately 5% of the river flow in the riverbed below a diversion.** The river channel below the diversion is then called the residual flow stretch or channel. While 5% is an improvement over zero, it cannot be considered "ecological". Negotiating for more residual flow under current economic conditions, however, is becoming increasingly difficult. For ecological goals, it is also not simply a matter of the quantity of water as the suitability of instream habitat in residual flow stretches varies with channel morphology, season and species among other factors (Person et al. 2014). However, **another major issue for the Balkan scenario is both compliance, which is difficult to enforce, as well as climate change. All too often residual flows are foreseen but in reality do not materialize and the results are catastrophic for all river life (Figs. 7-9).**

Fig. 7. *Ugar River, Bosnia-Herzegovina, a tributary of the Vrbas River and former spawning area for the endangered Hucho hucho reported in Freyhof et al. (2015).*

Fig. 8. *Power plant on the Rapuni River, Albania. Neither the flow in the fish pass nor the residual flow below the dam is sufficient for sustaining life in the river*

Fig. 9. *Storage diversion dam for hydropower generation on the Neretva River, Bosnia-Herzegovina showing no residual flow and a dry river channel below the dam.*

The future will definitely put more pressure on hydropower facility operators to fight for every drop of water, as climate change models for Southeastern Europe predict large reductions in hydropower potential due to reduced precipitation; for example; by 2070, a 43% drop for Greece, -35% for Bosnia, and -25% for Slovenia and Croatia (Lehner et al. 2005; van Vilet et al. 2016; Bonjean Stanton et al. 2016). Indeed, **increasing droughts are already a major problem for many freshwater fishes in southeastern Europe** and **reduced water supplies will put all stakeholders, including hydropower plant operators in a state of increasing competition and potential conflict.** With this future scenario, it is difficult to see how the residual flow issue will improve to the benefit of downstream habitats. **The logical expectation is that it will become increasingly difficult to obtain sufficient flows for sustainable ecological goals, whether legislated or not.**

4) Pump-storage: Pump-storage hydropower belongs in its own category, because there is no net production of electrical energy. Nevertheless, with rising interest in energy storage and grid flexibility there is currently increased interest in pump-storage. Pump-storage plants use electricity from other sources to pump water to a higher elevation (normally during periods of low demand, or opportunistically when cheap electricity is available) in order to let it back down the gradient when needed (during peak demand). A net electricity loss of at least 20-25% is assumed. **The environmental problems associated with pump-storage**

are primarily limited to the land being used; the availability or source of the water being used; and, whether or not the system is closed or open. If the system is open, then a surge of water is being released into the environment, which, like hydropeaking, can have catastrophic effects. **If the system is closed, then there are usually no environmental effects from the operation itself.** Recently, with the surge in renewable energy growth, especially in the wind and solar sectors, and a corresponding lack or limited control over how much electricity is being fed into the grid, **pump-storage has also been used to simply stabilize the grid, in that surplus energy is taken up by a pump-facility, independent of demand to produce electricity.**

All of the technologies mentioned can be combined in various ways, can utilize run-off or snowmelt directly, and so do not always directly affect a riverine environment. **The most prominent and ecologically damaging plans in the Balkans at this time are large storage facilities on relatively intact river systems on one hand, and the high density or cascades of plants of varying design on the other, as they consume riverine habitat across long stretches of river.** Additional landscape-level effects involve the disruption of bed-load dynamics, which promotes downstream erosion. With time, this leads to riverbed incision (or degradation), meaning **river beds deepen, with rates varying from 30 mm to 500 mm per year (Petts 1984) and this in turn causes a number of long-term problems relating to groundwater levels, infrastructure stability (e.g. bridges), fragmentation of tributaries (fish can no longer access them) and bank stability.** These landscape-level geomorphological consequences of dams are well-known but seldom considered in development plans (Petts & Gurnell 2005; Bizzi et al. 2014) and ultimately lead to erosion of river deltas in our oceans (Gupta et al. 2012). **Globally, sediment accumulation behind dams reduces generation capacity at a rate that exceeds newly installed facilities and climate change should exacerbate this problem** (Gaudard & Romerio 2014 and citations therein). **Considering the transboundary scale of the current plans on the Balkans, these issues should be integrated into discussions of feasibility, long-term costs, and liability.**

Fish passage

Fish passage facilities are usually only relevant at ROR and RORD hydropower sites as most if not all storage facilities are too high. Even some larger ROR plants present major problems for fish passage, and at some such facilities, fish-lifts have been installed, with varied success (Bellariva & Belaud 1998, Croze et al. 2008), but the use of such technology is very limited, and normally only applied for some commercially valuable anadromous species, such as shad

(*Alosa sp*.) or Atlantic salmon (*Salmo salar*). The topic of fish passage technology is broad and there is abundant technical literature on the subject (see Jungwirth et al. 1998, Clay 1995). For our purpose of landscape-scale assessment of hundreds, if not several thousand projects, **we summarize the following issues: *Efficiency/Mortality, Compliance/Maintenance*, and *Habitat*. First, there is usually some level of fish mortality or failure for both upstream and downstream movement at all fish passage facilities.** Schwinn et al. (2017) reported 74% reduced survival of downstream migrating salmonids in a Danish stream, and Calles et al. (2012) reported between 10 and 67% mortality for salmon, trout and eel. In a quantitative review of 65 fish passage efficiency studies, Noonan et al. (2012) reported an upstream passage efficiency of approximately 42% considering all species, but as little as 21% for non-salmonids. These studies were largely conducted with species and systems where state-of-the-art technologies were available if not applied. **This alone should make hydropower development in national parks or European Natura 2000 areas questionable, especially those areas that were established specifically for the protection of a river and its fauna, as the case is for the Mur in Slovenia (see Weiss 2017).** If a protection area has been established for the protection of one or more specific species, activities resulting in the direct mortality of half or more of the population of those species would appear to be illegal. **Next, most if not all fish pass facilities require maintenance and monitoring to insure that the legislated flows are maintained,** the facility is operating as planned, **and obstructions such as garbage or driftwood that accumulate during high water events are regularly removed.**

Fig. 10. *Debris jam on the downstream side of a vertical fish pass on the Saalach River, Austria. (BMLFUW 2012).*

Fig. 11. *Debris jam on the vertical-slot pass on the Ill River, at the Hochwuhr power plant in Voralberg, Austria (BMLFUW2012).*

These issues present problems even for passage of economically valuable species such as salmon and shad where major stakeholders are involved. **The expectation that hundreds or thousands of fish passage facilities in the Balkans will be in compliance, regularly maintained and operated as planned when only small groups of local stakeholders, if any at all, are present, is not realistic**

Fish passage, regardless of technology invariably requires water that is not used for power generation. **Thus, fish passage presents an additional source of competition for water,** together with residual flow and energy needs in an ever-tightening electricity market, **in a region of the world where precipitation and water availability is already decreasing and will decrease substantially in the upcoming decades** (see above). **Lastly, fish passage, even if moderately functional, does not replace lost habitat.** The original problem with dams and fish passage concerned migratory species such as shads (*Alosa* sp.), and salmon (*Salmo salar, Oncorhynchus* sp.) that were trying to reach upstream spawning grounds, hundreds or even several thousand kilometers upstream (e.g. on the Snake River, Idaho, Caudill et al. 2013). While relict populations of sturgeon (e.g. in the Danube), eel (e.g. in the Neretva or Vjosa rivers) and shad (Neretva and Vjosa rivers, Aegean Sea in Greece) are also a concern in the Balkans, we are now primarily dealing with freshwater resident fishes. These species undergo short migrations between seasonal habitats or feeding and spawning grounds, or even population-level or meta-population level movements supporting natural dispersal and gene exchange.

Regardless of the problem, **if there is little or no habitat left, the issue of fish passage becomes irrelevant.** Chains of dams and their corresponding reservoirs eliminate or degrade habitats especially for rheophilic fishes and **thus fish passage technology,** while helpful at some sites or for some species **is not a solution for combating or neutralizing the negative effects of a massive landscape-scale hydropower development on biodiversity and fish abundance.**

Karst systems

The Dinaric Alps of our study area stretches from Slovenia to Albania parallel to the Adriatic coast. Geologically, the region is dominated by limestone and is known for its extensive karst fields, with caverns, sinkholes, springs and underground rivers. In such geological settings, many rivers disappear underground and re-surface many kilometers away, and there is often very little surface retention of rainfall, despite areas with up to 5,000 mm of rain annually. In some areas, there has been extensive hydrological engineering to retain and use water for a variety of goals including consumption, agriculture and hydropower. The geology of the region is intensely studied (see Milanović 2015) and much is known about underground connections between distant surface springs and rivers. However, **exploiting aquatic resources in a karst geological region, whether above or beneath the earth's surface, is nonetheless very challenging and often results in unforeseen consequences to both nearby and distant sites.** These impacts range from water level loss or gain to lakes, springs or other rivers, unintentional redirection of flows, changes in seismic activity, and contamination of groundwater via components such as grout curtains (Roje-Bonacci & Bonacci 2013; Bonacci et al. 2016; Rezaei et al. 2013; Rezaei et al. 2017). Predicting impacts for aquatic organisms is likewise difficult; for the karst-adapted fishes of southern Croatia and Bosnia-Herzegovina, especially those with restricted ranges, it is often impossible to know exactly what will happen when nearby surface or sub-surface waters are exploited. Thus, we issue concerns or warnings concerning the endangered or critically endangered species, such as the karst minnows of the genus *Telestes*, even when there is no planned project directly in their habitat.

Species maps and fact sheets

The following 82 pages of fact sheets are arranged by family (see Table 1) and then alphabetically within each family. Dwarf gobies (*Knipowitschia*) receive a fact sheet but no maps (see Ćaleta et al. 2015). Some species that were not mapped, or are not found on any protection list are also discussed due to expected large-scale losses or their high interest (e.g. the genus *Salmo*). **Red circles in the maps indicate planned hydropower facilities, black circles indicate existing facilities and bright green lines represent species occurrence.**

Species Table

Table 1. *List of species by family assessed in this study. Shown is the scientific name, the IUCN threatened category (see Appendix for abbreviations) including the year of assessment (* indicates in need of updating), annex listing for both the Bern Convention and the European Habitats Directive, our assessment of the species' sensitivity to hydropower the threat related to Balkan hydropower expansion, and if mapped, the page number.*

Species	IUCN Red List Category	published in IUCN	Bern Convention Annexes	EUR-HAB-DIR Annexes	Hydropower sensitivity	Balkan dam threat	page
Acipenseridae							
Acipenser gueldenstaedtii	CR	2010		V	Very High	High	27
Acipenser naccarii	CR	2011	II	II, IV	Very High	High	28
Acipenser nudiventris	CR	2010		V	Very High	High	-
Acipenser ruthenus	VU	2010	III	V	High	High	29
Acipenser stellatus	CR	2010	III	V	Very High	High	30
Huso huso	CR	2010	II,III	V	Very High	High	31
Anguillidae							
Anguilla anguilla	CR	2014			Very High	Moderate	32
Baltoridae							
Oxynoemacheilus pindus	VU	2016			Very High	High	33
Clupeidae							
Alosa fallax	LC	2008	III	II, V	Very High	High	34
Alosa immaculata	VU	2008	III	II, V	Very High	High	35
Alosa macedonica	VU	2006*		II, V	Low	Low-to-Mod.	36
Alosa maeotica	LC	2008		II, V	Low	Low	-
Alosa sp. nov. 'Skadar'	VU	2008		II, V	Low	Mod.-to-High	37
Alosa vistonica	CR	2006*		II, V	Low	Low	-
Cobitidae							
Cobitis arachthosensis	EN	2006*	III	II	Moderate	Mod.-to-High	38
Cobitis dalmatina	VU	2006*	III	II	Moderate	High-to-Very High	39
Cobitis elongata	LC	2008	III	II	Moderate	Mod.-to-High	40
Cobitis hellenica	EN	2006*	III	II	Moderate	Very High	41
Cobitis herzegoviniensis	NE		III	II	Moderate	Low-to-Mod.	42
Cobitis illyrica	CR	2008	III	II	Moderate	Mod.-to-High	43

Table 1. *continued*

Species	IUCN Red List Category	published in IUCN	Bern Convention Annexes	EUR-HAB-DIR Annexes	Hydropower sensitivity	Balkan dam threat	page
Cobitis jadovaensis	LC	2011	III	II	Moderate	High	44
Cobitis meridionalis	DD	2006*	III	II	Low	Low	-
Cobitis narentana		2006*	III	II	Moderate	Moderate	45
Cobitis puncticulata		2014			Moderate	Low	46
Cobitis punctilineata		2006*			Moderate	Moderate	-
Misgurnus fossilis		2011	III	II	Moderate	Moderate	-
Cottidae							
Cottus gobio	LC	2011		II	Very High	Mod.-to-High	-
Cottus haemusi	DD	2008			Very High	Very High	47
Cyprinidae							
Alburnoides ohridanus	VU	2008	III		Low-to-Mod.	Mod.-to-High	48
Alburnoides prespensis	VU	2008	III		Low	Low-to-Mod.	49
Alburnus belvica	VU	2006*	III	II	Moderate	Mod.-to-High	50
Alburnus macedonicus	CR	2008	III	II	Low	Low	-
Alburnus mandrensis	CR	2008	III	II	High	Low	51
Alburnus sava	NE		III	II	Very High	Very High	52
Alburnus schischkovi	EN	2008	III	II	Very High	Presently Low	53
Alburnus vistonicus	CR	2008	III	II	Very High	Mod.-to-High	54
Alburnus volviticus	EN	2008	III	II	Very High	Presently Low	55
Aspius aspius	LC	2008	III	II,V	High	Low-to-Mod.	56
Aulopyge huegelii	EN	2006*		II	Mod.-to-High	Very High	57
Barbus balcanicus	LC	2008		II	Very High	High	-
Barbus barbus	LC	2011		V	Moderate	Low	-
Barbus macedonicus	DD	2006*		V	High	Mod.-to-High	58
Barbus plebejus	LC	2011	III	II,V	Very High	Very High	59
Barbus prespensis	LC	2011		V	High	High	60
Barbus rebeli	LC	2011		V	High	High	61
Barbus strumicae	LC	2008		V	High	High	62
Chondrostoma knerii	VU	2006*	III	II	Very High	High	63
Chondrostoma phoxinus	EN	2006*	III	II	Low-to-Mod.	Moderate	64
Chondrostoma prespense	VU	2006*			Very High	High	65
Delminichthys adspersus	VU	2006*	III	II	High	Mod.-to-High	66
Delminichthys ghetaldii	VU	2006*		II	Very High	Mod.-to-High	67
Delminichthys jadovensis	CR	2006*	III	II	Very High	Very High	68
Delminichthys krbavensis	CR	2006*	III	II	Very High	High	69
Gobio kovatschevi	VU	2008			High	Low	70
Gobio ohridanus	VU	2008			Low	Low	-
Gobio skadarensis	EN	2008			Mod.-to-High	Mod.-to-High	71
Pelasgus epiroticus	CR	2006*		II	Low	High	72
Pelasgus prespensis	EN	2006*		II	Low	High	-
Pelecus cultratus	LC	2008	III	II,IV	Mod.-to-High	Mod.-to-High	73
Phoxinellus alepidotus	EN	2006*		II	High	Moderate	74
Phoxinellus dalmaticus	CR	2006*		II	High	Very High	75

Table 1. *continued*

Species	IUCN Red List Category	published in IUCN	Bern Convention Annexes	EUR-HAB-DIR Annexes	Hydropower sensitivity	Balkan dam threat	page
Phoxinellus pseudalepidotus	VU	2006*		II	Very High	Presently Low	76
Phoxinus strandjae	EN	2008			Very High	Moderate	-
Phoxinus strymonicus	EN	2008		II	Very High	Very High	77
Romanogobio elimeius	LC	2008	III	II	Moderate	High	-
Romanogobio banaticus	NE		III	II	Moderate	Moderate	-
Romanogobio benacensis	EN	2006*			Low-to-Mod.	Low	78
Romanogobio banarescuii	NE		III	II	Moderate	Mod.-to-High	-
Rutilus panosi	VU	2008*	III	II	Low	Low	-
Rutilus virgo	LC	2008*	III	II,V	High	High	79
Rutilus prespensis	VU	2006*	III	II	Low	Low	-
Squalius janae	VU	2011			Low-to-Mod.	Low	80
Squalius microlepis	EN	2006*	III		Low-to-Mod.	Moderate	81
Squalius svallize	VU	2006*	III		Moderate	Moderate	82
Squalius tenellus	EN	2008	III		Moderate	Moderate	83
Telestes croaticus	EN	2006*		II	High	Mod.-to-High	84
Telestes dabar	NE			II	Very High	High	85
Telestes fontinalis	CR	2006*		II	Very High	High	86
Telestes karsticus	CR			II	Very High	Mod.-to-High	87
Telestes metohiensis	VU	2006*		II	Very High	Mod.-to-High	88
Telestes miloradi	NE				Very High	High	89
Telestes montenigrinus	LC	2006*	III	II	Mod.-to-High	High	-
Telestes pleurobipunctatus	LC	2006*		II	Mod.-to-High	Moderate	-
Telestes polylepis	CR	2006*	III		Very High	High	90
Telestes souffia	LC	2008	III	II	Moderate	Moderate	-
Telestes turskyi	CR	2006*	III		High	High	91
Telestes ukliva	EX*	2006*			High	Very High	92
Cyprinodontidae							
Aphanius fasciatus	LC	2006*	II, III	II	Low	Low	-
Gobiidae							
Padogobius bonelli	LC	2006	III	II	Moderate	Moderate	-
Pomatoschistus canestrinii	LC	2008	II,III	II	Moderate	Moderate	93
Knipowitschia croatica	VU	2006*			Mod.-to-High	High	94
Knipowitschia montenegrina	DD	2011	II,III	II	Mod.-to-High	Very High	-
Knipowitschia mrakovcici	CR	2011	II,III	II	Mod.-to-High	Very High	94
Knipowitschia panizzae	LC	2011	II,III	II	Mod.-to-High	Moderate	94
Knipowitschia radovici	VU	2008	II,III	II	Mod.-to-High	High	94
Percidae							
Gymnocephalus baloni	LC	2011	III	II,IV	Moderate	Moderate	95
Gymnocephalus schraetser	LC	2008	III	IV,V	Mod.-to-High	High	96
Zingel balcanicus	DD	2006*		II	Very High	Very High	97
Zingel streber	LC	2011	III	II	Very High	High	98
Zingel zingel	LC	2011	III	II,V	Mod.-to-High	High	99

Table 1. *continued*

Species	IUCN Red List Category	published in IUCN	Bern Convention Annexes	EUR-HAB-DIR Annexes	Hydropower sensitivity	Balkan dam threat	page
Petromyzontidae							
Eudontomyzon hellenicus	CR	2006*	III	II	Very High	High	100
Eudontomyzon stankokaramani	LC	2006*		II	Mod.-to-High	Mod.-to-High	101
Eudontomyzon vladykovi	LC	2008	III	II	High	High	102
Lampetra soljani	LC	2006	III	II,V	High	Low-to-Mod.	-
Salmonidae							
Hucho hucho	EN	2008	III	II,V	High	High	103
Salmo marmoratus	LC	2006*		II	High	High	104
Salmo obtusirostris	EN	2006*		II	High	Very High	105
Salmo ohridanus	VU	2006*			Low	Low	-
Salmo pelagonicus	VU	2008		II	High	High	-
Salmo peristericus	EN	2006*		II	Very High	Very High	106
Thymallidae							
Thymallus thymallus	LC	2011	III	V	Very High	Mod.-to-High	-
Umbridae							
Umbra krameri	VU	2011	II	II	Very High	High	107
Valenciidae							
Valencia letourneuxi	CR	2006*		II	High	Mod.-to-High	108

Acipenser gueldenstaedtii

Russian sturgeon (eng.), Russischer Stör (ger.), Nesetra (bg.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex V

Bern Convention:

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Bulgaria, Serbia

Russian sturgeon reach sizes well over two meters in length and 100 kg. In our study area, the potential spawning area for the Black Sea populations is limited to the Danube River below the Iron Gate dam, Đerdap I (Gessner et al. 2010; Lenhardt et al. 2006a,b), but the species has become extremely rare, and no longer spawns naturally in the lower Danube (Vecsei 2001); both overfishing and pollution are serious problems (Gessner et al. 2010; Bacalbaşa-Dobrovici 1997). Russian sturgeon feed in shallow depths on mollusks and small benthic fishes; they spawn in flows of 1 to 1.5 m/s over gravel or coarse sand (Vecsei 2001). **Also listed under Annex II of the CITES convention.**

Three more large dams on the lower Danube would end any chance to rehabilitate the Black Sea population.

Acipenser naccarii

Adriatic sturgeon (eng.), Adriatischer Stör (ger.), Jadranska jesetra (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II, IV

Bern Convention:
Annex II

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat – Historically – Slovenia, Croatia, Montenegro, Bosnia-Herzegovina, Albania

Adriatic sturgeon historically occurred in our study area from the Soca River in Slovenia to the Buna drainage in Albania (Kottelat & Freyhof 2007). Naturally reproducing populations along the Balkan coast are believed to be extinct (Bronzi et al. 2005; Bronzi et al. 2011), with the last record coming from the Buna River, Albania (depicted in map) in 1997 (Ludwig et al. 2003). The Adriatic sturgeon's habitat was large rivers and near shore (river mouth) marine habitats in depths between 10 and 40 m (Bronzi et al. 2011). It is anadromous but able to build landlocked populations (Kottelat & Freyhof 2007). The remaining potential spawning grounds are thought to be in the Po River basin of Italy. **The species is additionally listed in Appendix II of the CITES convention.**

Currently, survival of this species is based on captive breeding of a very limited brood stock (Boscari & Congiu 2014).

Acipenser ruthenus

Sterlet (eng.), Sterlet (ger.), Kečiga (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex V

Bern Convention:
Annex III

Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat - Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Bulgaria

The smallest of the European sturgeons, sterlet are native to large deep rivers, and spawn in fast flowing current on gravel (Kottelat & Freyhof 2007). Anadromous populations are extinct. Massive declines followed construction of the Iron Gate dams (Lenhardt et al. 2006), which disrupted spawning runs, and significantly altered the sterlet's prey availability (Dijaknovic et al. 2015). Occurs from Slovenia to the lower Danube including the Drau and Mur in Slovenia and Croatia, the Sava in Serbia, the Tiza in Serbia, and the Drina in Bosnia-Herzegovina and Serbia. Sterlet are able to survive in reservoirs but most probably due to extensive stocking (Kottelat & Freyhof 2007). There is a great need for information on spawning requirements and documentation of potential spawning grounds (Lenhardt et al. 2014). **The species is additionally listed in Appendix II of the CITES convention.**

Assuming that most populations are supported by stocking and not natural reproduction, the ca. 50 dams in planning in all remaining sterlet habitats threaten to eliminate naturally reproducing populations of this species in the Balkan region.

Acipenser stellatus

Stellate sturgeon (eng.), Sternhausen (ger.), Pastruga (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex V

Bern Convention:
Annex III

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Serbia, Bulgaria

The stellate sturgeon is less robust than the Russian sturgeon but also reach over 2 meters in length; anadromous populations in the Balkan study area are limited to very rare spawning in the lower Danube below the Iron Gate dams (Kottelat & Freyhof 2007). Commercial catches in the lower Danube dropped over 70% in the early 2000s, before the fishery was permanently closed; illegal fishing continues (Lenhardt et al. 2014). The species prefers strong current and gravely substrates for spawning, but will also spawn on finer substrates; like for other sturgeons, pollution in addition to blocked spawning grounds and overfishing is a major threat (Qiwei 2010; Kottelat & Freyhof 2007). **The species is listed in Appendix II of the CITES convention** (Vecsei et al. 2007). While the plight of sturgeons in the Danube appears quite grim, we note that occasional records still provide hope for rehabilitation. We note here another record, for a species not included in our fact sheets; the ship sturgeon Acipenser nudiventris, was recorded in the middle Danube Serbia, in 2003 (Simonović et al 2005).

Three more large dams are planned on the lower Danube; the construction of these dams would most likely eliminate the last rare spawning events, and hinder any chance of rehabilitation.

Huso Huso

Beluga (eng.), Europäischer Hausen (ger.), Mopyha (bg.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex V

Bern Convention:
Annex II, III

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat – Bulgaria, Serbia

Beluga historically reached 7-8 meters in size, making them the world's largest freshwater fish. They are anadromous with potential spawning grounds in our study area limited to the Danube River below the Iron Gate dams; currently no natural spawning in the Danube occurs (Gesner et al. 2010). The last wild populations live in the Caspian basin (Kottelat & Freyhof 2007). The Danube harbored the largest spawning run of the species (Vecesi et al. 2002). Beluga were extirpated from the middle and upper Danube after construction of the Iron Gate dams (1970 and 1984). Currently, survival of the species is dependent on stocking (Vecesi et al. 2002, Kottelat & Freyhof 2007); 20,000 individuals in a single year have been released in the lower Danube (Gesner et al. 2010). Illegal fishing and overfishing remains a problem for the species survival (Gesner et al. 2010).

Further damming of the Danube would all but eliminate any chance of restoring this iconic species to the Balkan region.

Anguilla anguilla

European eel (eng.), Europäischer Aal (ger.), Jegulja (bh.)

IUCN:
Critically Endangered

EUR-HAB-DIR:

Bern Convention:

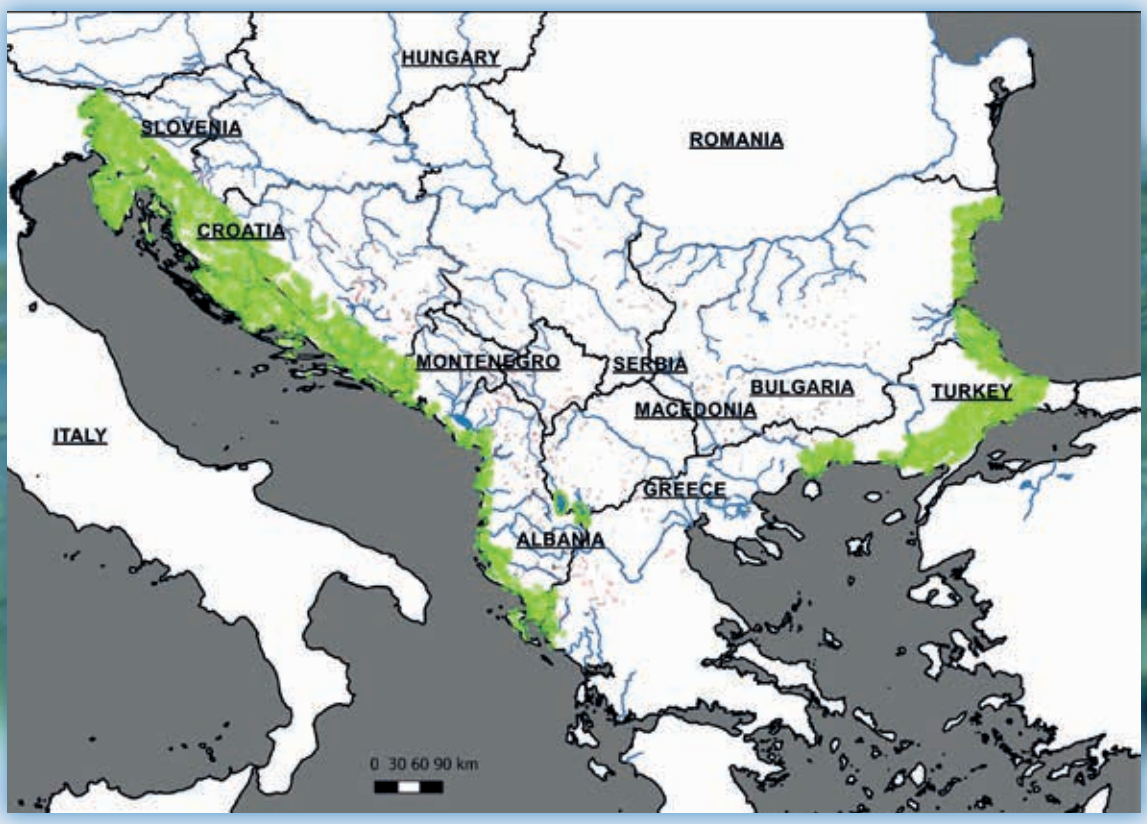
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Moderate

Distribution and Habitat - Slovenia, Croatia, Bosnia-Herzegovina, Montenegro, Albania, Greece, Bulgaria

European eels, in theory, could access all rivers along the Adriatic and Aegean coasts and occasionally the Black Sea (Kottelat & Freyhof 2007; Jacoby & Gollock 2014). A catadromous species living most of its life in freshwater and migrating to the Sargasso Sea in the southwest Atlantic Ocean to spawn. The causes of declining recruitment are multi-variate and not entirely understood (Jacoby & Gollock 2014) but loss of spawning habitat and mortality during both up- and downstream migration due to dams is at least one of the main concerns (Jansen et al. 2007, Besson et al. 2016). **Important rivers for the eel include the Neretva in Croatia and Bosnia-Herzegovina, the Vjosa in Albania and the Strymon und Evros rivers in Greece.**

Expansion of hydropower facilities in the last major free-flowing rivers on the Balkan Peninsula (such as in Albania) are a major threat to regional populations.



Oxynoemacheilus pindus

Pindus stone loach (eng.), Pindus Schmerle (ger.), Pindovínos (gr.)

IUCN:
Vulnerable

EUR-HAB-DIR:

Bern Convention:

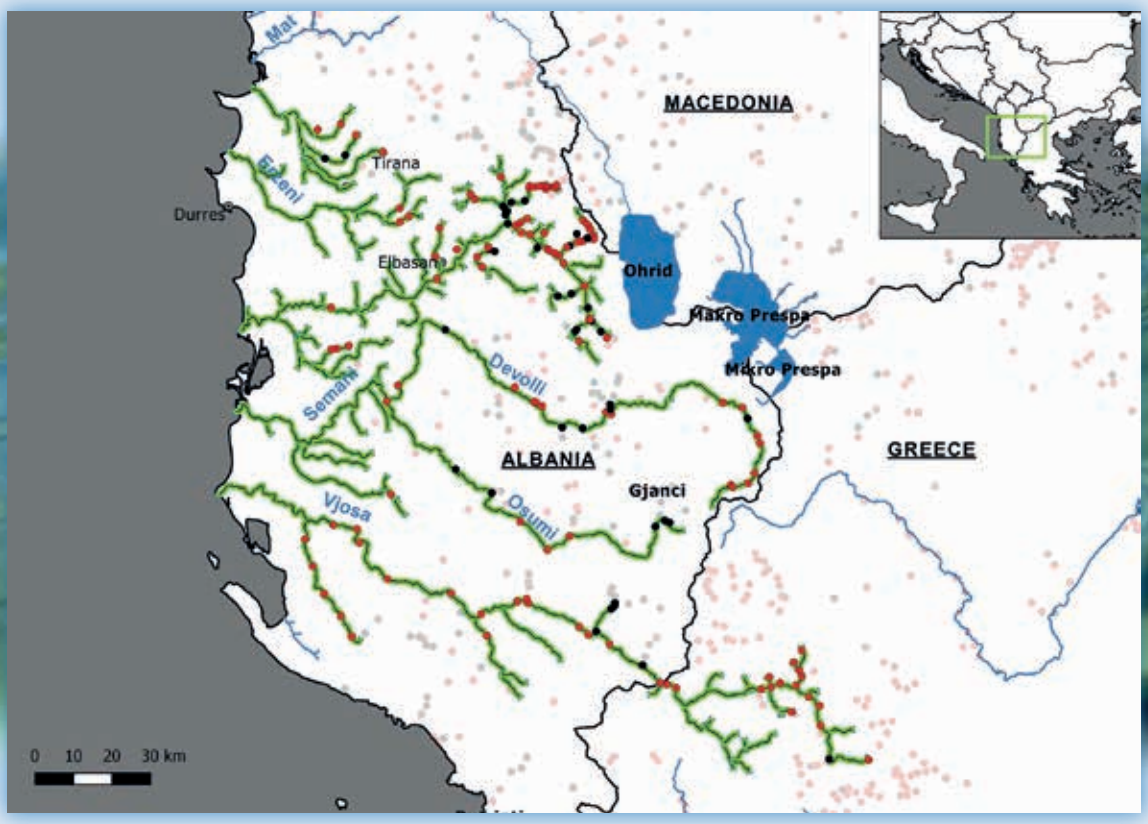
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat – Albania, Greece

The **Pindus stone loach** was previously assigned to the genus *Barbatula*; stone loaches (see Bănărescu & Nalbant 1995) belong to a very diverse group (over 40 species) of fishes that are primarily found in Anatolia and the Middle East (Freyhof et al. 2011). First described by Economidis (2005), the Pindus stone loach is relatively widespread in Albania, reported from the Erzen, Schkumbin, Seman and Vjosa rivers, including the upper Vjosa (Aoos) in Greece (Šanda et al. 2008b). Little is known about the biology of this species; they occur in flowing water over stoney substrates (Kottelat & Freyhof 2007) and are assumed to be very sensitive to dam construction (Freyhof 2012).

Over 100 hydropower schemes are planned in the habitat of the Pindus stone loach threatening up to 50% of their global habitat.



Alosa fallax

Twaite shad (eng.), Finte (ger.), Cepa (hr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II, V

Bern Convention:
Annex III

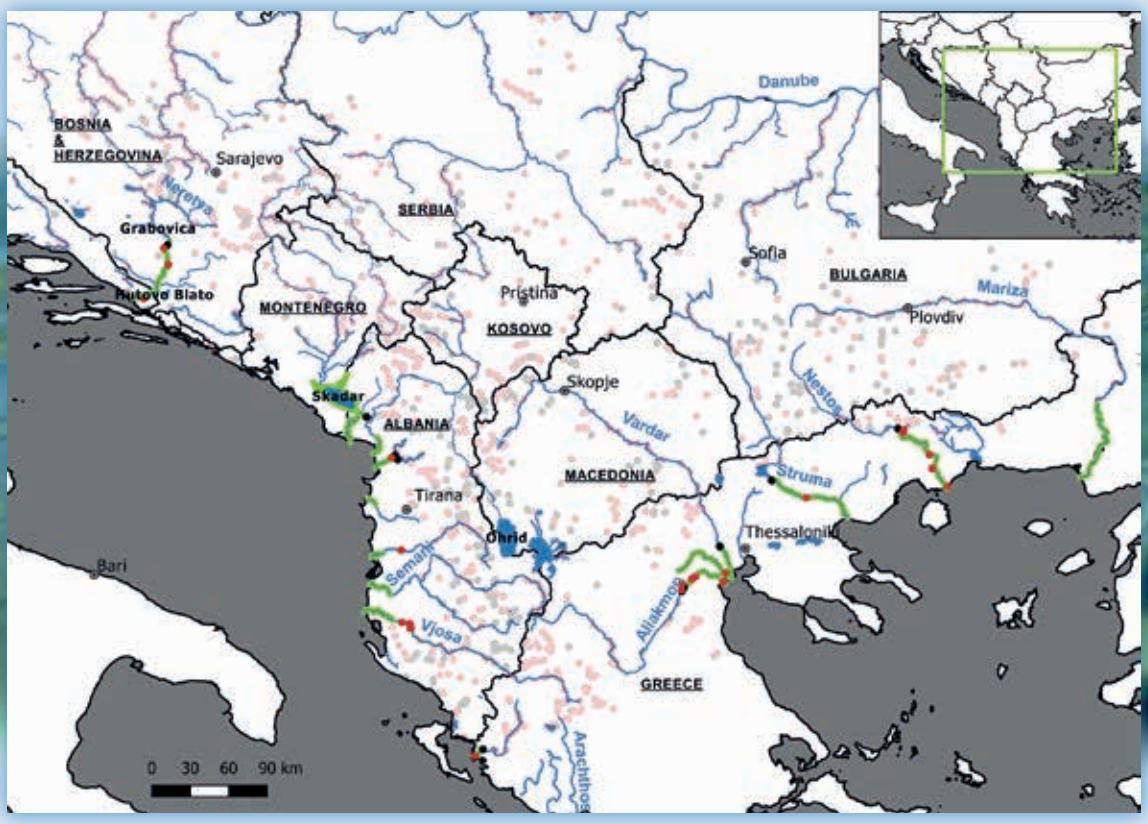
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia, Montenegro, Albania, Bulgaria, Greece, Turkey

Twaite shad are a relatively large-growing (500 mm SL) anadromous member of the herring family. In our study region they are very sparsely distributed in the lower reaches of medium to larger rivers. They have become very rare in the Black Sea (Dobrovolov et al. 2012) and Lake Skadar in Montenegro (Mrdak, 2009). Reported from lower Neretva (Croatia), Strymon and Evros rivers (Greece) (Bianco 2002). Anadromous shad mature after 2-9 years at sea before returning to freshwater to spawn (Aprahamian et al. 2003). Pollution and damming have reduced their range and abundance during the first decades of the 20th century (Kottelat & Freyhof 2007). Shad in Lake Skadar (Albania) probably represent an undescribed freshwater resident species *Alosa*. sp. Skadar (Kottelat & Freyhof 2007) and not *A. fallax* (Rakaj & Crivelli 2001).

Dams planned on most of the remaining Balkan rivers where Twaite shad are found will likely eliminate the species from this region.



Alosa immaculata

Pontic shad (eng.), Donauhering (ger.), Dunavska skumriy (bg.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II, V

Bern Convention:
Annex III

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Bulgaria, Serbia

Pontic shad of the Black and Azov seas are anadromous and historically migrated as far as 1650 km up the Danube to Budapest (Lenhardt et al. 2016). In our study area, the species is primarily blocked by the Iron Gate dams but ca. 100 individuals per year pass via ship-locks and reach the lower Sava River (Višnjić-Jeftić 2013). Pontic shad spawn in fast-flowing water at 2-3 meters depth. Aside from dams, pollution and overfishing pose major threats to this species. The fishery in the lower Danube is still worth at least two million USD annually (Navodaru 1996). Lower Danubian stocks are currently stable (Lenhardt et al. 2016) but any further regulation or damming of the lower Danube would endanger the remaining stocks of this species in the Danube River Basin.

Up to seven large-sized hydroelectric dams are planned on the Danube and lower Sava, which could easily eliminate the remaining stocks of this species in the Balkan region.

Alosa macedonica

Macedonian shad (eng.), Mazedonischer Hering (ger.), Liparia (gr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II, V

Bern Convention:

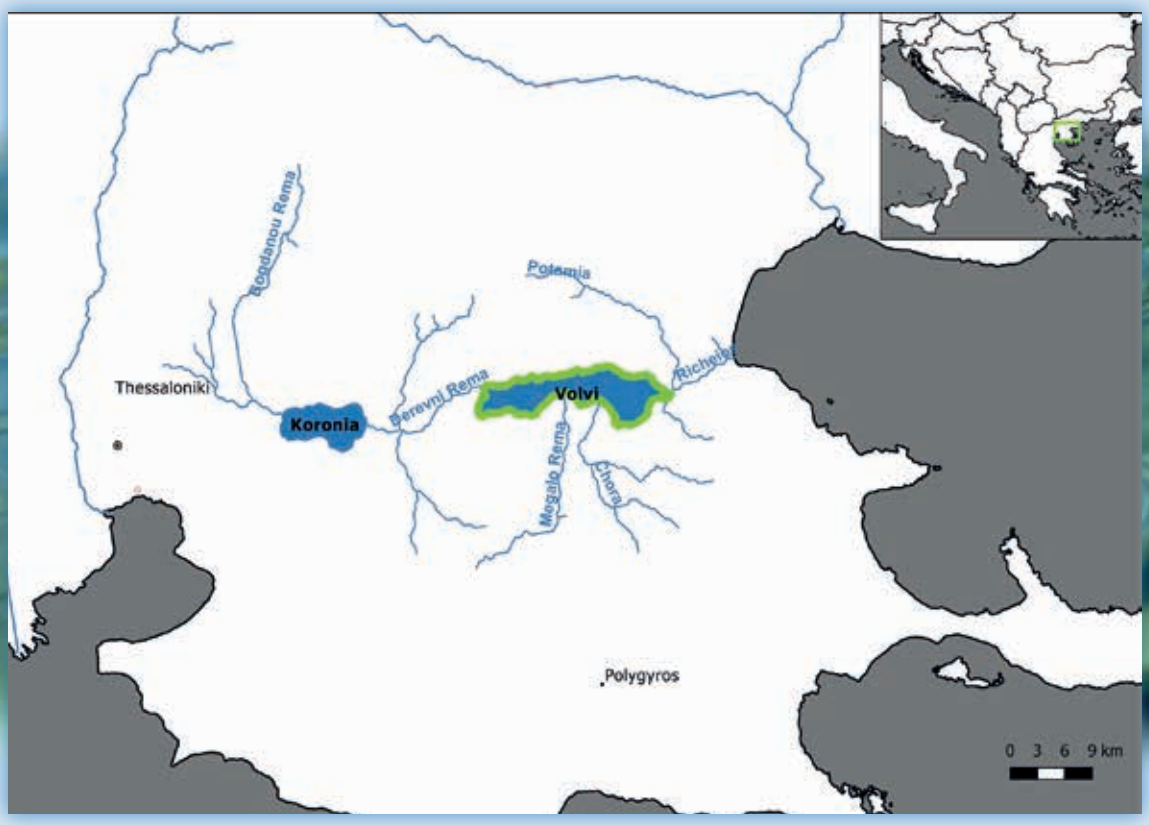
Hydropower Sensitivity:
Low

Balkan Dam Threat:
Low-to-Moderate

Distribution and Habitat - Greece

Macedonian shad are a landlocked species reaching up to 300 mm SL. They were previously present in two lakes but the Lake Koronia population is extinct; thus the species is now limited to Lake Volvi (Giantsis et al. 2015). The species apparently spawns in the lake and overfishing is its primary threat. Most recently, stocks appear to be doing well as commercial fisherman have lost interest in the species (Giantsis et al. 2015).

As it is a landlocked species, and does not spawn in tributaries, there is currently little threat from hydropower.



Alosa sp. nov. "Skadar"

Skadar shad (eng.), Skadarherring (ger.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II, V

Bern Convention:

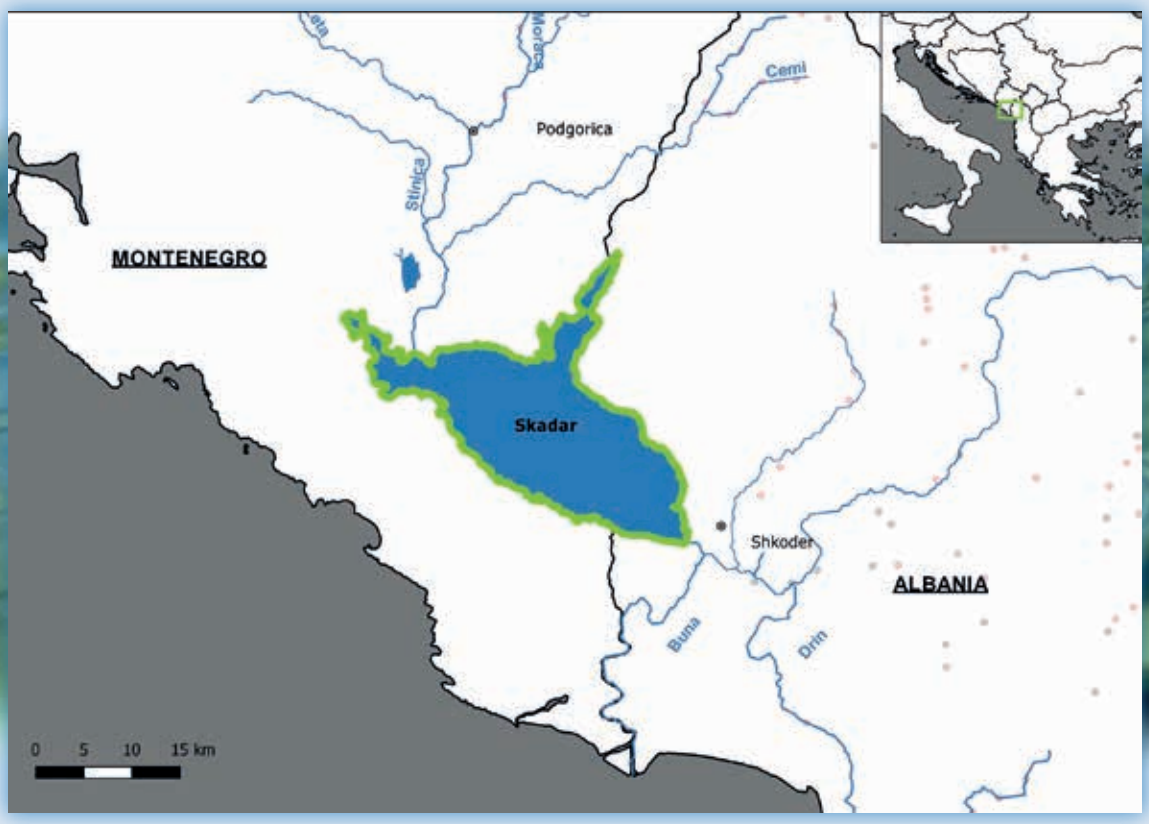
Hydropower Sensitivity:
Low

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Montenegro, Albania

Skadar shad most likely represent an undescribed landlocked endemic shad from Skadar Lake. The species is probably similar to Alosa agone (see Rakaj & Crivelli 2001). The species does not migrate to tributaries but remains in the lake and spawn along the shores on sand and gravel (Kottelat & Freyhof 2007). While landlocked shad are not ordinarily directly sensitive to hydropower exploitation, the series of planned schemes on the Morača River may threaten the existence of most if not all endemic fish species from Lake Skadar due to water surface loss and altered hydrology (see Mrdak et al. 2009).

The 27 dams planned on Lake Skadar's tributaries (not shown here) threaten the global existence of this yet-described species.



Cobitis arachthosensis

Arachthos spined loach (eng.), Arachthos Steinbeisser (ger.), Arachthovelonitsa (gr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

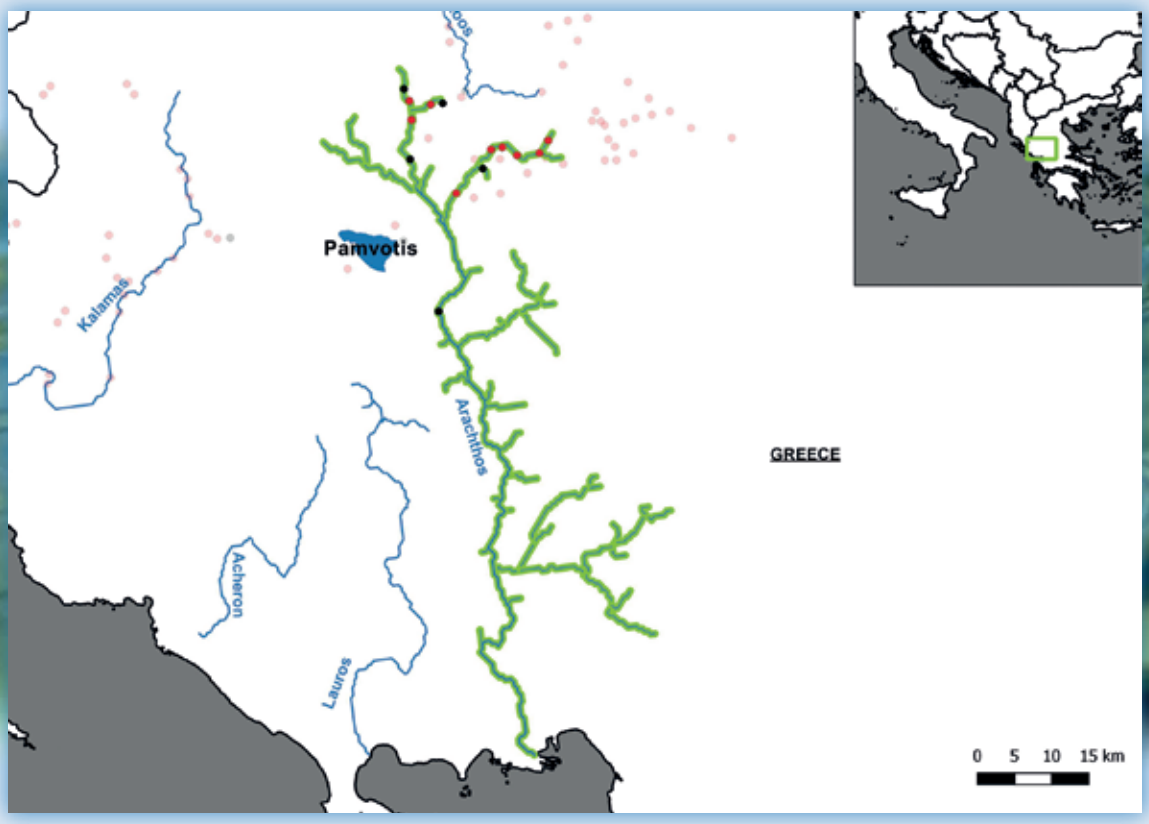
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Greece

The **Arachthos spined loach** is a small benthic loach endemic to the Arachthos drainage of which the upper third is in our study area (Zogaris et al. 2009). With similar habitat preferences as *C. hellenica*, it prefers still to moderate flowing water with sand or silt substrates with vegetation. Canals between the Arachthos and Louros River are bringing *C.arachthosensis* and *C. hellenica* into contact (Crivelli 2006a). The IUCN Red List entry states that the status requires updating. Freyhof (2012) lists the species as moderately sensitive to dam construction, as they can colonize reservoirs; they are however sensitive to the introduction of invasive species. If reservoirs are flushed or hydropeaking is part of the operation regime of a hydropower facility, loaches can be extirpated.

Up to nine hydropower schemes are planned in the upper Arachthos drainage, threatening to eliminate or drastically reduce this species in the study area.



Cobitis dalmatina

Dalmatian spined loach (eng.), Dalmatinischer Steinbeisser (ger.), Cetinski vijun (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

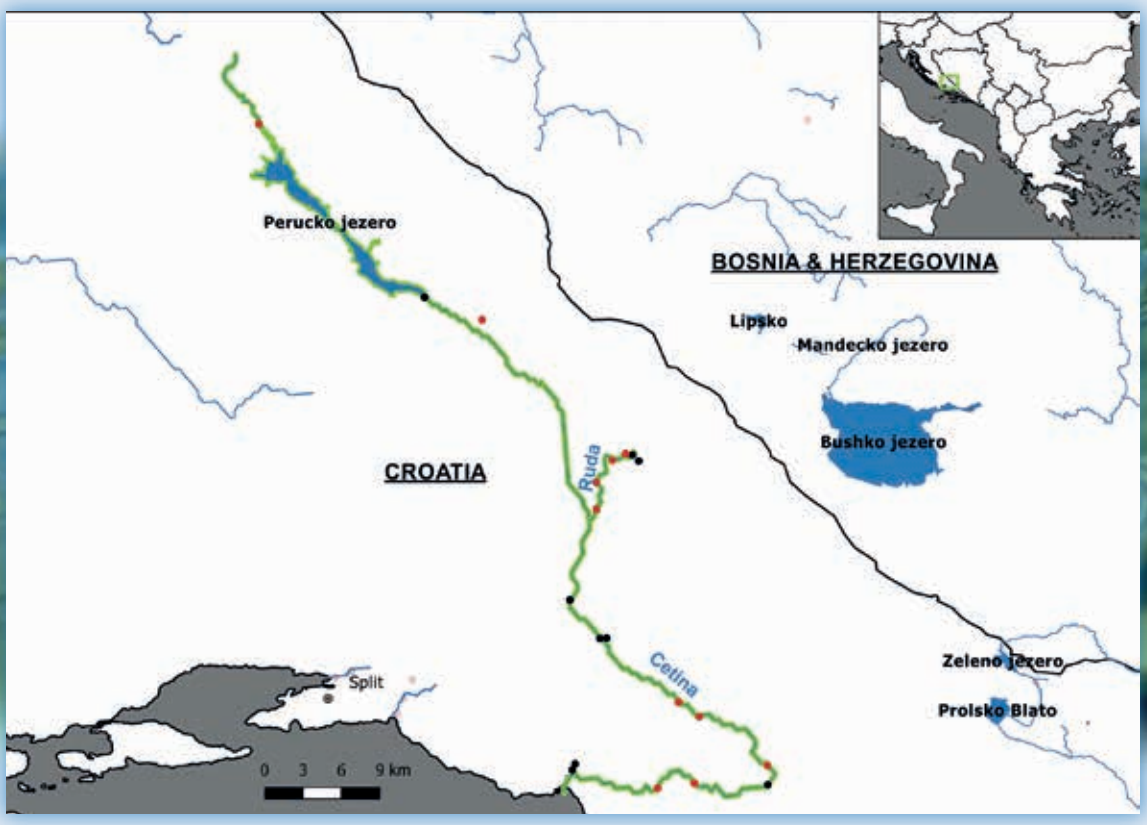
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
High-to-Very High

Distribution and Habitat - Croatia

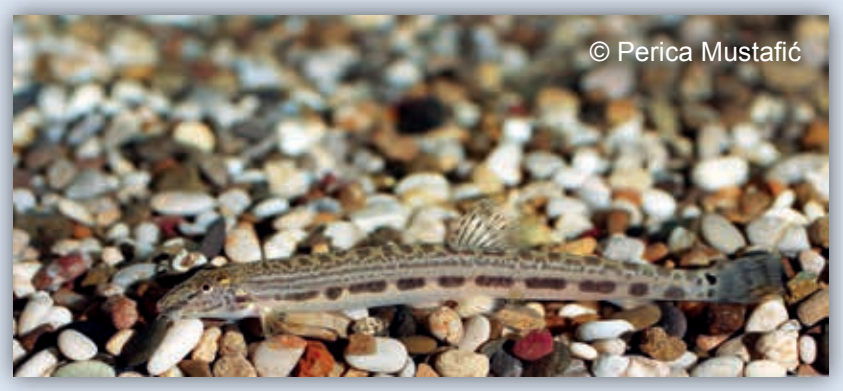
The **Dalmatian spined loach** is endemic to the Cetina River in Croatia (Mrakovčić et al. 2008), a hotspot for endangered fish diversity; one of eight species in the basin listed as vulnerable, endangered or critically endangered. The species is found over soft substrates in still to slow flowing water, near dense vegetation, typical for all loaches in the karst fields and rivers of the region (Šanda et al. 2008, Ćaleta et al. 2015). Loaches are filter feeders, and thus require fine sediments; however, early life-history stages require dense vegetation, and these habitats are sensitive to hydrological disturbance. The unpredictable hydrological changes accompanied with such development in this karst river (Roje-Bonacci & Bonacci 2013; Bonacci et al. 2016) could put most of the species in this system at a high risk of extinction.

Up to eleven planned hydropower schemes in this biodiversity hotspot threaten the long-term existence of this steno-endemic species.



Cobitis elongata

Balkan spined loach (eng.), Balkan Steinbeisser (ger.), Veliki vijun (hr.)(gr.)



IUCN:
Least Concern

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

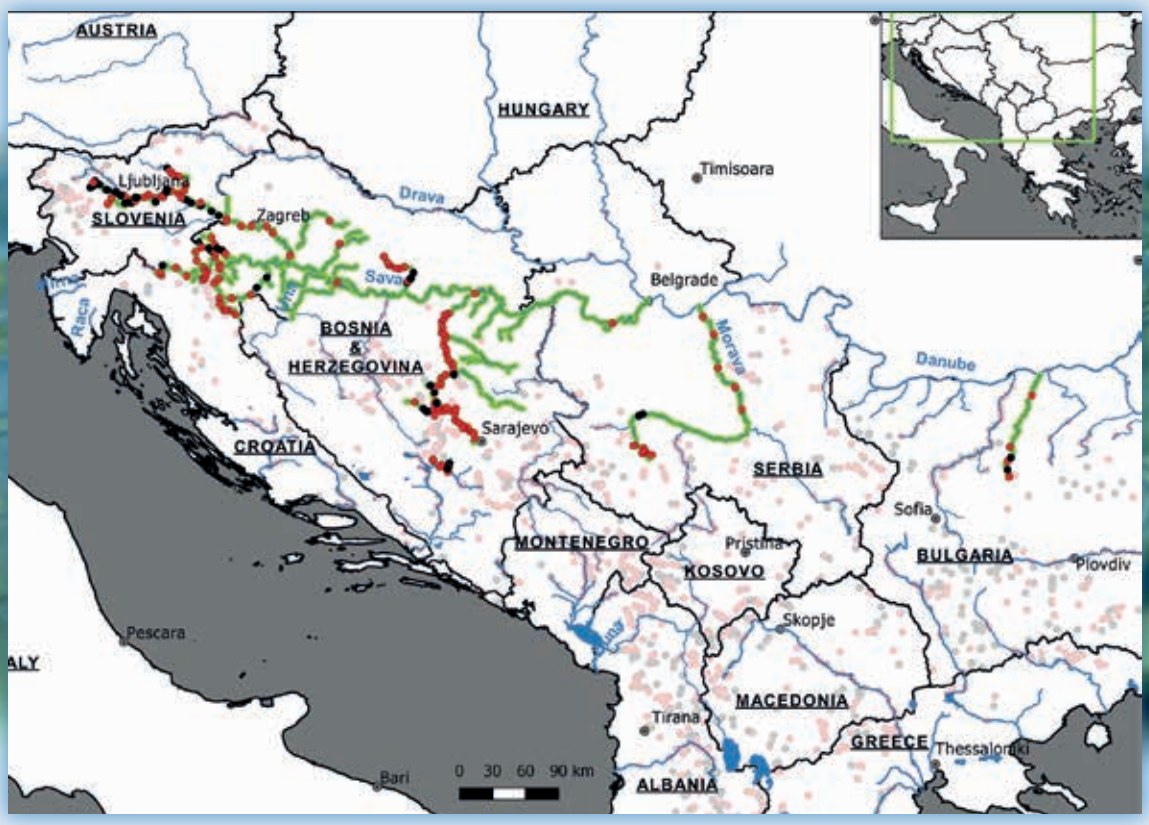
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Bulgaria

The **Balkan spined loach** is one of the more widely distributed loaches in the region. Reported from the Kolpa, Una, Sava, Morava and Zapadna Morava systems as well as the Vit River in Bulgaria (Mustafić et al. 2003; Pehlivanov et al. 2009; Ćaleta et al. 2015). Mičetić et al. (2008) reported the species from the Petrinjčica River in Croatia. More of a large river specialist found on sandy shores and banks, occasionally over rocks with vegetation (Kottelat & Freyhof 2007). Kottelat & Freyhof (2007) also report that the species is not known to enter small streams or larger rivers without at least moderate current. While widespread, and moderately tolerant of pollution (Kopjar et al. 2008) most of its habitat, especially in Slovenia and Bosnia-Herzegovina is targeted for large-scale hydropower development.

Threatened by more than 50 planned hydropower schemes, this species' habitat in the Balkans may suffer a loss of at least a third and up to 50%.



Cobitis hellenica

Louros spined loach (eng.), Louros Steinbeisser (ger.), Lourovelonitsa (gr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

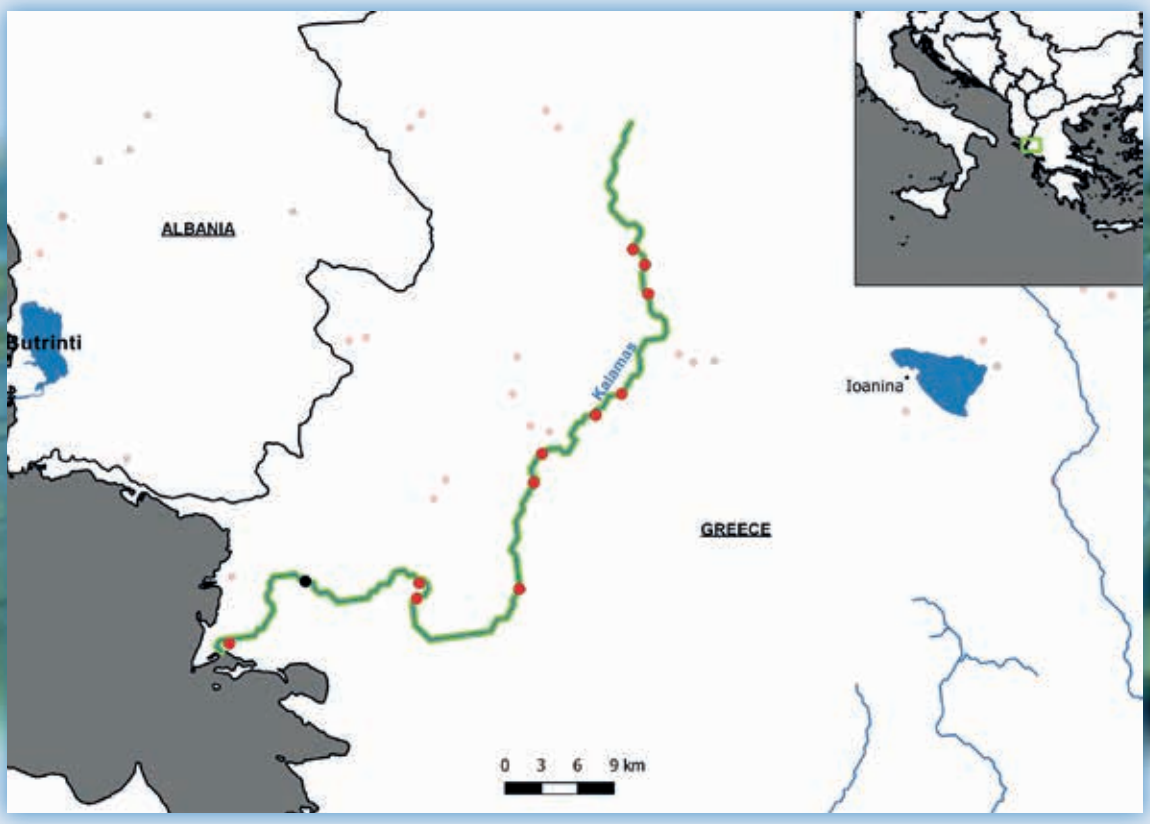
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Very High

Distribution and Habitat - Greece

In our study area, the **Louros spined loach** is limited to the Kalamas drainage (Zogaris et al. 2009). Found together with dense vegetation in clear streams, with low to moderate flow on sand or silt (Kottelat & Freyhof 2007). Water extraction, pollution and hybridization are listed as threats but the IUCN Red List entry is in need of updating (Crivelli 2006b).

Six hydropower facilities are already under construction on the Kalamas River, including the large Gjegjan 1 project. At least 12 more projects are in the planning stage, not including those in small tributaries. This chain of hydropower facilities along the entire length of the Kalamas would put a significant portion of the global population of this species at risk of extinction, especially considering the threat of hybridization with *C. arachthosensis* in the remaining (Lourus drainage) area of occupancy.



Cobitis herzegoviniensis

Mostarsko spined loach (eng.), Mostarsko Steinbeisser (ger.), Mostarski vijun (hr.)

IUCN:
Not evaluated

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

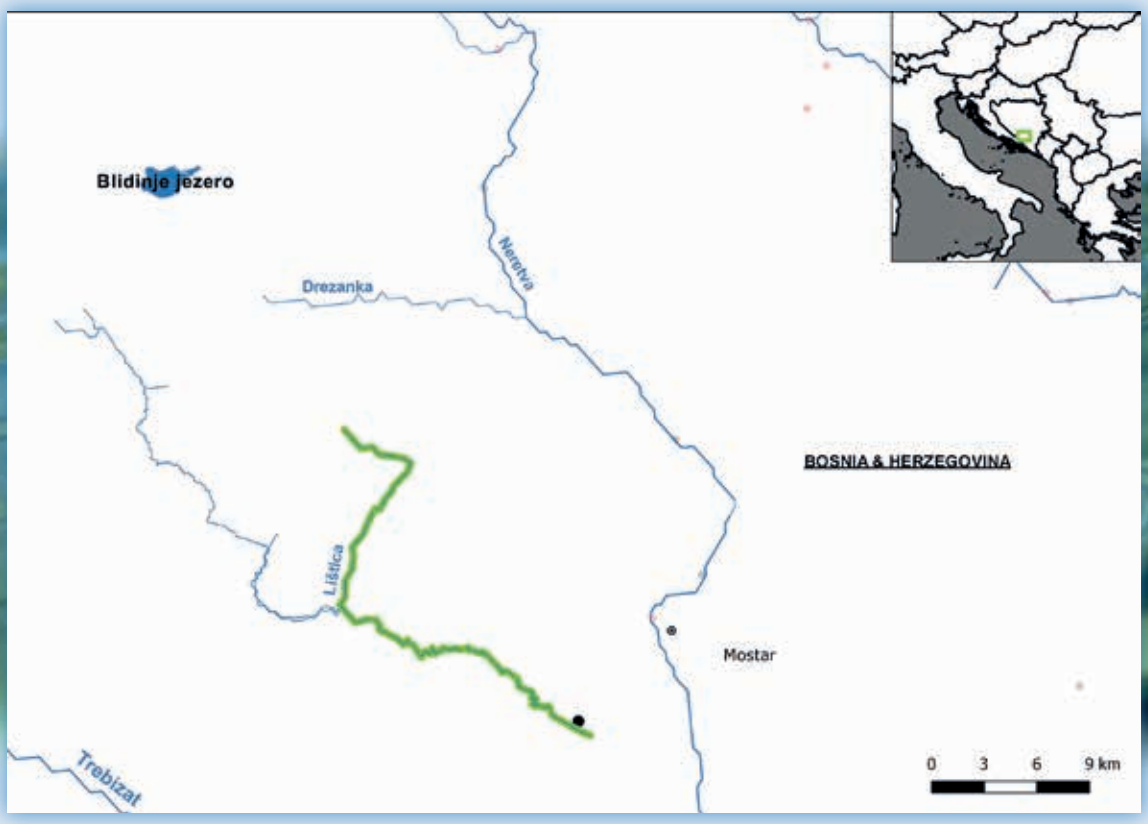
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Low-to-Moderate

Distribution and Habitat - Bosnia-Herzegovina

The **Mostarsko spined loach** is one of five steno-endemic loach species in the Dalmatian/Bosnian-Herzegovina region. *C. herzegoviniensis* was first described by Buj et al. (2014) from the Lištica River in the Mostarsko blato karstic field in Bosnia-Herzegovina; subsequent data can found in Buj et al. (2015a). No specific biological information is available; the species is assumed to have the same general characteristics as other loaches in the region (see Ćaleta et al. 2015).

At this time, there is no hydropower scheme planned in the immediate vicinity of this steno-endemic species. However, these karst systems are very complicated (see Bonacci et al. 2016) and thus even schemes in other drainages can drastically effect the hydrology of this habitat.



Cobitis illyrica

Imotzki spined loach (eng.), Imotzki Steinbeisser (ger.), Ilirski vijun (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

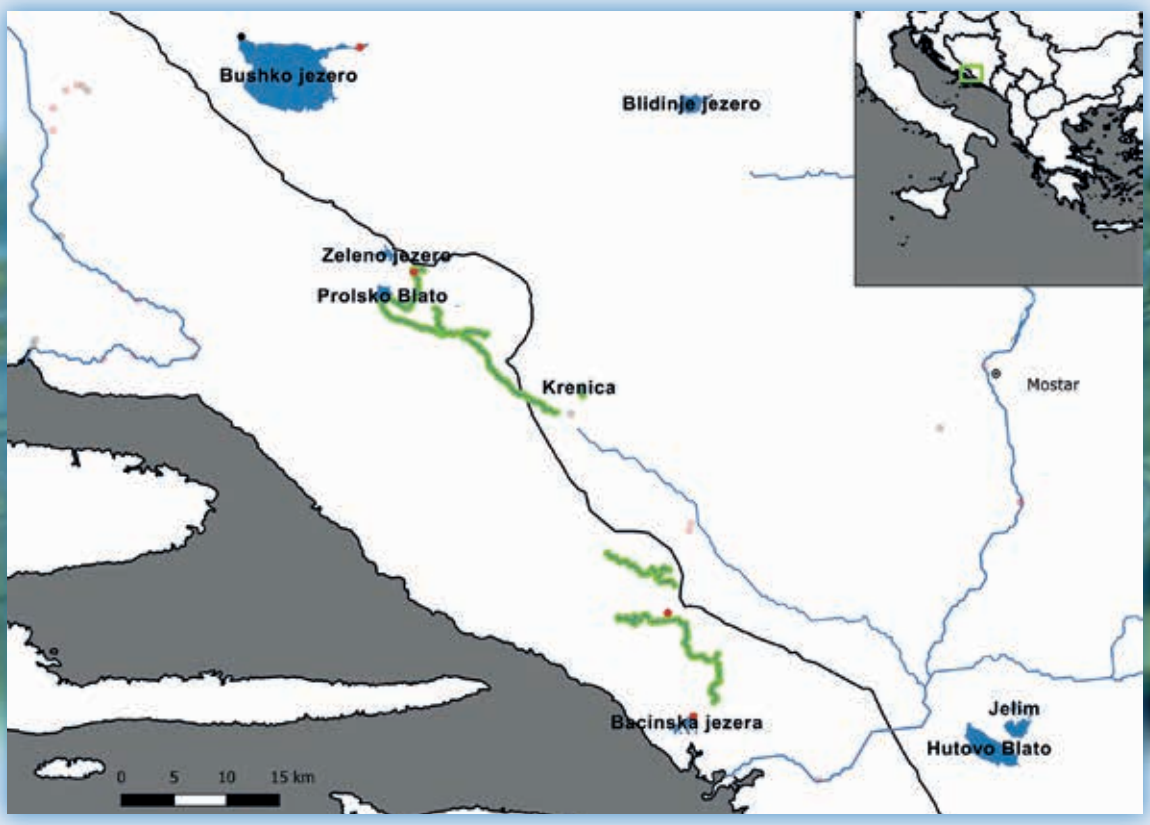
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Croatia, Bosnia-Herzegovina

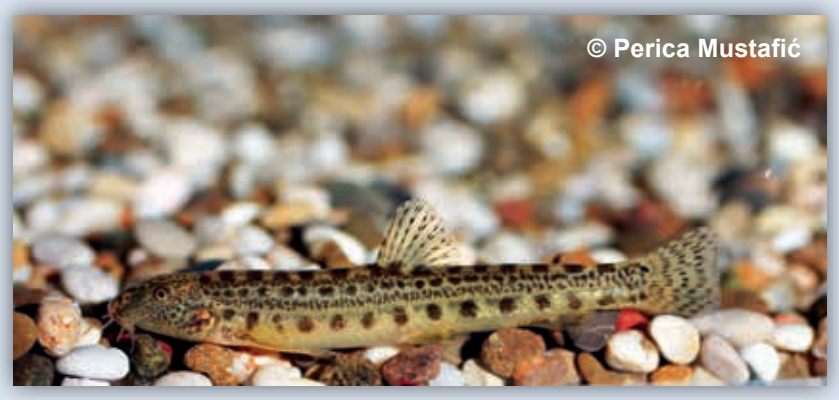
The **Imotzki spined loach** is one of five steno-endemic loach species in the Dalmatian/Bosnian-Herzegovina region. Described by Freyhof & Stelbrink (2007), the species occurrence is limited to the Imotzki polje; reported from the Baćina and Prološko Blato lakes as well as the Matica River and Krenica Lake in Bosnia-Herzegovina (Buj et al. 2014, 2015b). Occurs in shallow habitats of clear streams with zero to moderate flow; generally on silty or sandy substrates rich in organic material (Ćaleta et al. 2015). Early life history stages, however, may be highly dependent on dense vegetation (Ćaleta et al. 2015). **Readers should note that the word "jezero" in Croatian means artificial reservoir, and as such are often not primary habitat for various endangered species in this region.**

Several hydropower schemes in the limited range of this species may affect the availability of habitat, due to unpredictable changes in both surface and groundwater hydrology. Almost any alteration to their habitat may put the remaining populations at risk of extinction as they are highly specialized.



Cobitis jadovaensis

Jadova spined loach (eng.), Jadova Steinbeisser (ger.), Jadovski vijun (hr.)



IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

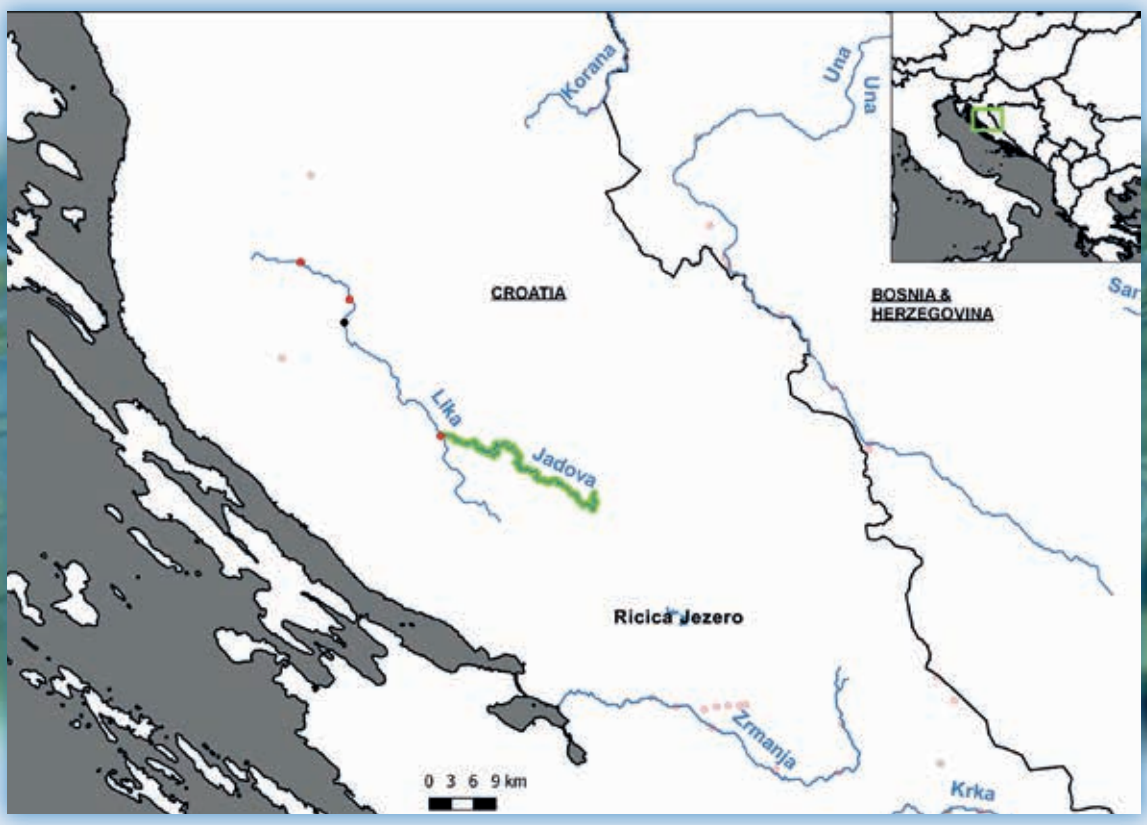
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
High

Distribution and Habitat - Croatia

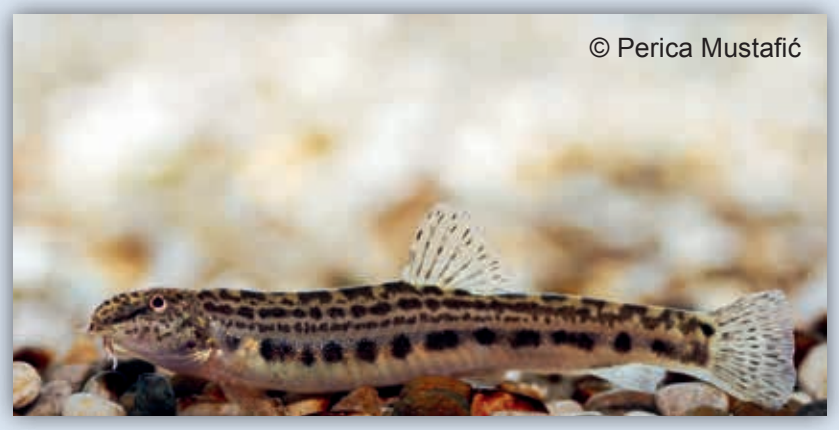
The **Jadova spined loach** is one of five steno-endemic loach species in the Dalmatian/Bosnian-Herzegovina region. First described by Mustafić et al. (2008) it occurs only in the 12.5 km-long Jadova River, a tributary of the Lika River (Ćaleta et al. 2015). The species shares habitat needs with other loaches of the region, but each species is assumed to be unique with respect to their overall requirements (see Ćaleta et al. 2015). The Jadova River dries out in summer, and the species is assumed to retreat to refuge ponds or subterranean habitats (Mihinjač et al. 2015b). Major threats are water abstraction, the introduction of alien species and increasing severity of droughts (Mihinjač et al. 2015b).

Three planned hydropower schemes on the Lika River should be a source of concern for the global survival of Jadova spined loach, due to unpredictable hydrological changes in karst systems and the promotion of invasive species.



Cobitis narentana

Neretva spined loach (eng.), Neretva Steinbeisser (ger.), Neretvanski vijun (hr.)



IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

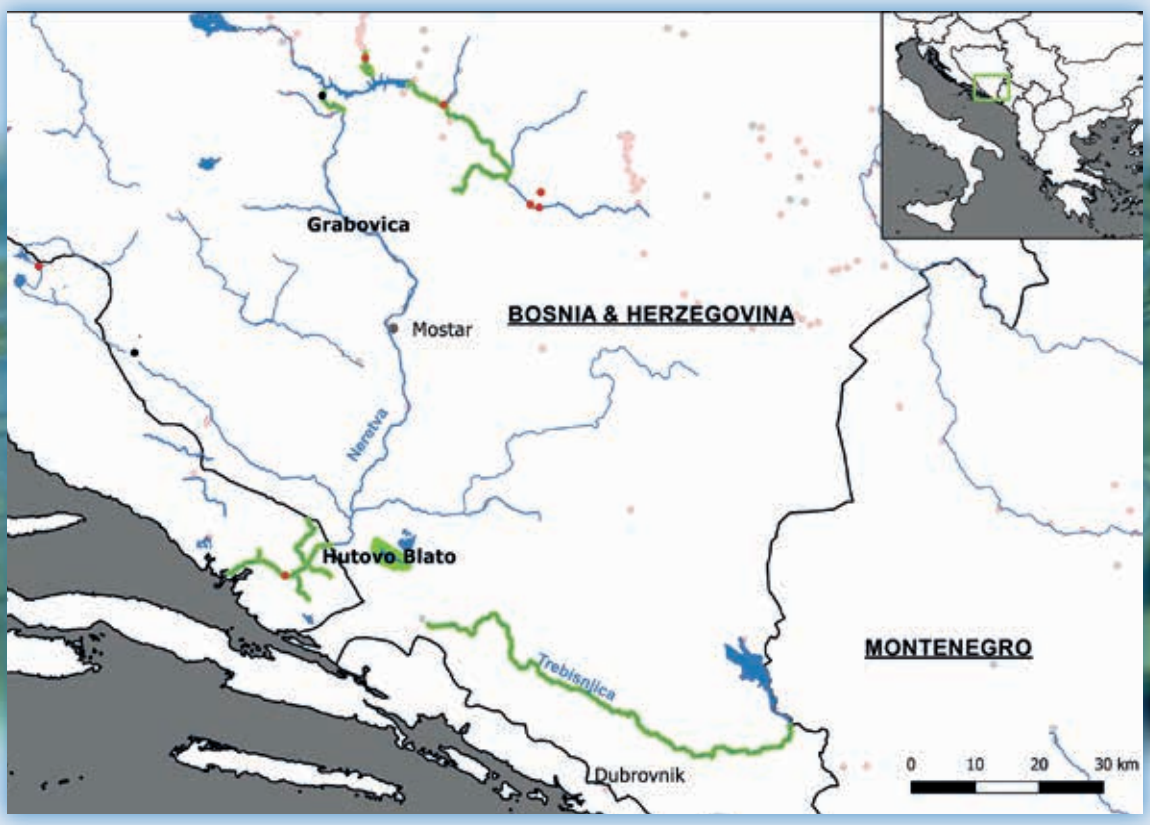
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat – Croatia, Bosnia-Herzegovina

The **Jadova spined loach** is more widespread than other loaches in the region. In Bosnia-Herzegovina the species was found in the lower Neretva Basin, the Trevišnica River and Hutovo Blato wetlands; in Croatia the species was found in Modro Oko and the Desne and Kuti lakes (Šanda et al. 2008b; Ćaleta et al. 2015). They have broader habitat tolerance than most loaches in the region, living in lakes, rivers and channels, over fine sediments, rocks and gravel as well on dense macrophytes (Šanda et al. 2008). Nonetheless, its occurrence is very sporadic (Zanella et al. 2009). One of at least 14 threatened or endangered species in the Neretva River catchment. Like all of the region's loaches, this species is sensitive to the spread of non-native invasive species (Freyhof 2012).

Much of this species range (at least 50%) in the Neretva River basin is threatened by hydropower development, especially in the upper and lower Neretva River itself.



Cobitis puncticulata

Spotted spined loach (eng.), Maritza Steinbeisser (ger.), Tasyiyen baligi (tr.)

IUCN:
Endangered

EUR-HAB-DIR:

Bern Convention:

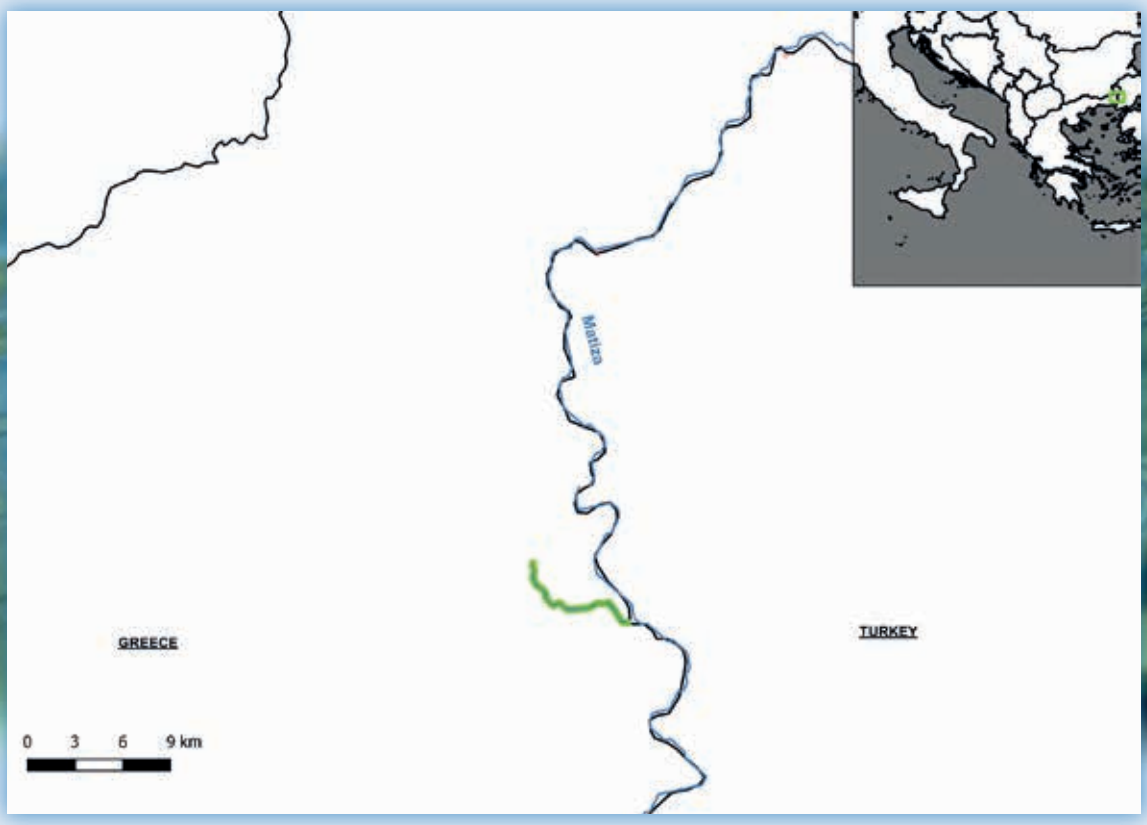
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Low

Distribution and Habitat – Greece, Turkey

The **Spotted spined loach** in our study area, is currently found in only one tributary of the Matrica (Evros) River just north of Provatones, Greece. Ekemekçi et al. (2010) report more sites outside the Balkans in Turkey. Found in habitats atypical for other *Cobitis* species with lots of mud and very dense vegetation (Freyhof et al. 2008). The species has changed IUCN status several times due to new findings, but most recently has been listed as endangered (Freyhof 2014). While suggested to exist in more habitats of the lower Evros, current findings show only a very limited distribution in this region.

Currently, there is no hydropower plans in the Greek distribution area and pollution is listed as the major threat (Freyhof 2014).



Cottus haemusi

Vit sculpin (eng.), Vit Koppe (ger.), Glavoch (bg.)

IUCN:
Data Deficient

EUR-HAB-DIR:

Bern Convention:

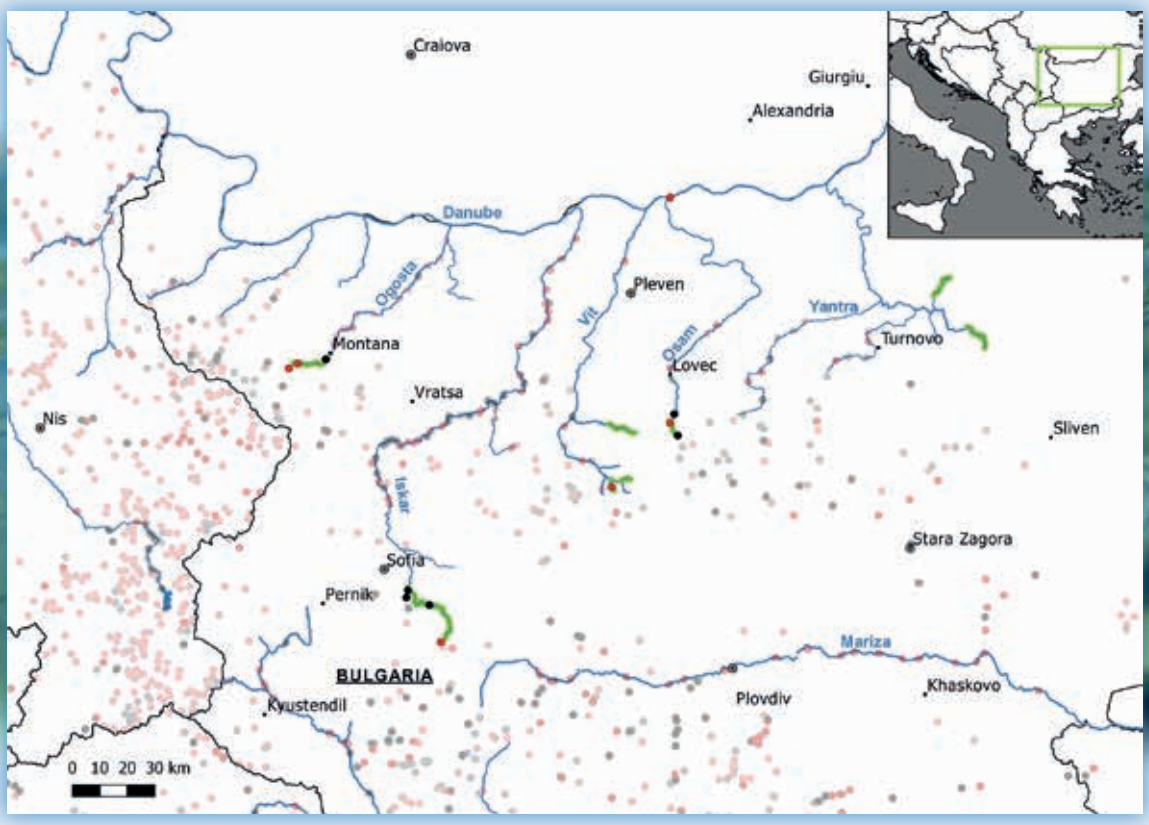
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Very High

Distribution and Habitat – Bulgaria

The **Vit sculpin** was described as occurring in the Vit River catchment (Kottelat & Freyhof 2007), where its distribution has been reduced to the Kostina & Toplja tributaries (Uzunova 2011). Following Pehlivanov et al. (2012) and Apostolos (pers. comm), the species occurs in the uppermost headwaters of the Ogosta, Iskar, Vit, Osam, and Yantra drainages. However, Uzunova et al. (2017) view the Vit sculpin as limited to the Vit system, with *C. gobio* occurring in the other depicted tributaries. According to Uzunova (pers. comm.), there are at most 100 individuals of Vit sculpin remaining, in a 200 m long reach of the Kostina River. **This means the species should be designated as critically endangered by the IUCN.** Sculpins are very sensitive to habitat alterations involving hydrology, bed-load transport and substrate composition.

Small hydropower schemes further threaten at least 90% of the remaining habitat of *Cottus* in most of these tributaries, and *C. haemusi* is threatened with almost certain extinction.



Alburnoides ohridanus

Ohrid spirlin (eng.), Ohrid Schneider (ger.), Barkgjera e Ohrit (alb.)

IUCN:
Vulnerable

EUR-HAB-DIR:

Bern Convention:
Annex III

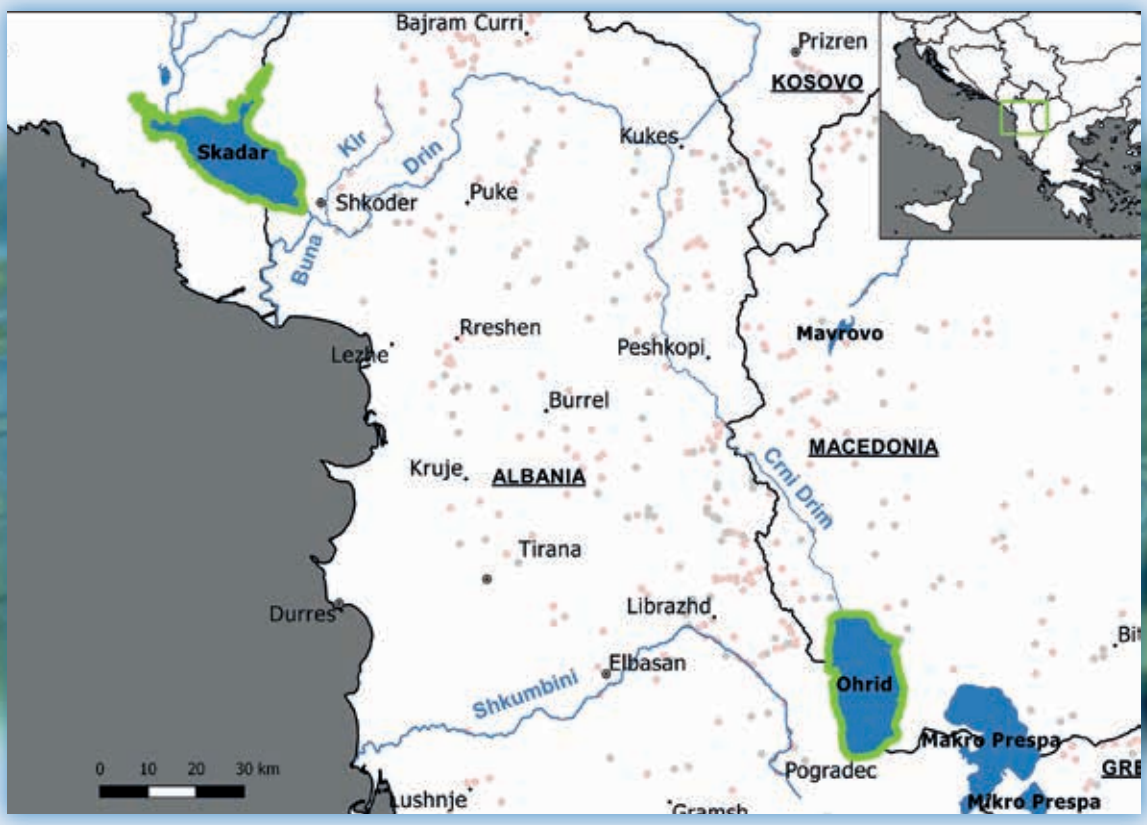
Hydropower Sensitivity:
Low-to-Moderate

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Albania, Macedonia, Montenegro

The **Ohrid spirlin** is listed as endemic to Lake Ohrid in Kottelat & Freyhof (2007) but local studies list the species as occurring in both Ohrid and Skadar lakes (Talevski et al. 2009; Talevska & Talevski 2015; Milošević & Talevski 2015). Previously treated as *Alburnoides bipunctatus ohridanus*, this lacustrine cyprinid fish uses the littoral zone as habitat, while spawning on rocky substrates (Talevska & Talevski 2015). The population in Lake Ohrid is likely not threatened by hydropower development, but populations in Lake Skadar, like many of the lakes endemics may be highly vulnerable to changes in water levels and/or introduced invasive species resulting from exploitation of the lake's only major tributary, the Morača River **(See Hotspot Morača/Skadar**).

Twenty-seven planned dams (not shown here) in the Skadar Lake Basin could threaten or eliminate more than 50% of the species range.



Alburnoides prespensis

Prespa spirlin (eng.), Prespa Schneider (ger.), Prespanska gomnuschka (mk.)

IUCN:
Vulnerable

EUR-HAB-DIR:

Bern Convention:
Annex III

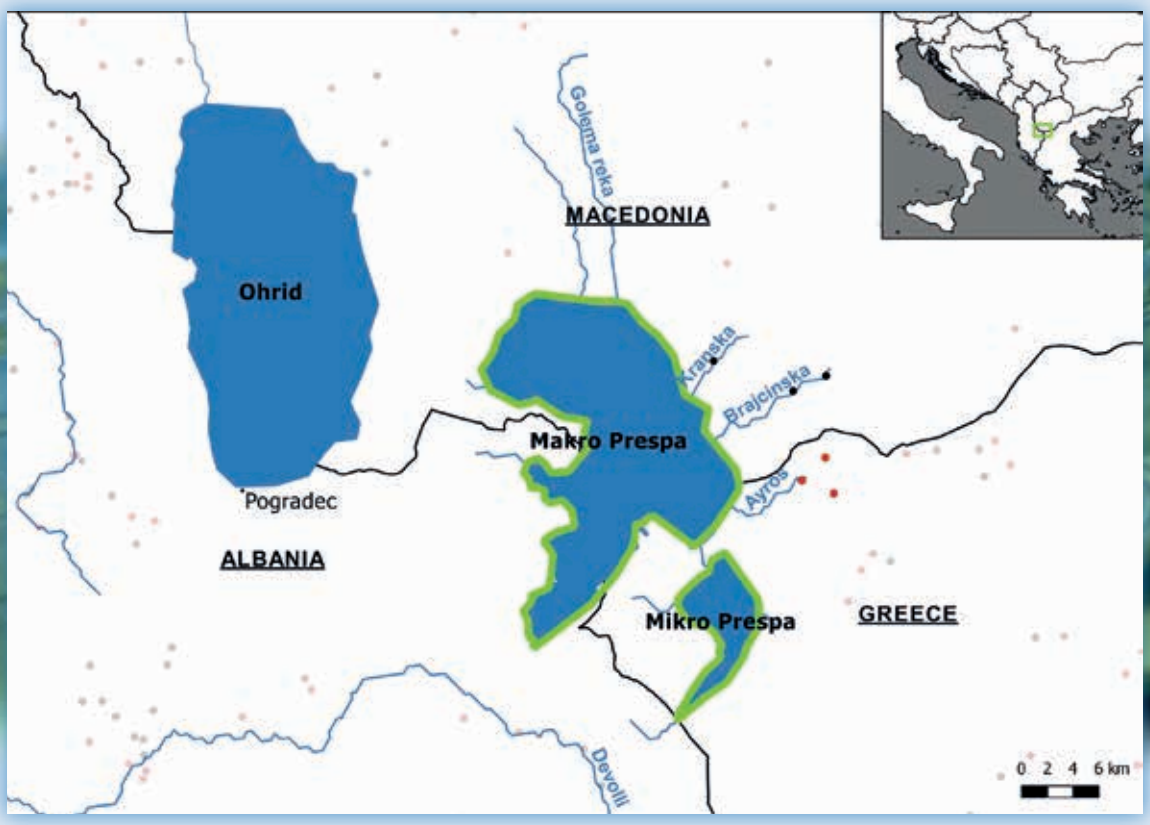
Hydropower Sensitivity:
Low

Balkan Dam Threat:
Low-to-Moderate

Distribution and Habitat – Macedonia, Greece, Albania

Prespa spirlin are one of seven species endemic to Lake Prespa (Kottelat & Freyhof 2007; Talevski 2010). Previously listed as *Alburnoides bipunctatus prespensis*, the species is strictly lacustrine and utilizes the shallow littoral zone as habitat. Like for most Lake Prespa's endemics, water extraction for irrigation, pollution, and the introduction of invasive species are the major threats to its survival. The species should not be overly vulnerable to hydropower development as there are no major tributaries or outflows to be exploited.

Any additional water use or diversion is problematic for all of Lake Prespa's endemic species as water levels in the littoral zone become altered and such projects invariably promote invasive species; small scale hydropower is planned on several small tributaries, such as the Ayros in Greece.



Alburnus belvica

Prespa bleak (eng.), Prespa Laube (ger.), Mpelovitsa (gr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

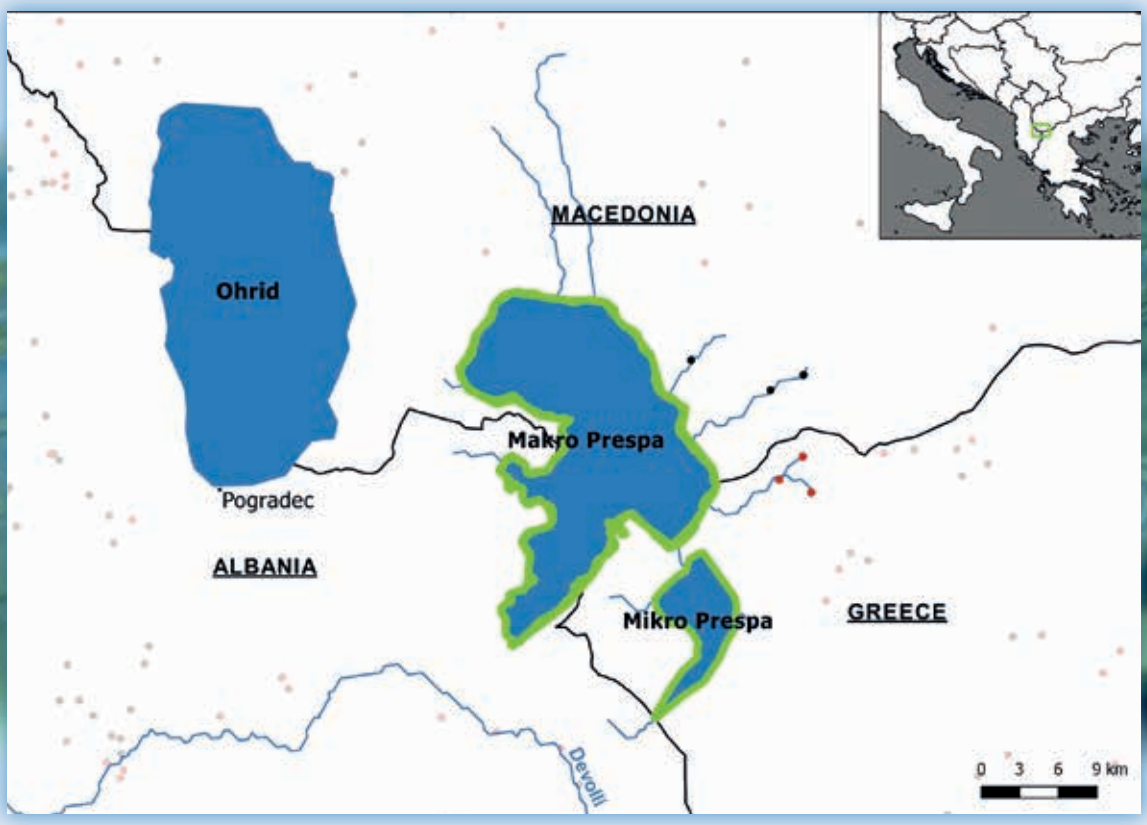
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Macedonia, Greece, Albania

Prespa bleak are a plankton feeding cyprind; they spawn in tributaries as well as gravel substrates along the shores (Kottelat & Freyhof 2007). One of seven fish species endemic to Lake Prespa (Kottelat & Freyhof 2007; Talevski 2010), they are the preferred prey of the world's largest colony of **Dalmatian pelicans** (*Pelecanus crispus*) (Pyrovetsi & Economidis 1998). Like of all Lake Prespa's endemic fauna, water abstractions, pollution and the introduction of non-native species are the major threats to their survival.

Tributary spawning populations may be under a high level of threat due to planned hydropower plants in the Agos Germanos (or Ayros) tributary in Greece. In this tributary, the endangered Prespa trout *Salmo peristericus* is also found. Additional dams in other tributaries, built for irrigation, may also pose problems.



Alburnus mandrensis

Mandras bleak (eng.), Mandras Seelaube (ger.), Briana (bg.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex III

Bern Convention:
Annex III

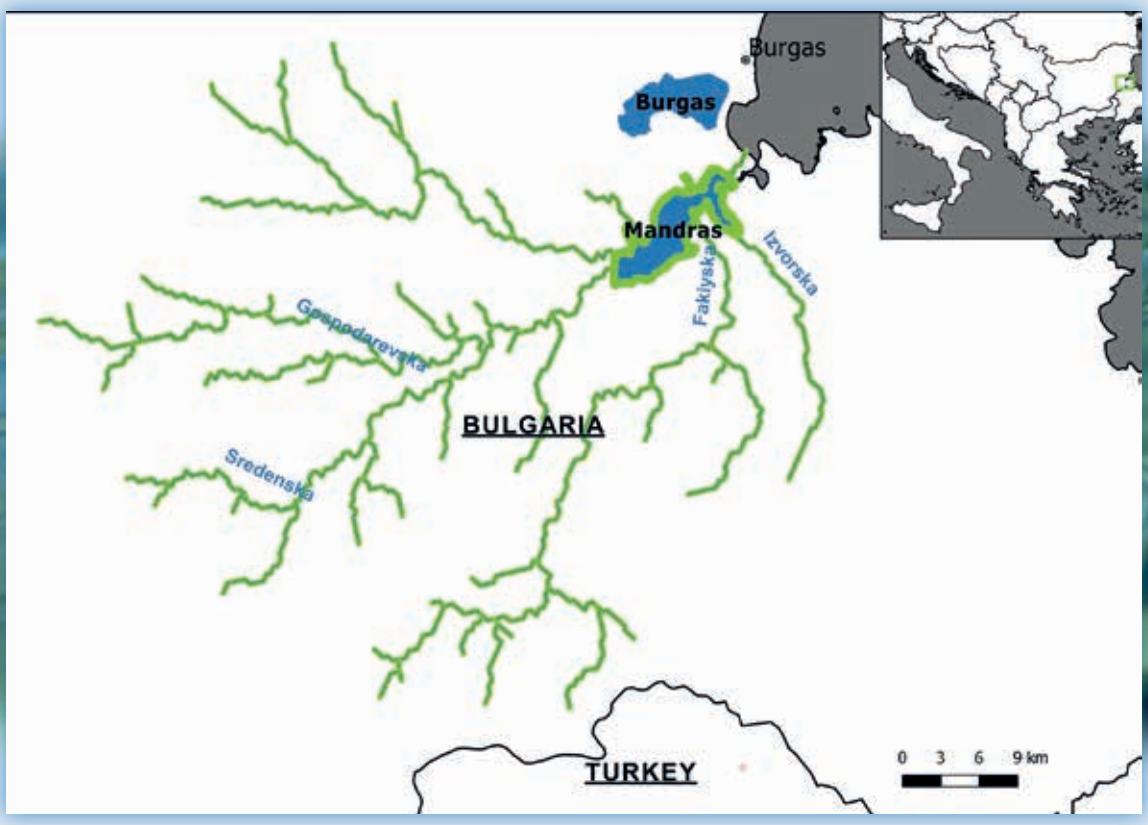
Hydropower Sensitivity:
High

Balkan Dam Threat:
Low

Distribution and Habitat - Bulgaria

Mandras bleak are endemic to the Lake Mandras drainage in Bulgaria. They use the impounded area of Lake Mandras for foraging (Kottelat & Freyhof 2007) but migrate into headwater tributaries to spawn in strong current over gravel. Suggested to be highly sensitive to hydropower development due to the blockage of migratory corridors to reach spawning grounds (Freyhof 2012). As the species is critically endangered and limited to this single drainage, any impact on these spawning grounds could bring the species to extinction.

At this time, there are no planned hydropower schemes listed in the Mandras catchment.



Alburnus sava

Kolpa schemaya (eng.), Kulpa Schemaya (ger.), Velika pliska (hr.)

IUCN:
Not Evaluated

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

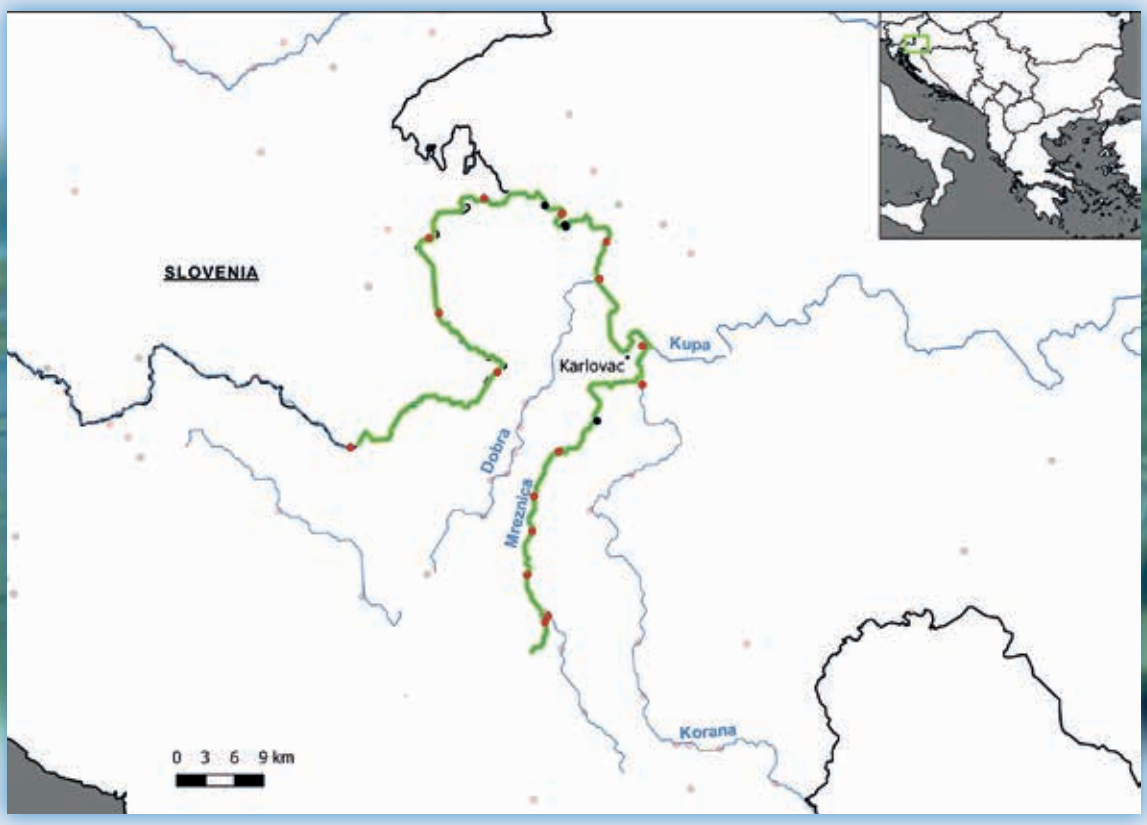
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Very High

Distribution and Habitat - Slovenia, Croatia

The Kolpa schemaya was described by Bogutskaya et al. (2017) from the Kolpa River (croatisch Kupa River) on the border between Slovenia and Croatia. This species was previously grouped with *A. sarmaticus*, but is easily differentiated based on two characteristics (gill rakers and scaled ventral keel, Bogutstkaya et al. 2017). Z. Marčić (pers. comm.) recognized the species from the nearby Dobra and Mrežnica rivers, but **they have disappeared from the Dobra after construction of the Lesce hydropower plant.** It is not known to what extent other populations in the upper Danube Basin may be assigned to this species; there are reports of catches in the Sava River in Bosnia, and specifically from the Bosna River near the town of Zenica (Z. Marčić pers. Comm.). If the rivers shown below hold the last remaining viable populations of *A. sava*, then the species should be downgraded to critically endangered.

A total of sixteen hydropower schemes are planned on the Kolpa and Mreznica rivers; the species might well be driven to extinction. The Kolpa is additionally one of the six free-flowing river stretches (> 100 km) in the Balkans harboring a self-sustaining population of huchen (Freyhof et al. 2015).



Alburnus schischkovi

Resowska schemaya (eng.), Rezowska Seelaube (ger.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

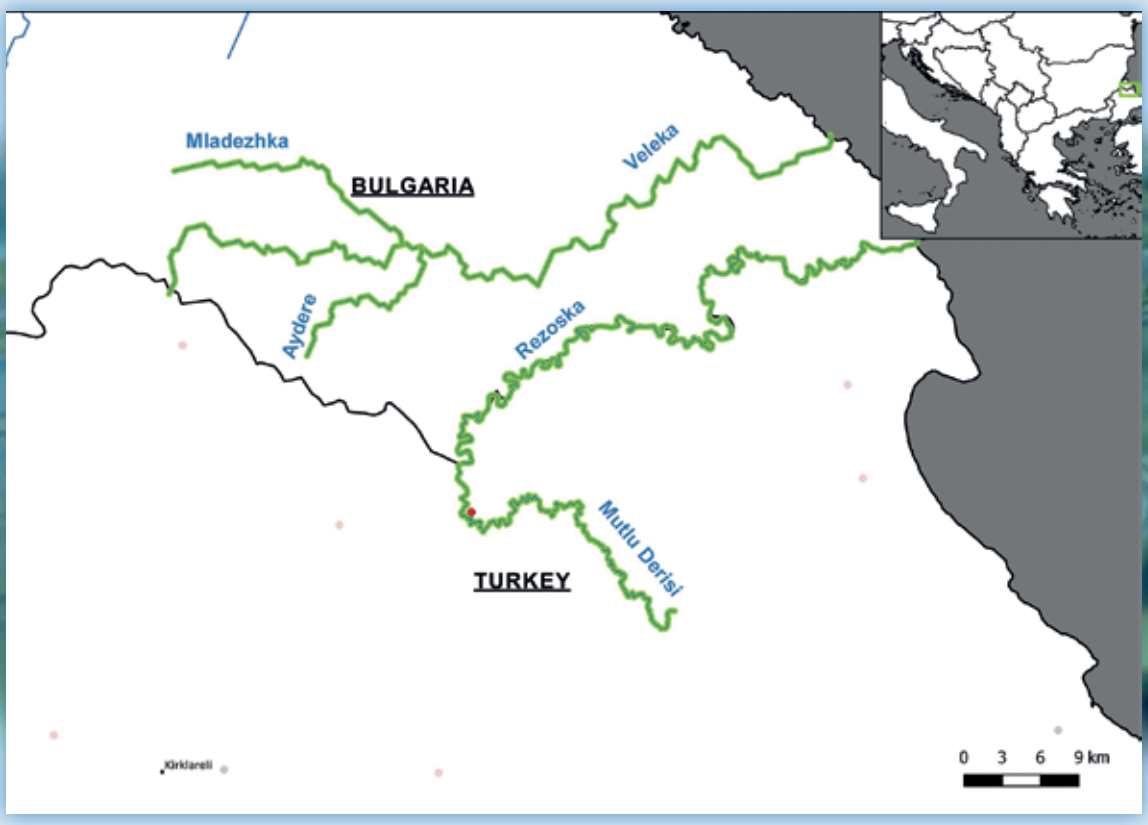
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Presently Low

Distribution and Habitat - Bulgaria, Turkey

The **Resowska schemaya** is listed in Kottelat & Freyhof (2007) as occupying the Resowska (Turkey) and Veleka (Bulgaria) drainages. Considered a migratory species, spawning in riffles with strong current, and highly vulnerable to hydropower development (Freyhof 2012).

At present, there is one dam planned in the habitat of this species.



Alburnus vistonicus

Vistonis schemaya (eng.), Vistonida Seelaube (ger.), Alaia (gr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Greece

The **Vistonis schemaya** is a lacustrine cyprinid that migrates to the upper reaches of tributaries to spawn (Kottelat & Freyhof 2007). Schemayas were previously recognized as a distinct genus *Chalcalburnus*, but are now grouped together with *Alburnus* (Kottelat & Freyhof 2007). The species is listed as endemic to Lake Vistonida, but is perhaps found in the Filiouris drainage (Freyhof & Kottelat 2008a). Most spawning habitat has been lost due to the construction of irrigation dams (Freyhof & Kottelat 2007, 2008a).

There are six medium-sized (1-10 MW) hydropower plants in planning in the upper Kosynthos River and several small plants (< 1 MW) planned in the Kompsatos River, the two major tributaries of the lake. Disruption of bed-load transport or the flushing of fine sediments can easily destroy spawning grounds downstream.

Alburnus volviticus

Yelartza (eng.), Volvi Seelaube (ger.), Yelartza (gr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

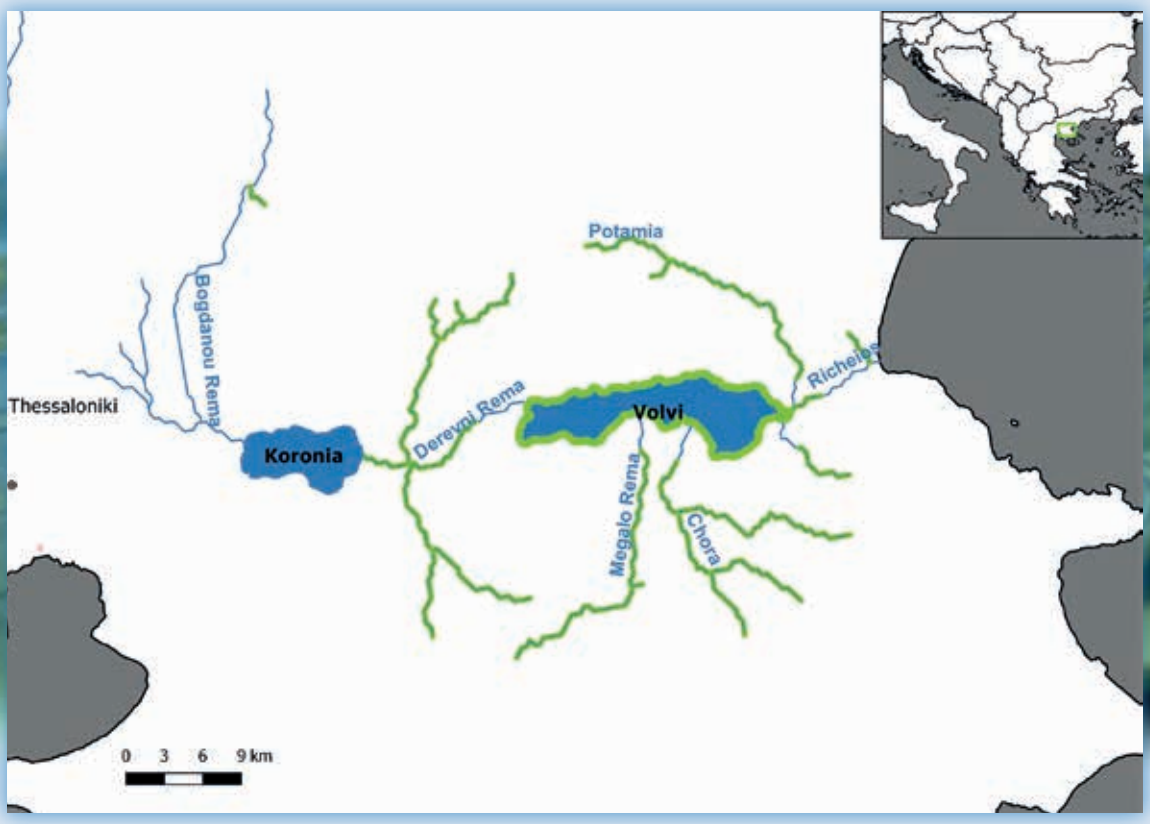
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Presently Low

Distribution and Habitat - Greece

Yelartza are reported to reach sizes of just over 200 mm SL (Kokkinakis & Sinis 1995); previously treated as *Chalcalburnus chalcoides macedonicus* (together with populations from Lake Vistonidis); nomenclature revised by Freyhof & Kottelat (2007). The species currently occurs only in Lake Volvi (Freyhof & Kottelat 2008b). Yelartza are lacustrine but migrate into tributaries to spawn. The major threat to this species is drought or water abstraction from tributaries where the spawning grounds are found.

While irrigation dams block spawning migrations, there are currently no hydropower schemes planned in the drainage.



Aspius aspius

Asp (eng.), Rapfen (ger.), Bolen (hr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II, IV

Bern Convention:
Annex III

Hydropower Sensitivity:
High

Balkan Dam Threat:
Moderate

Distribution and Habitat – all countries, except Albania

The asp is a widespread predatory cyprinid, reaching sizes of 800 mm SL and more than 10 years of age (Kottelat & Freyhof 2007). Found in large rivers and lakes but requires fast-flowing water for spawning. Asp undergo long migrations (up to 166 km, Fredrich 2003) and early life-history stages may additionally use floodplain habitats (Schiemer & Spindler 1989). Thus, despite their tolerance of lacustrine habitat, open river corridors (both laterally and longitudinally) are required to maintain riverine populations. **In addition to the marked range on the map below, Asp are probably found in the lower 5-10 km of most major tributaries of the Danube and lower Sava and Drau rivers.** Lake and reservoir populations always migrate into tributaries to spawn (Říha et al. 2013).

Nearly all of the Asp's riverine habitat in the Balkan region is threatened by large-scale hydropower development. Up to 50 hydropower schemes on the Danube, Sava, Drava and Mur rivers could drive riverine populations in this region to extinction.

Aulopyge hueglii

Dalmatian Barbelgudgeon (eng.), Barbengründling (ger.), Oštrulja (hr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

Hydropower Sensitivity:
Moderate-to-High

Balkan Dam Threat:
Very High

Distribution and Habitat - Croatia, Bosnia-Herzegovina

The Dalmatian Barbelgudgeon occurs in the Zrmanja, Krka and Cetina river drainages of Croatia, as well as small rivers in Livanjsko, Glamočko and Duvanjsko poljes in Bosnia-Herzegovina as well as lakes Buško and Blidinje (Kottelat & Freyhof 2007); recently reported from the Šujuca River, Bosnia (Benovics et al. 2017). Growing up to 200 mm SL, the species prefers more lacustrine habitats of karstic streams and wetlands; however, it is still considered very vulnerable to hydropower development (Freyhof 2012). It moves into subterranean habitats seasonally or during droughts (Ćaleta et al. 2009).

Approximately 20 hydropower schemes in Croatia threaten to eliminate more than 50% of the species range. Karstic areas are also very sensitive to hydropower schemes in distant locations due to unpredictable changes in groundwater flows.

Barbus macedonicus

Macedonian barbel (eng.), Mazedonische Barbe (ger.), Moustakato (gr.)

IUCN:
Data Deficient

EUR-HAB-DIR:
Annex V

Bern Convention:

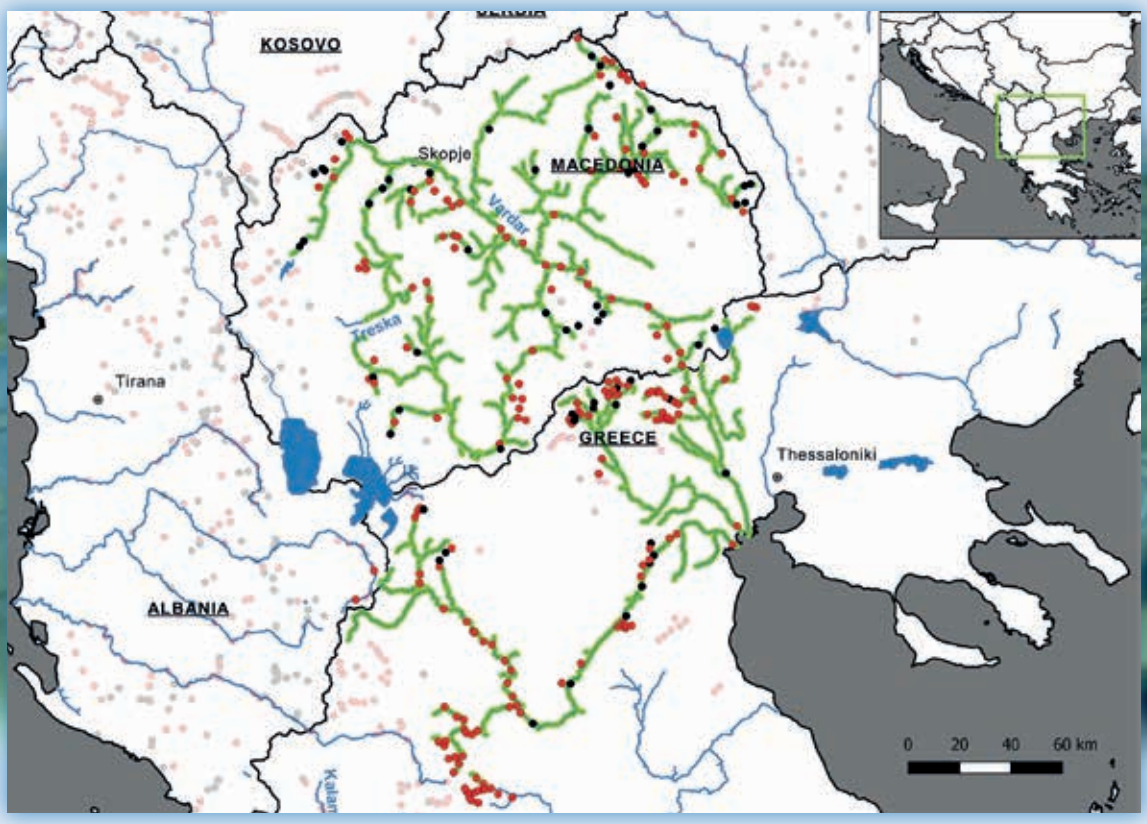
Hydropower Sensitivity:
High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Greece, Macedonia

The **Macedonian barbel** is listed in Kottelat & Freyhof (2007) and Ćaleta et al. (2015) as endemic to the Adriatic Basin. However, it was also reported from northern Anatolia (Dirican & Çilek 2012; Turgut et al. 2011). A typical Barbel species, it resides in larger rivers fast-flowing water and stone to gravelly substrates (Kottelat & Freyhof 2007). Barbels are strictly rheophilic with respect to their spawning requirements – without access to flowing water and clean substrates they cannot reproduce. Adults can be somewhat tolerant of reservoir habitats but they normally do not reach high population size there and cannot reproduce in such habitats.

Nearly 150 dams are planned within the habitat range of Macedonian barbel. We estimate that at least 50% and perhaps up to 75% of their habitat in the study area would be destroyed if these plans were carried out.



Barbus plebejus

Pananian or Italian barbel (eng.), Tiberbarbe (ger.), Mren (hr.)

IUCN:
Least Condern

EUR-HAB-DIR:
Annex II, V

Bern Convention:
Annex III

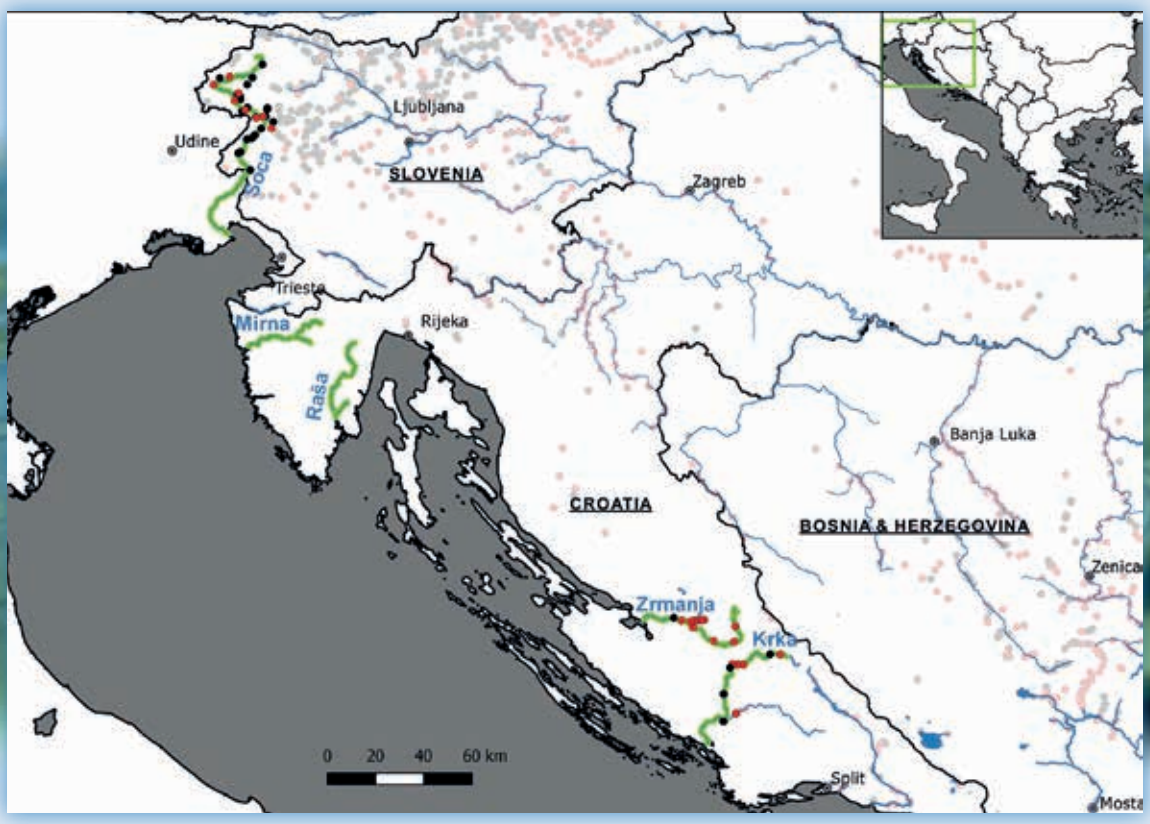
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Very High

Distribution and Habitat - Slovenia, Croatia, Turkey

The **Italian barbel is** listed in Kottelat & Freyhof (2007) and Ćaleta et al. (2015) as endemic to the Adriatic basin. However, it is also reported from northern Anatolia (Dirican & Çilek 2012; Turgut et al. 2011). This large-sized (600 mm SL) barbel resides in deeper water of the upper to middle reaches of turbulent rivers (Ćaleta et al. 2015); it moves to shallow riffles to spawn. Listed as endangered in Croatia, largely due to dam construction as well as water pollution and the introduction of alien species – like *B. barbus*, it is a target of sport fishing.

Approximately 20 hydropower schemes across the Soca, Zrmanja and Krka drainage threaten to eliminate at least 75% of the Balkan range of this species.



Barbus prespensis

Prespa barbel (eng.), Prespa Barbe (ger.), Mrena e Prespës (alb.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex V

Bern Convention:

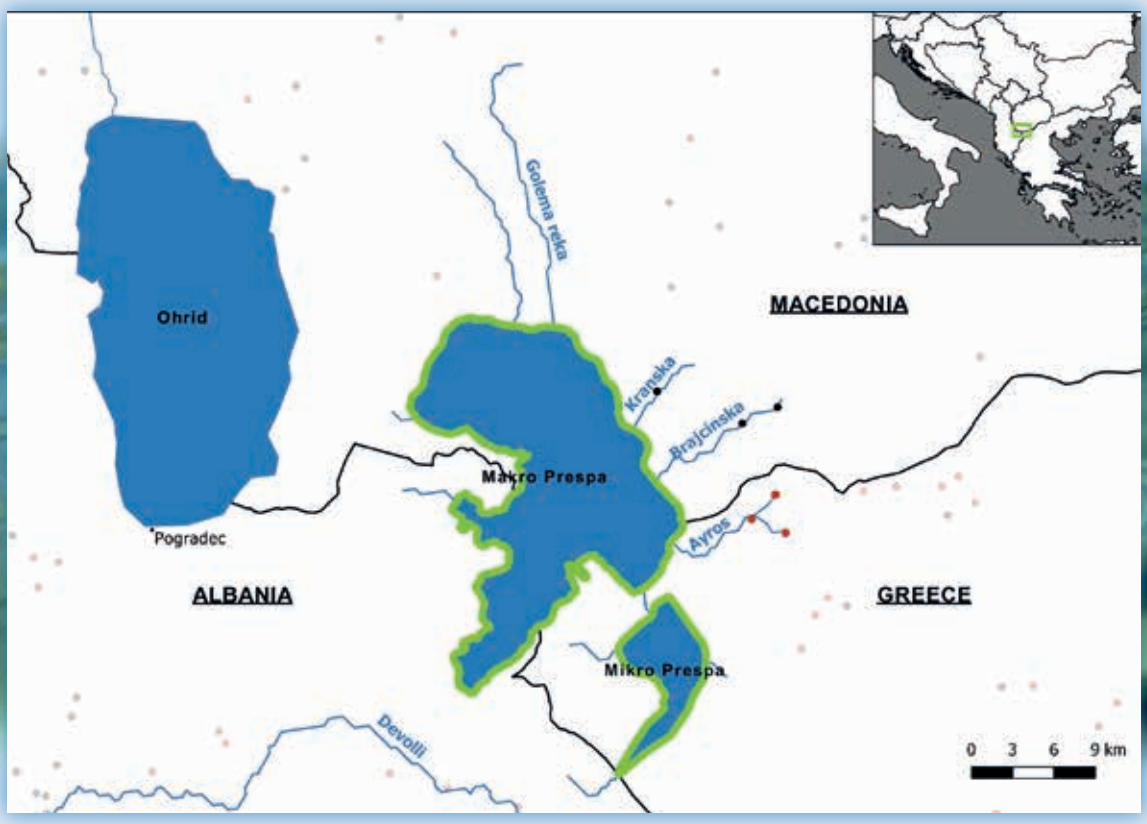
Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat - Greece, Macedonia, Albania, Montenegro

The **Prespa barbel** was thought to be endemic to Lake Prespa, but now many authors report that it is more widely spread in the southwestern Balkans and perhaps synonymous with *B. rebeli* populations from the Shkumbini, Semani, Vjosa and Dukati drainages in Albania (Marková et al. 2010). For the purposes of this report, we treat Prespa barbel as a species, and report the distribution of B. rebeli separately. In Lake Prespa, they reach 240 mm SL (Kottelat & Freyhof 2007). Prespa barbel are reported to spawn over springs or gravely shorelines in Lake Prespa (Kottelat & Freyhof 2007).

Three hydropower schemes in the Agios Germanos (Ayros) drainage in Greece could threaten spawning habitat there, along with that of Prespa barbell and Prespa trout.



Barbus rebeli

Western Balkan barbel (eng.), Westbalkan Barbe (ger.), Mrena e Fanit (alb.)

IUCN:
Least Condern

EUR-HAB-DIR:
Annex V

Bern Convention:

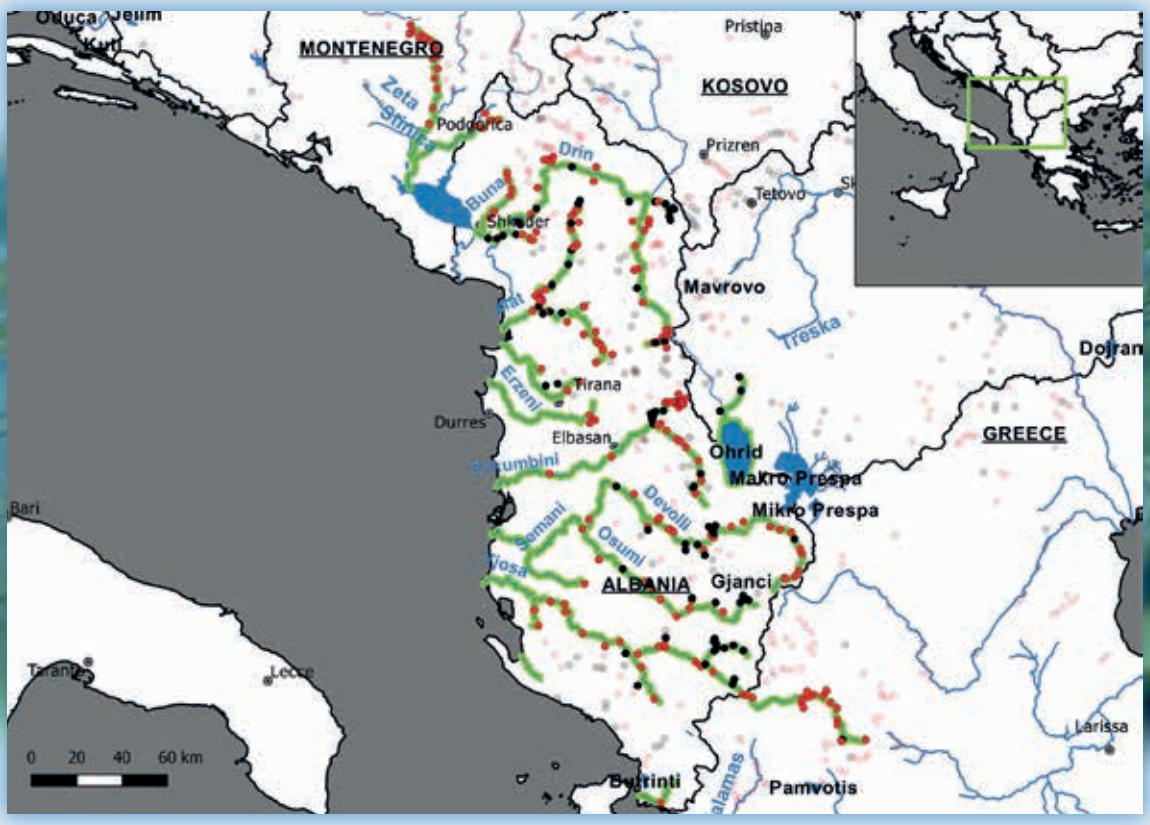
Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat - Greece, Macedonia, Montenegro, Albania

The **Western Balkan barbel** is found in the Adriatic basin from Drin to upper Vjosa River (Aoos) in Greece (Kottelat & Freyhof 2007). Found extensively in Albanian rivers, Marková et al. (2010) reported three distinct mtDNA lineages of *B. rebeli* found in the following basins; a) Drin drainage from Zeta River to Lake Ohrid; b) northern Albanian rivers from Mati to Erzeni; c) Albanian rivers Shkumbini to Dukati but including Lake Prespa. But for the purposes of this report, we treat *B. prespa* as a distinct species. Also reported from both lakes, Ohrid and Skadar (Talevski et al. 2009), and the Cijevna River in Montenegro (Marić et al. 2012). The species occurs both in lakes and streams, with overfishing potentially a problem in Albania (Kottelat & Freyhof 2007).

Several hundred hydropower plants are being planned throughout the entire range of the species. Their construction would lead to the elimination of at least 75% of the species habitat.



Barbus strumicae

Sturmica barbel (eng.), Sturma Barbe (ger.), Virjana (gr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex V

Bern Convention:

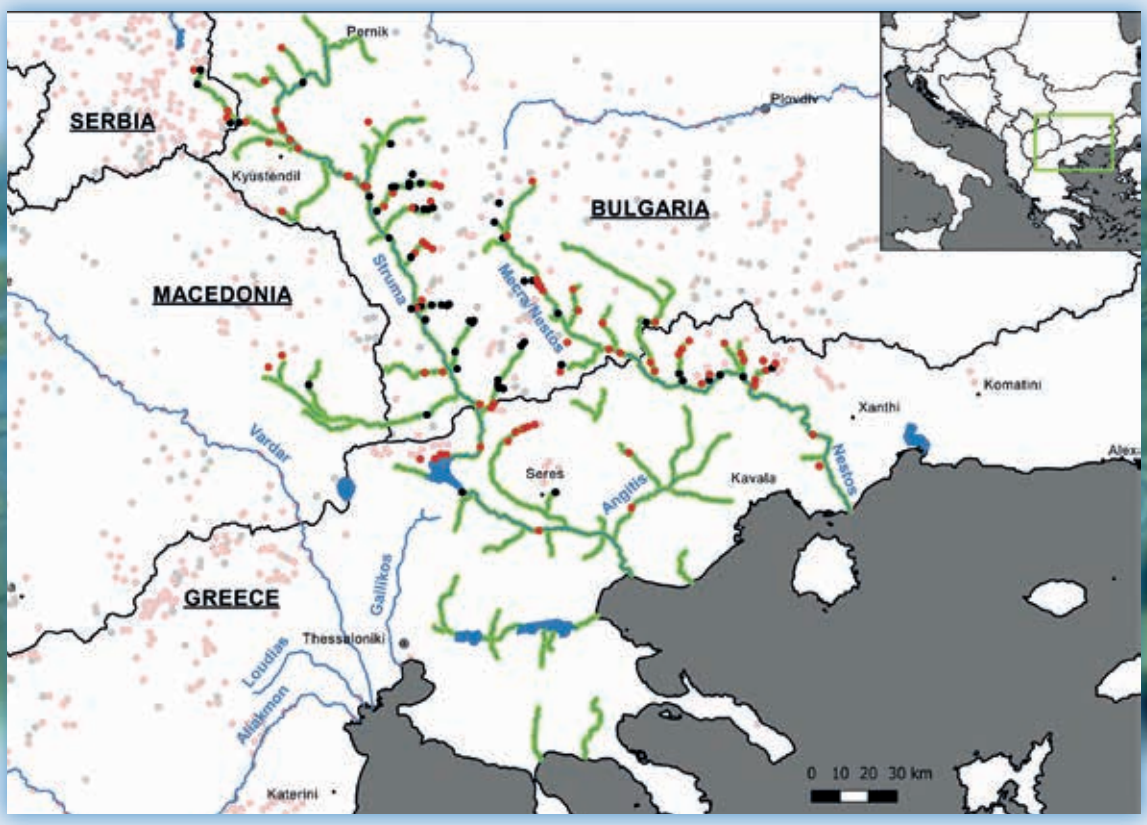
Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat – Serbia, Macedonia, Bulgaria, Greece

The **Sturmica barbel** is a small-sized riverine cyprinid (to 300 mm SL) that primarily feeds on midge (Chironomidae) larvae (Sapounidis et al. 2015); the species is still recognized by some as *Barbus cyclolepis*. Recorded in the Nestos/Mesta river in the main stem and tributaries (Koutrakis et al. 2013), from Kerkini Reservoir in Greece (Petriki et al. 2014), the Mpogdanas stream in Greece (Bobori et al. 2014), and in the Dragovištica River (Strymon drainage) in Serbia (Marić et al. 2004). **Marić et al. (2004) reported loss of migration and productivity on the Božica River due to a hydropower plant and water diversion from the Ljubata River.** Most *Barbus* sp. require flowing water and gravel substrates for spawning.

The species is still widespread, but half of its range is targeted with at least 60 new hydropower facilities. It is likely that up to 50% or more of its populations would be lost if these plans were carried out.



Chondrostoma knerii

Dalmatian nase (eng.), Dalmatinische Näsling (ger.), Podustva (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

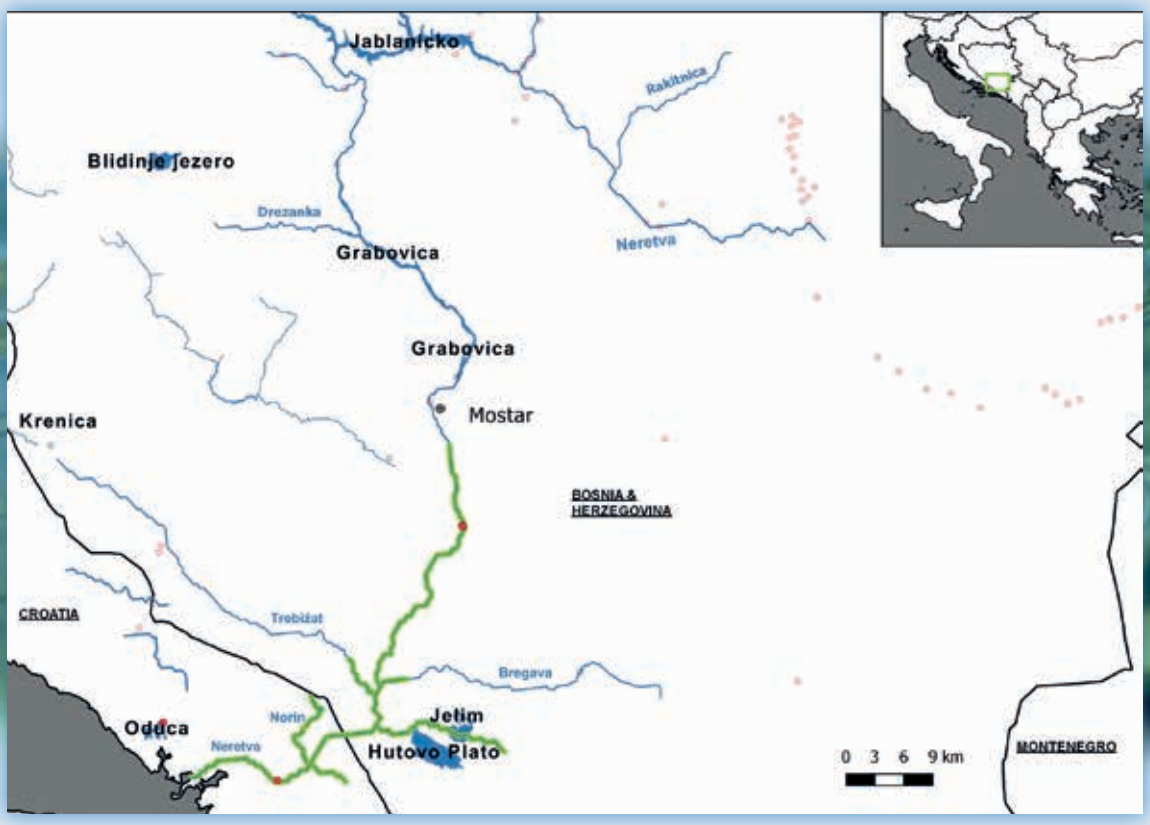
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia, Bosnia-Herzegovina

The **Dalmatian nase** is endemic to the Neretva basin in Croatia and Bosnia-Herzegovina. It is primarily found in the mid to lower reaches and delta region of the Neretva River (Croatia) as well as Modro Oko and Desne lakes, Crna Rijeka and Norin rivers, and in Bosnia-Herzegovina the Buna and Krupa rivers and Hutovo Blato wetlands (Glamuzina et al. 2007; Ćaleta et al., 2015). Generally rheophilic but like other karst species, it also resides in sink holes and springs, with relatively cool water (Tutman et al. 2008). Very sensitive to invasive species (Glamuzina et al. 2007), whose presence is often promoted by hydropower development. Listed as endangered in Croatia.

At least two mid- to large-sized (10-50 MW) hydropower facilities in addition to a sea water control dam are planned on the lower Neretva River between Mostar and the sea. These projects could eliminate one of the most important spawning areas of the species in the basin.



Chondrostoma phoxinus

Minnow nase (eng.), Elritzen Näsling (ger.), Podbila (hr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

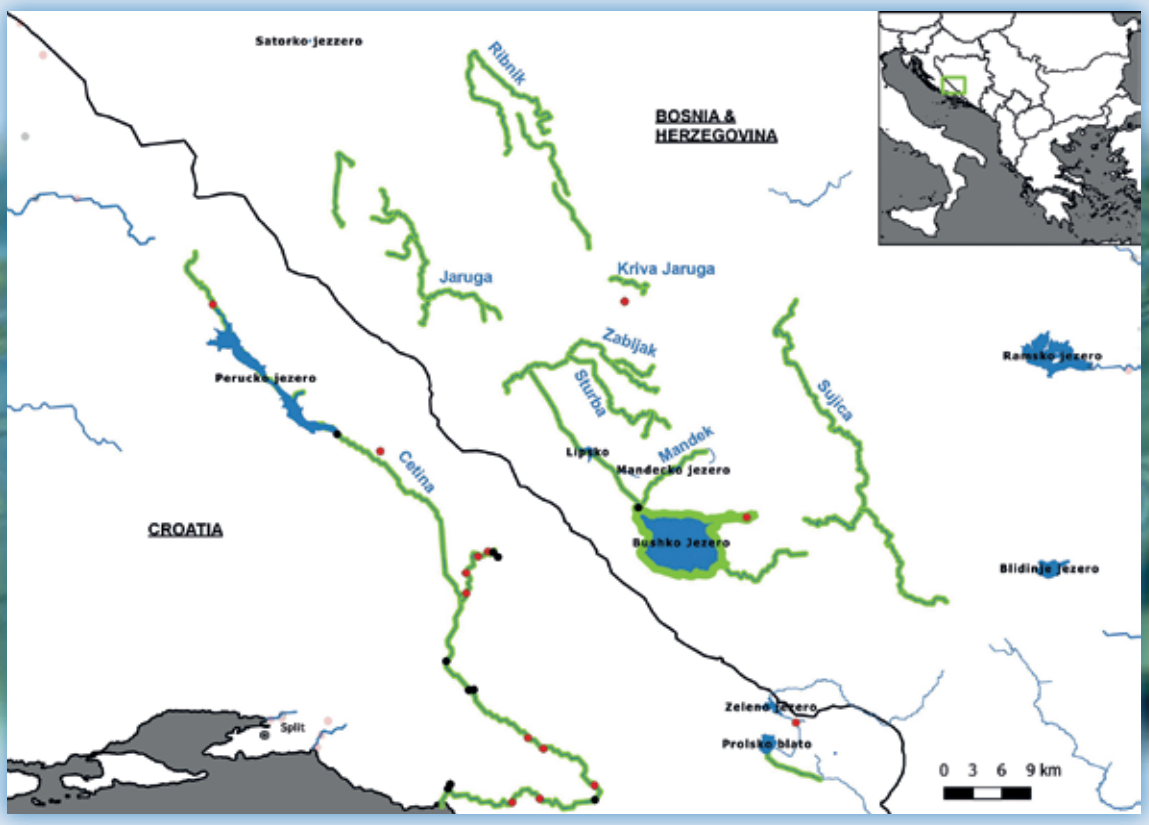
Hydropower Sensitivity:
Low-to-Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat - Croatia, Bosnia-Herzegovina

The minnow nase is only found in the Cetina River basin (Ruda and Sija streams and Prološko Blato) of Croatia and the Glamocko, Livansjiko and Duvanjskok poljes of Bosnia-Herzegovina as well as Bushko Lake (Ćaleta et al. 2015, Ćaleta et al. 2009). They live in both streams and lakes, and can survive impoundment as long as wetlands and shallow shores are available (Freyhof 2012). Nonetheless, this species is very sensitive to the spread of invasive species, whose spread is often promoted by hydropower development (Freyhof 2012). Considered critically endangered in Croatia (Ćaleta et al. 2015).

Up to eleven planned hydropower schemes in the Cetina River, home to at least eight threatened or endangered fish species, could eliminate the Croatian range of this species.



Chondrostoma prespense

Prespa nase (eng.), Prespa Nase (ger.), Mrena e Prespës (alb.)

IUCN:
Vulnerable

EUR-HAB-DIR:

Bern Convention:

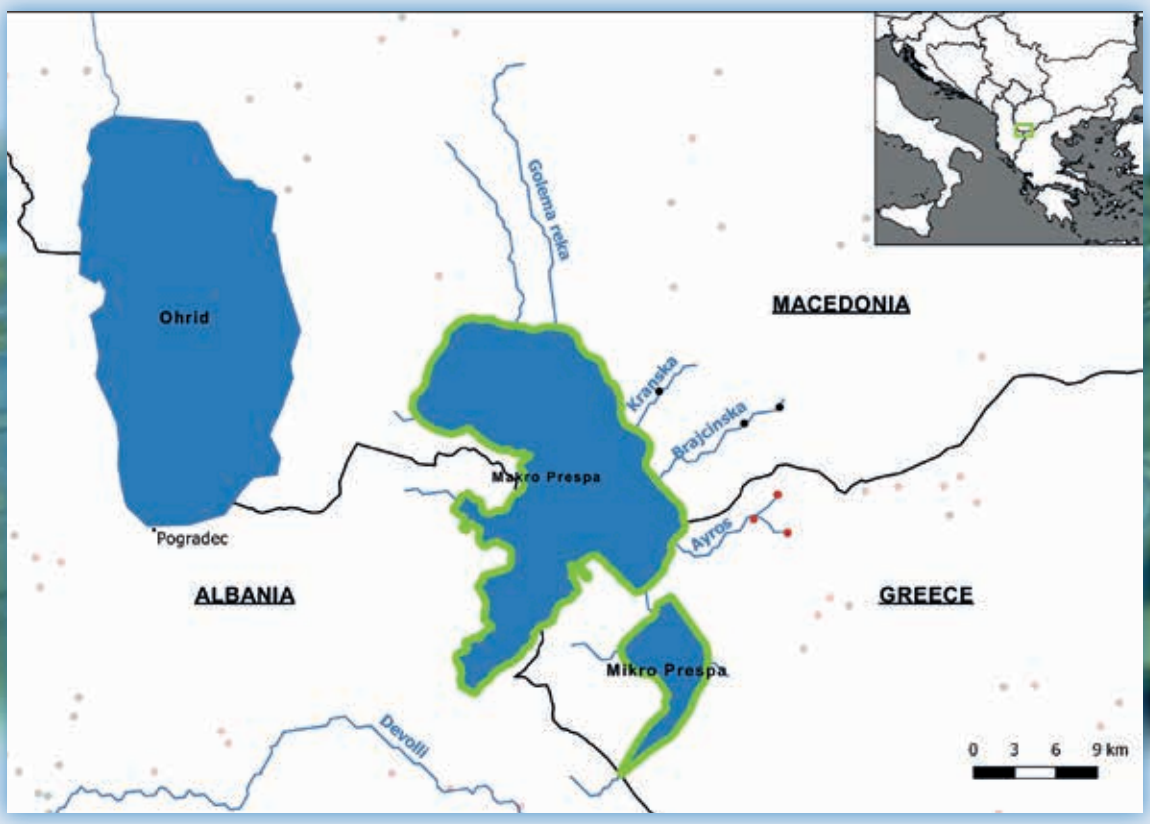
Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat - Greece, Macedonia, Albania

The **Prespa nase** is one of seven endemic fish species to Lake Prespa (Talveski 2010). Generally a lacustrine species, but it requires flowing tributaries for spawning (Freyhof 2012). Recorded to migrate into Agios Germanos (Ayros) of Makro Prespa (Greece) at night to spawn (Crivelli et al. 1997). Thus, the species is considered highly vulnerable to damming if this tributary was blocked – other small tributaries of the system might also harbor spawning runs. According to Kottelat & Freyhof (2007), the species also spawns on gravel beaches.

As for all Prespa endemics, further exploitation of tributaries would endanger the existence of the global population of the species. At least three endemic species (Prespa nase, Prespa trout, and Prespa barbel) use Agios Germanos (Ayros) as their general habitat or spawning grounds. Three planned dams on the Ayros system in Greece threaten all three of these rare species.



Delminichthys adspersus

Spotted minnow (eng.), Imotska Elritze (ger.), Imotska gaovica (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

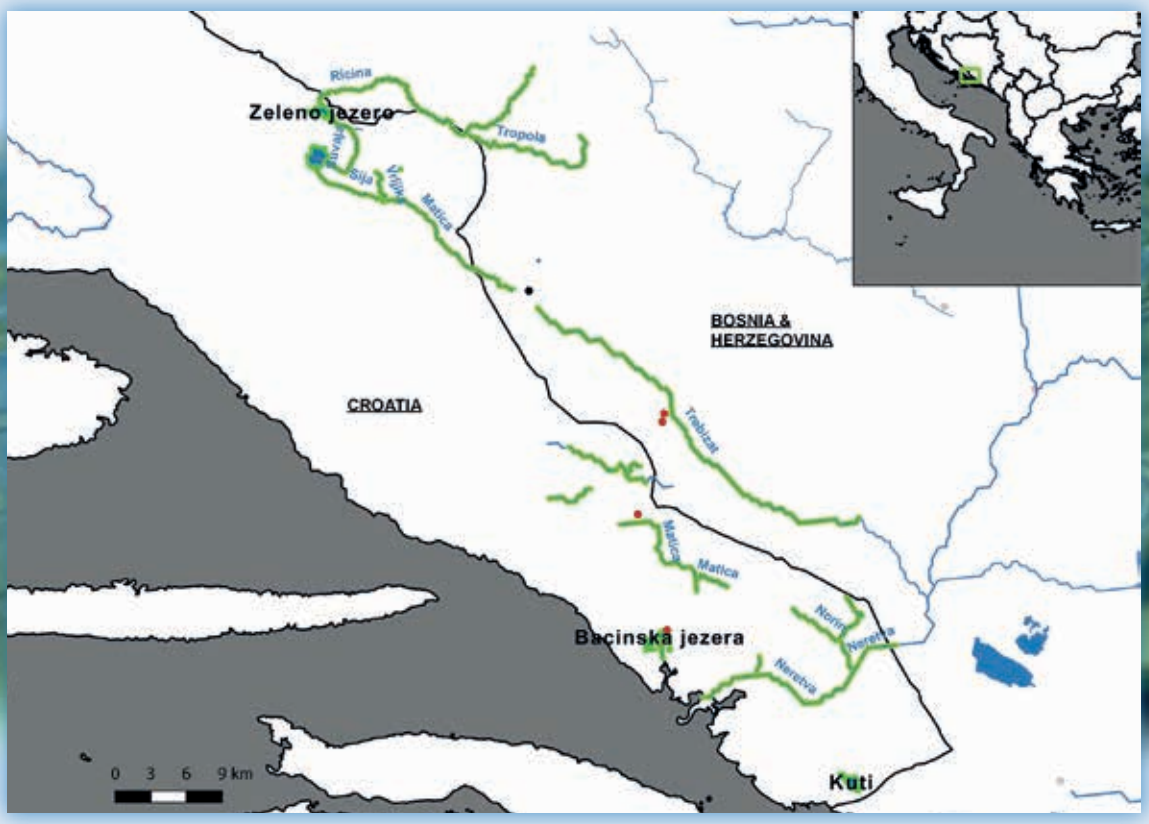
Hydropower Sensitivity:
High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Croatia, Bosnia-Herzegovina

The **Spotted minnow** was found in the catchment areas of Rastočko, Vrgoračko, Imotski fields (e.g. Vlrjika and Silja rivers) including Tihaljina (also Trebižat) tributary of the Neretva River (Palandačić et al. 2012; Ćaleta et al. 2015). These authors list more sites than Crivelli (2006c), and thus assessment (as noted) requires updating. This minnow reaches up to only 12 cm in length, spend the winter relatively dormant in subterranean habitats and are very vulnerable to invasive species or hydrological disturbance.

One hydropower plant directly on the Ricica River and several more in the Trebižat drainage threaten to alter hydrological conditions of this sensitive karst system, and further promote the spread of invasive species.



Delminichthys ghetaldii

Southern Dalmatian minnow (eng.), Süddalmatinische Elritze (ger.), Popovska gaovica (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:

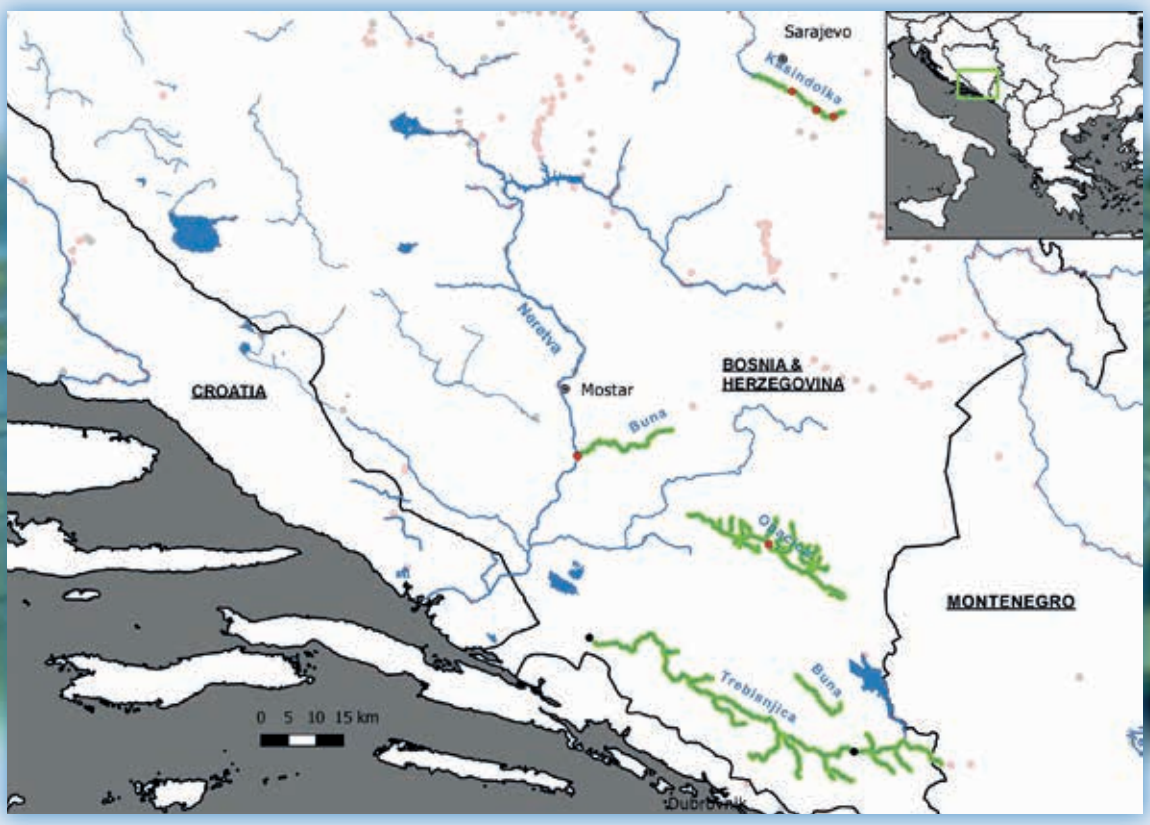
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Croatia, Bosnia-Herzegovina

In Croatia, the **Southern Dalmatian minnow,** a karst specialist, is found just inland of Dubrovnik (Ombla spring) (Ćaleta et al. 2015) and in some springs in Konavle region, south of Dubrovnik; this occurrence may be due to washing down from karstic fields in Bosnia-Herzegovina where it is more widespread and common in the Popovo, Dabar and Fatnica karst fields, and in the Buna River and Kasindolka stream (Ćaleta et al. 2015). Previously listed under *Phoxinellus*; placed into a new genus based on genetic data (Freyhof et al. 2006). Like other karst minnows of the genus, they spend winters relatively dormant in subterranean habitats (Ćaleta et al. 2015). All are very vulnerable to invasive species or hydrological disturbance.

Several hydrological schemes planned in the range of this species may threaten its survival, due to the unpredictable effects on underground flows that such alternations bring in this unstable and complex karst region.



Delminichthys jadovensis

Jadova minnow (eng.), Jadova Elritze (ger.), Jadovska gaovica (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

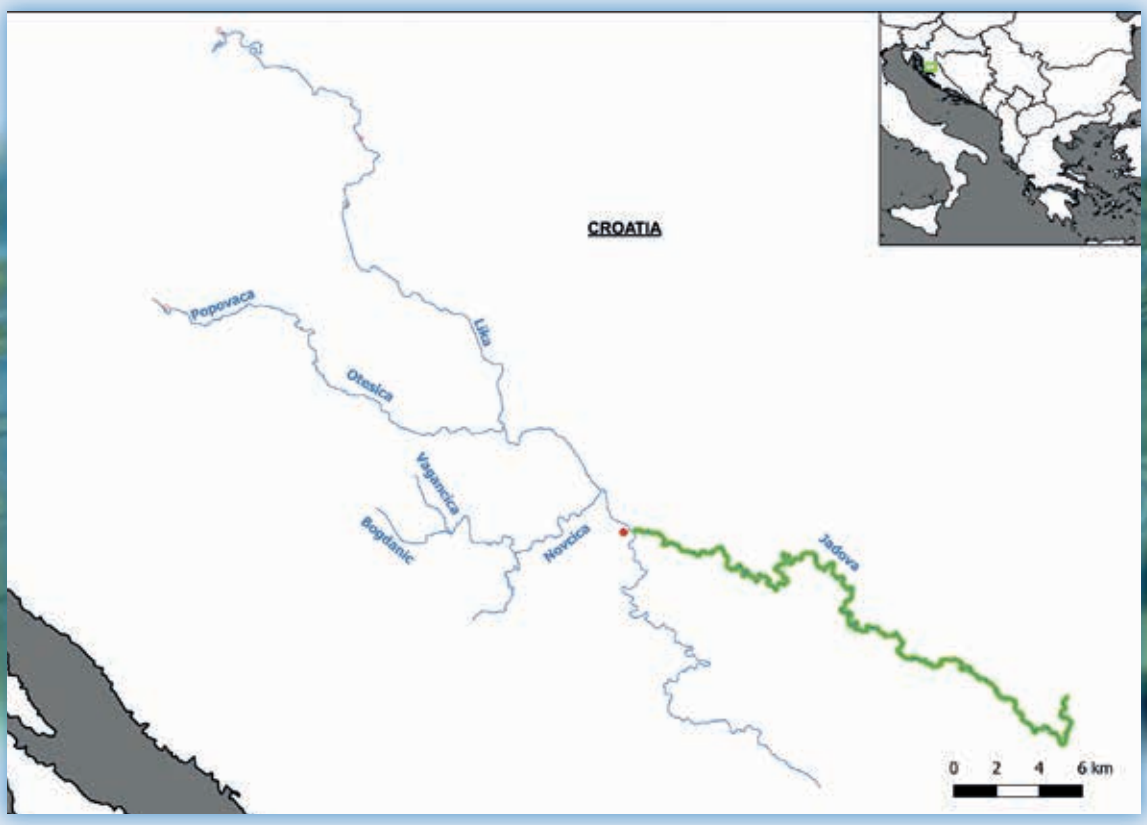
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Very High

Distribution and Habitat - Croatia

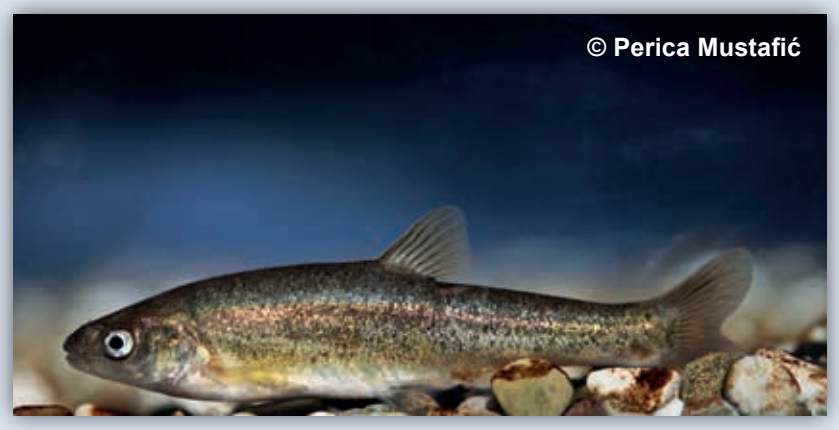
The **Jadova minnow** is endemic to the Jadova River, including its tributaries Balotin and Japoga rivers (Ćaleta et al. 2015). The smallest of the karst minnow genus *Delminichthys* (up to only 9.5 cm SL), this steno-endemic has disappeared from some sites where it was originally collected, and has been found at others where it was previously unknown, but all in the same drainage (Bogutskaya et al. 2012; Jelić et al. 2016). Like all members of the genus, it is considered extremely vulnerable to the spread of invasive species and hydrological disturbances (Freyhof 2012; Ćaleta et al. 2015).

Three planned hydropower schemes in the Lika River threaten this species with global extinction due to unpredictable effects on both the surface and subterranean hydrology of this karst region, and the promotion of invasive species that stem from the creation of new impoundments.



Delminichthys krbavensis

Krbava minnow (eng.), Krbavska Elritze (ger.), Krbavska gaovica (hr.)



IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

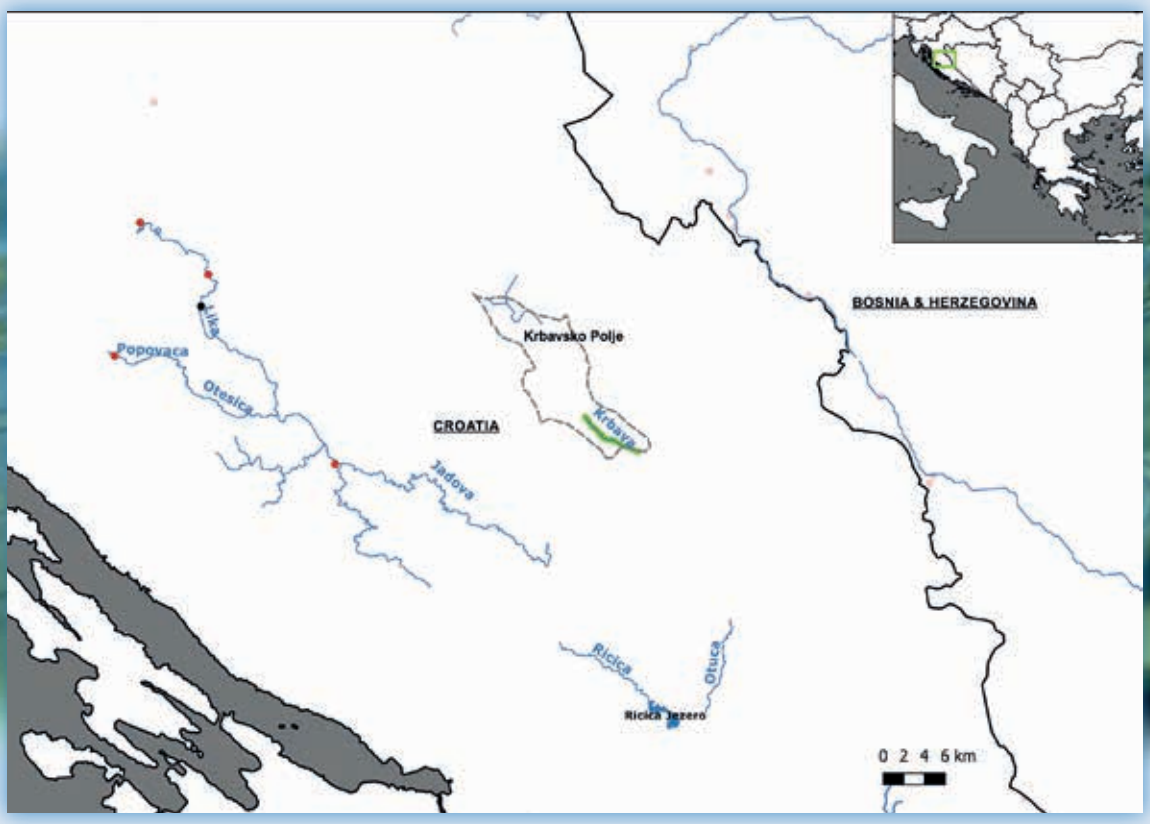
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia

The **Krbava minnow** is endemic to the Krbava field; it is the only member of the genus found in the Danube basin (Ćaleta et al. 2015). Specifically reported from the Vukova pećina, Ribičko jezero and špilja Suvaja (Mihinjač et al. 2015). Similar to other *Delminichthys* species, the Krbava minnow occupies karst habitats and spends extensive periods of time in subterranean habitats during low water periods in summer or winter. Karst minnows are extremely vulnerable to alien species introductions and hydrological disturbance (Freyhof 2012, Ćaleta et al. 2015).

There are presently no planned hydropower schemes in the Krbava karst field, but nearby schemes may affect the region due to the unpredictable consequences of altering hydrological regimes in this karst system (see again Roje-Bonacci & Bonacci 2013; Bonacci et al. 2016).



Gobio kovatschevi

Varna gudgeon (eng.), Varna Gründling (ger.), Varna gudgeon (bg.)

IUCN:
Vulnerable

EUR-HAB-DIR:

Bern Convention:

Hydropower Sensitivity:
High

Balkan Dam Threat:
Low

Distribution and Habitat – Bulgaria, Turkey

The **Varna gudgeon** is native to the Black Sea basin with a very limited distribution. It was previously reported from only from the upper reaches of the Provadyiska River in Bulgaria whereby pollution is reported to have eliminated distribution from lower reaches (Freyhof & Kottelat 2008c). The species is also reported to occur in the nearby Kamchia River, as well as the Corlu Cayi in Turkey (Turan et al. 2016). Varna gudgeon occupy habitats with slow currents. Very little biological information exists for this species.

There are currently no dams planned in the Bulgarian portion of the species range, due to the low gradient of the habitat, but one hydropower scheme is planned on the Corlu Cayi in Turkey.

Gobio skadarensis

Skadar gudgeon (eng.), Skadar Gründling (ger.), Mrena njëmustakore e Shkodrës (alb.)

IUCN:
Endangered

EUR-HAB-DIR:

Bern Convention:

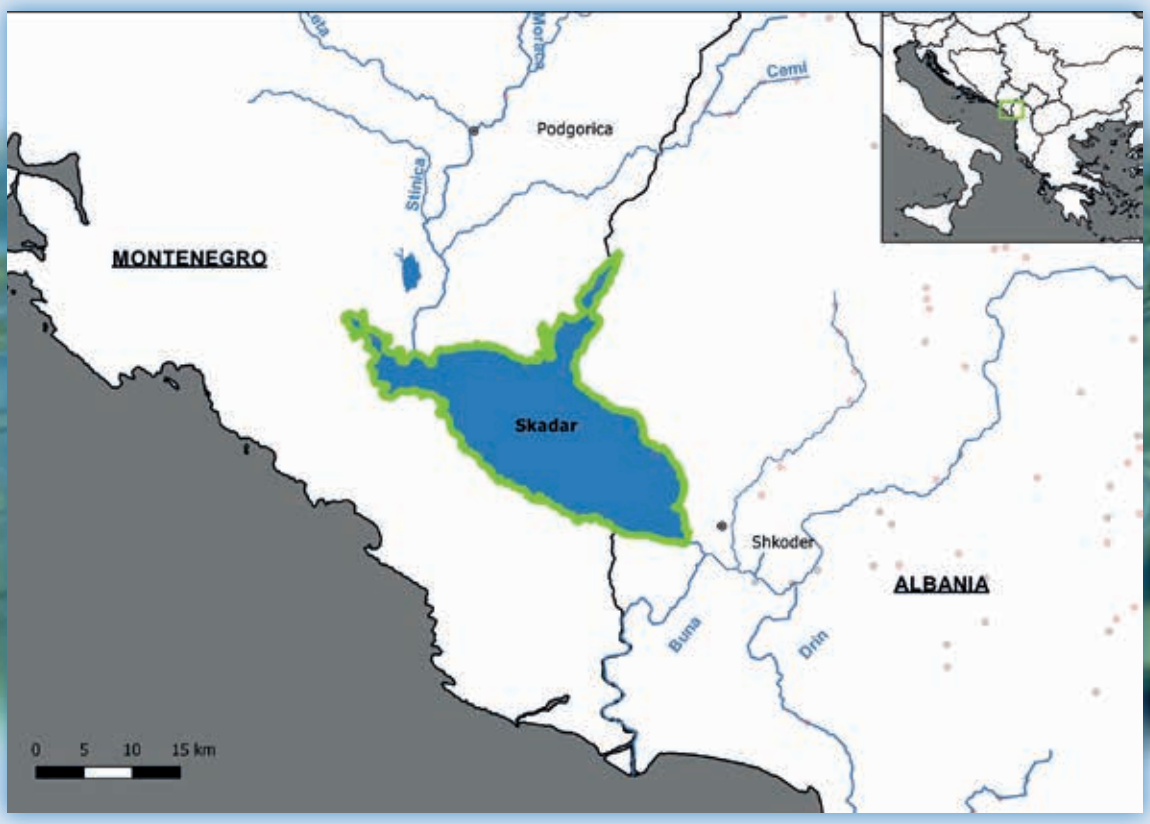
Hydropower Sensitivity:
Moderate-to-High

Balkan Dam Threat:
Moderate-to High

Distribution and Habitat – Montenegro, Albania

The **Skadar gudgeon** is one of seven fish species endemic to the Lake Skadar basin. They are found in the lower reaches of the Zeta and Morača rivers, and can also live in the lake itself (Kottelat & Freyhof 2007). The species requires inflowing streams to spawn and is additionally sensitive to hybridization with *Gobio obtusirostris* (Freyhof 2012).

Like all Lake Skadar endemics, hydropower exploitation of the Morača River, where a nearly closed chain of 20 hydropower facilities is planned (not shown), will alter the hydrological regime and may disturb spawning areas for many species. As Skadar gudgeon is a local endemic, the species is at risk of global extinction if these plans are carried out.



Pelasgus epiroticus

Epirus minnow (eng.), Epirus Elritze (ger), Tsima (gr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

Hydropower Sensitivity:
Low

Balkan Dam Threat:
High

Distribution and Habitat - Greece

The **Epirus minnow** is a small-sized (100 mm SL), lacustrine cyprinid; it lives among shoreline vegetation of Lake Pamvotis, Greece. The species has suffered a 90% decline in abundance since 1995 (Crivelli 2006). Overfishing, predation, pollution, water loss and introduction of invasive species are the major threats (Crivelli 2006d). Up to 20 exotic fish species have been introduced and the lake's fish fauna is now dominated by mosquitofish (*Gambusia affinis*), Lourogobios *(Economidichthys pygmaeus*), Prussian carp (*Carassius gibelio*) and Trichonis roach (*Rutilus panos*i) (Leonardos et al. (2008). The lake has now been listed as a Natura 2000 area (Gkenas et al. 2012).

While hydropower development has not played a role in the demise of this species', at least three small schemes are now planned around Lake Pamvotis. As the lake's hydrology and loss of surface area are a major concern, further alterations could drive this steno-endemic species to extinction.

Pelecus cultratus

Razor fish (eng.), Ziege (ger.), Sabljarka (bh.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II, V

Bern Convention:
Annex III

Hydropower Sensitivity:
Moderate-to-High

Balkan Dam Threat:
Moderate-to High

Distribution and Habitat - Slovenia, Croatia, Serbia, Bosnia-Herzegovina, Bulgaria

The **Razor fish** is widespread but in the Balkans it is a sporadically occurring species found throughout the Danube main channel corridor and major tributaries from Slovenia to the Black Sea. The species is found in both rivers and lakes, including reservoirs but river populations are very sensitive to migration barriers both longitudinally and laterally. The species can undertake very long migrations, but the large-scale ecological conditions that support the species remain somewhat of a mystery. Major declines have been associated with hydropower development (Ratschan 2014 and ref. therein, Kottelat & Freyhof 2007, Górski et al. 2010). In Slovenia, it is only sporadically present in the Mur River, where presently up to eight power plants are in planning, all within a Natura 2000 area (Weiss 2017).

At least 25 large dams on the Danube, Sava, Drava and Mura rivers seriously threaten a large portion of the riverine distribution of this species in the Balkans.

Phoxinellus alepidotus

Dinaric or Naked minnow (eng.), Schuppenlose Elritze (ger.), Dinarska pijurica (hr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

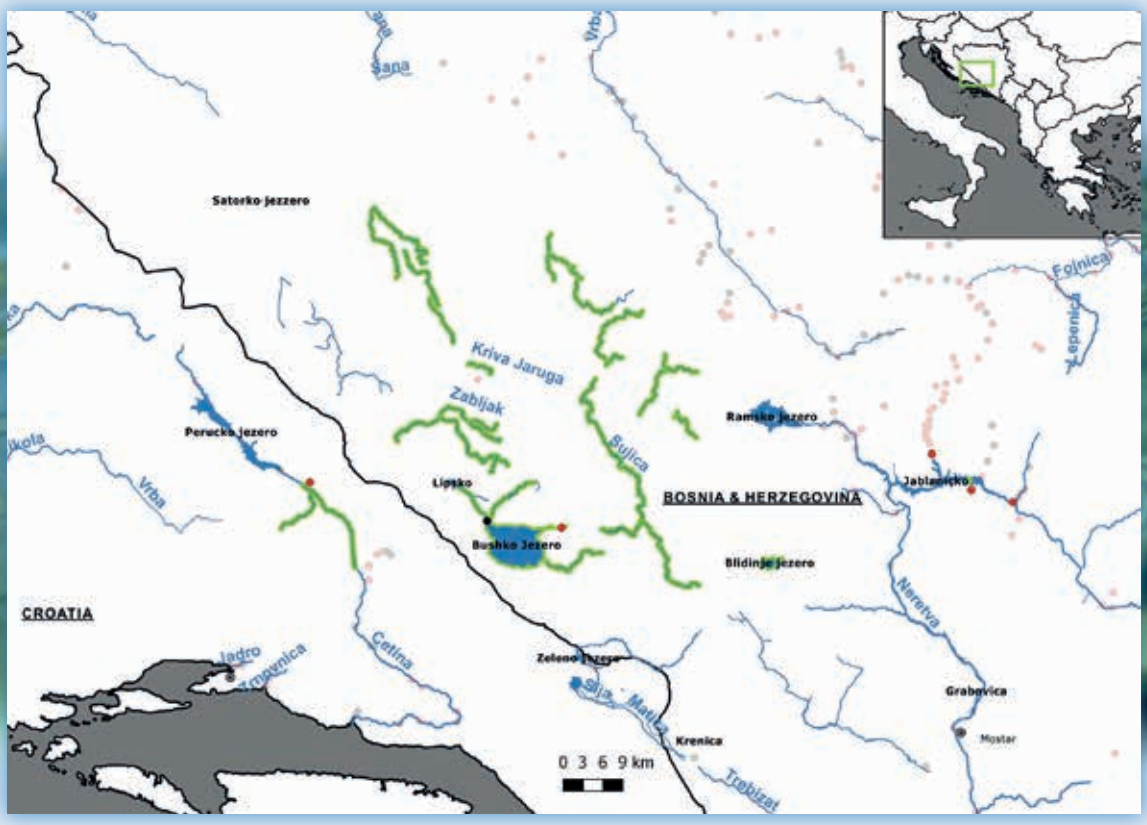
Hydropower Sensitivity:
High

Balkan Dam Threat:
Moderate

Distribution and Habitat - Croatia, Bosnia-Herzegovina

The **Dinaric minnow** was recorded from the Livno, Duvno and Glamoć fields, lakes Buško and Blidinje and the Korana River in Bosnia-Herzegovina (Ćaleta et al. 2015, Delić et al. 2005). In Croatia it is found in one location along the species-mosrich Cetina River (Sinj karst field) and in Stipančevo Lake (Ćaleta et al. 2015). A karst specialist inhabiting standing or slow-flowing habitats, the species might be dependent on dense vegetation for spawning (Freyhof 2012). Like other regional endemics, the Dinaric minnow can retreat to subterranean habitats during drought or winter and is extremely sensitive to invasive species or hydrological changes. In Croatia, it is strictly protected but considered data deficient (Ćaleta et al. 2015). Both the introduced Eastern mosquitofish (*Gambusia holbrooki*) in Croatia, and the translocated European chub (*Squalius cephalus*) have been very problematic for the Dinaric minnow (Ćaleta et al. 2015).

Hydropower schemes threatening the sensitive hydrological balance of karst systems or promoting the spread of invasive are generally a problem for nearly all of the region's endemic species.



Phoxinellus dalmaticus

Dalmatian minnow (eng.), Dalmatinische Elritze (ger.), Dalmatinska pijurica (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

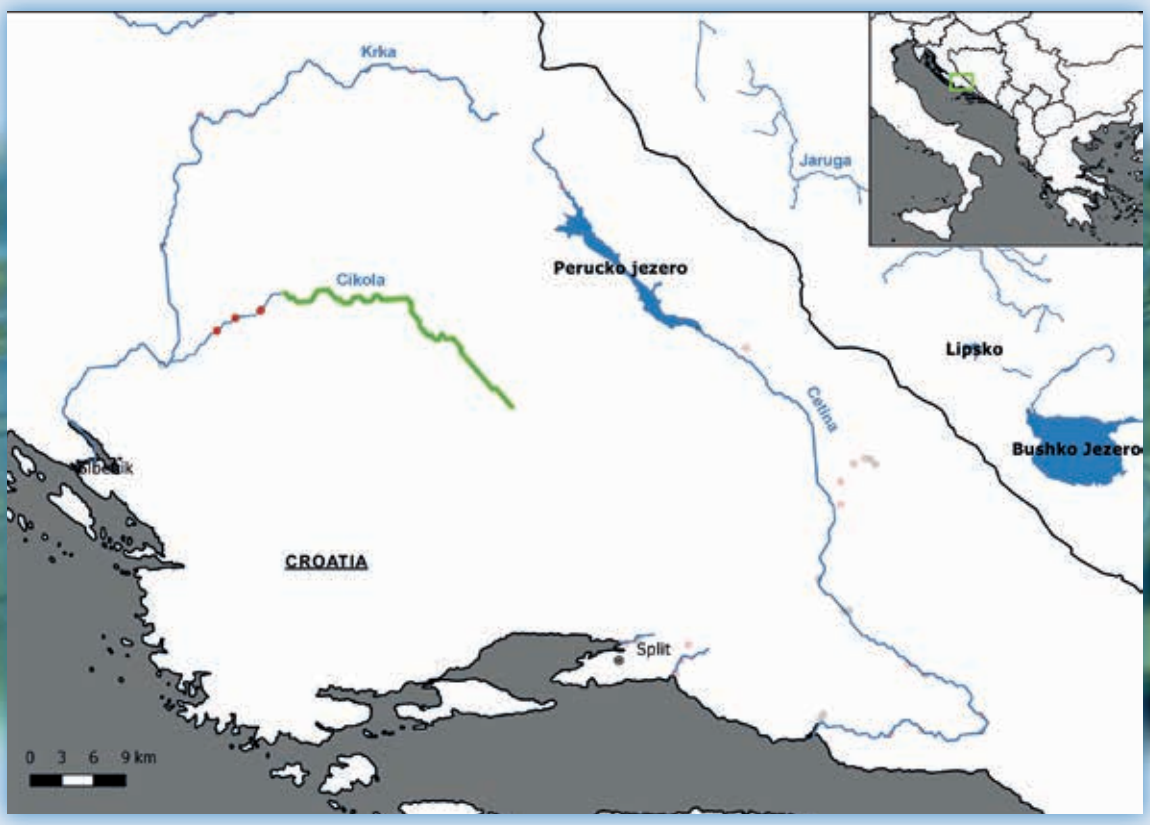
Hydropower Sensitivity:
High

Balkan Dam Threat:
Very High

Distribution and Habitat - Croatia

The small **Dalmatian minnow** (max 12 cm SL) was first described by Zupančič & Bogutskaya (2000) as endemic to the Čikola River of the Krka catchment. **It is found in sympatry with the critically endangered *Aulopyge huegelii* and the endangered *Telestes turskyi*.** The species occurs in clean slow-moving to stagnant waters, and may require submerged vegetation for spawning (Freyhof 2012). All members of this genus may retreat into subterranean habitats during adverse conditions such as a summer drought (Ćaleta et al. 2015). The species is considered very sensitive to dam construction and overall very sensitive to habitat alterations and alien species invasions, which often accompany hydropower development.

Three dams are planned directly in the Čikola River, and these will likely alter the hydrological regime of the river and promote the spread of invasive species, potentially leading to the global extinction of the species.



Phoxinellus pseudalepidotus

Mostar minnow (eng.), Mostar Elritze (ger.), Mostarska pijurica (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:

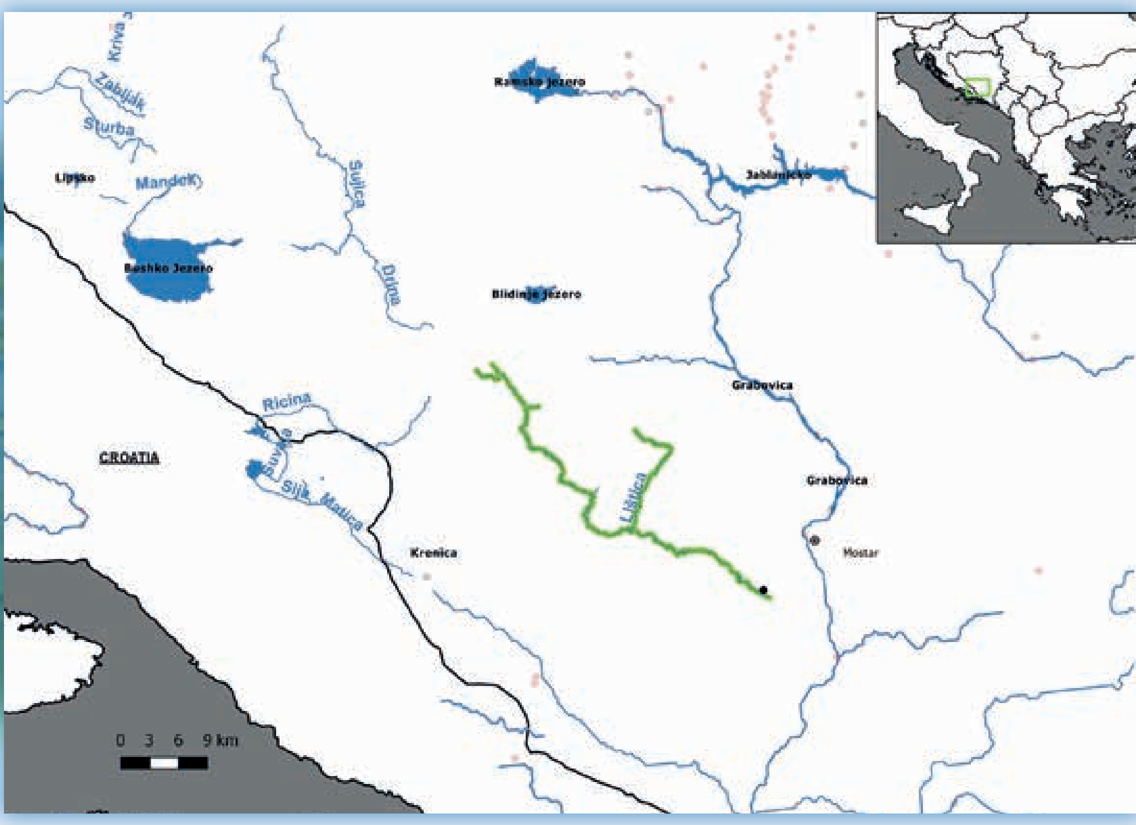
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Presently Low

Distribution and Habitat - Bosnia-Herzegovina

The **Mostar minnow** is endemic to the Neretva basin, and currently only reported from the Mostarkso Blato wetlands (Mihinjač et al. 2014). Phylogenetic placement is not yet entirely clear (Palandačić et al. 2010). Like other karst specialists of the region, the Mostar minnow uses both slow-flowing and standing water habitats, and may seasonally retreat into subterranean habitats during adverse conditions. All karst minnows are very sensitive to alterations in hydrological regime and the spread of invasive species.

As there are no hydropower schemes currently planned in the immediate vicinity of Mostarkso Blato, the species is not immediately threatened by such development; however, as for other karst specialists, unpredictable changes in surface or sub-surface water flow can occur via hydropower development many kilometers away from a disturbed site.



Phoxinus strymonicus

Aegean minnow (eng.), Ägäische Elritze (ger.), - (bg.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

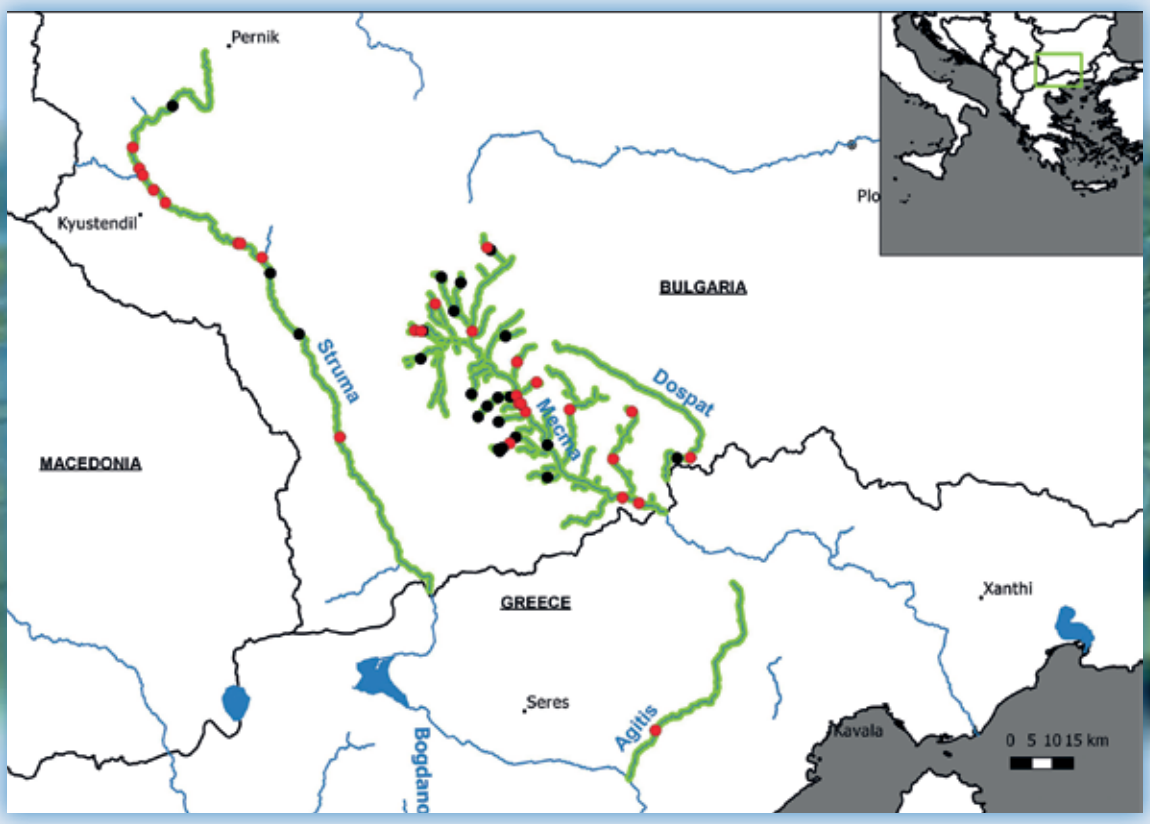
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Very High

Distribution and Habitat - Greece, Bulgaria

The **Aegean minnow** is listed in Kottelat & Freyhof (2007) as occurring in the Struma drainage in Greece (Aggitis River, Kottelat 2007) and perhaps Bulgaria; Koutrakis et al. (2013) recorded the species only in the Bulgarian portion of the Nestos/Mesta drainage. The species occurs in small streams with clear and cold water, but is occasionally found in irrigation canals; there is limited data on its biology and vulnerability to hydropower development (Kottelat & Freyhoff 2007). Sensitivity of the congeneric and endangered *Phoxinus strandjae* (Strandzha minnow) to hydropower development is considered very high (Freyhof 2012); we assign the same level of sensitivity to the Aegean minnow. Actual range of the species is probably much less than depicted in our map, as there is an insufficient scale of sampling.

Up to two thirds or more of the global distribution of this species is threatened by the construction of at least 25 hydropower schemes.



Romanogobio benacensis

Italian gudgeon (eng.), Po Gründling (ger.), Talijanska krkuša (hr.)

IUCN:
Endangered

EUR-HAB-DIR:

Bern Convention:

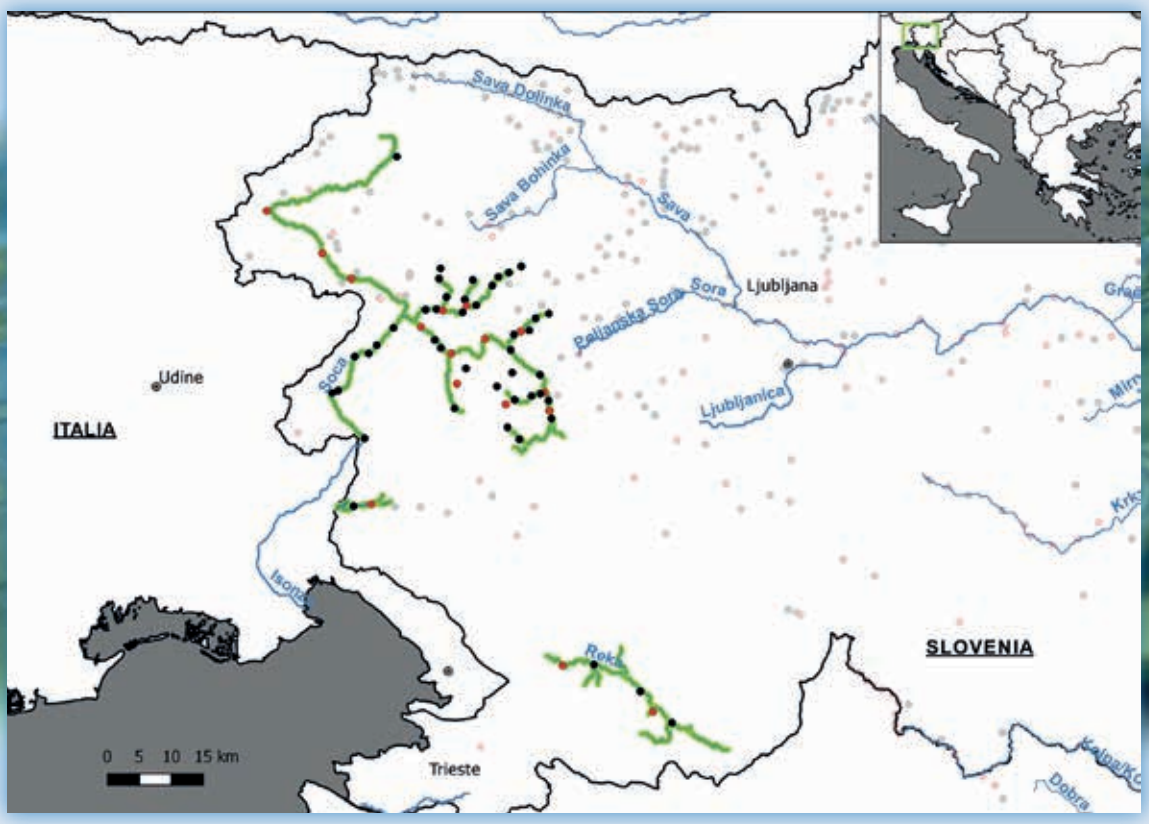
Hydropower Sensitivity:
Low-to-Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat - Slovenia

In the Balkan portion of the **Italian gudgeon's** distribution, the species is limited to the Soca, Reka and Rižana drainages in Slovenia. They occupy a variety of lowland river habitats but are also found in lakes, usually on sandy bottoms (Kottelat & Freyhof 2007). Populations are in decline due to pollution, riverbed engineering and competition from introduced Gudgeon *Gobio gobio* (Bianco 2014). Placement of the species back into the genus *Gobio* (Bianco 2011) is not supported by recent genetic analysis (Geiger et al. 2014, Friedrich et al. *In Press*). Most recently, Jelič et al. (2018) report *R. benacensis* from the Mrna River (just outside of our map) and the Butoniga tributary and question the species' occurrence in the Reka River. Members of this genus have varying tolerance of impoundments or needs concerning substrate conditions and river flow. As far as understood, Italian gudgeon are rather tolerant of slow-moving water and finer substrates.

Up to 20 new hydropower facilities are planned in the Italian gudgeon's Balkan range. These promote the spread of non-native invasive species, like the *Gobio gobio*. This alone could eliminate the Italian gudgeon from its Balkan distribution range.



Rutilus virgo

Cactus roach (eng.), Frauennerfling (ger.), Plotica (hr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II, IV

Bern Convention:
Annex III

Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat - Slovenia, Croatia, Serbia, Bosnia-Herzegovina

The **Cactus roach** is found in the Danube drainage above the Iron Gate (Kottelat & Freyhof 2007). Abundant in the Sava drainage of Slovenia and Bosnia-Herzegovina, found in the Sava, Sora, Ljubljanica, Mirna, Krka, Kolpa, Savinja, Sotla, Una and Drina rivers (Simonović et al. 2015). The cactus roach is rheophilic, requiring fast-flowing gravel substrates for spawning; found in medium to large-sized rivers (Kottelat & Freyhof 2007). Previously grouped with *R. pigus*, found in Italy and Switzerland (Bianco & Ketmaier 2014).

Construction of medium-to-large sized hydropower schemes in the Sava drainage in Slovenia (e.g. Mokrice and Brežice) have likely eliminated the largest spawning populations of the species in that region; continued hydropower expansion on the Sava threaten at least 50% of the species distribution in the Balkan region and perhaps a greater percentage concerning abundance.

Squalius janae

Istrian chub (eng.), Dragonja Döbel (ger.), Istarski klen (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:

Bern Convention:

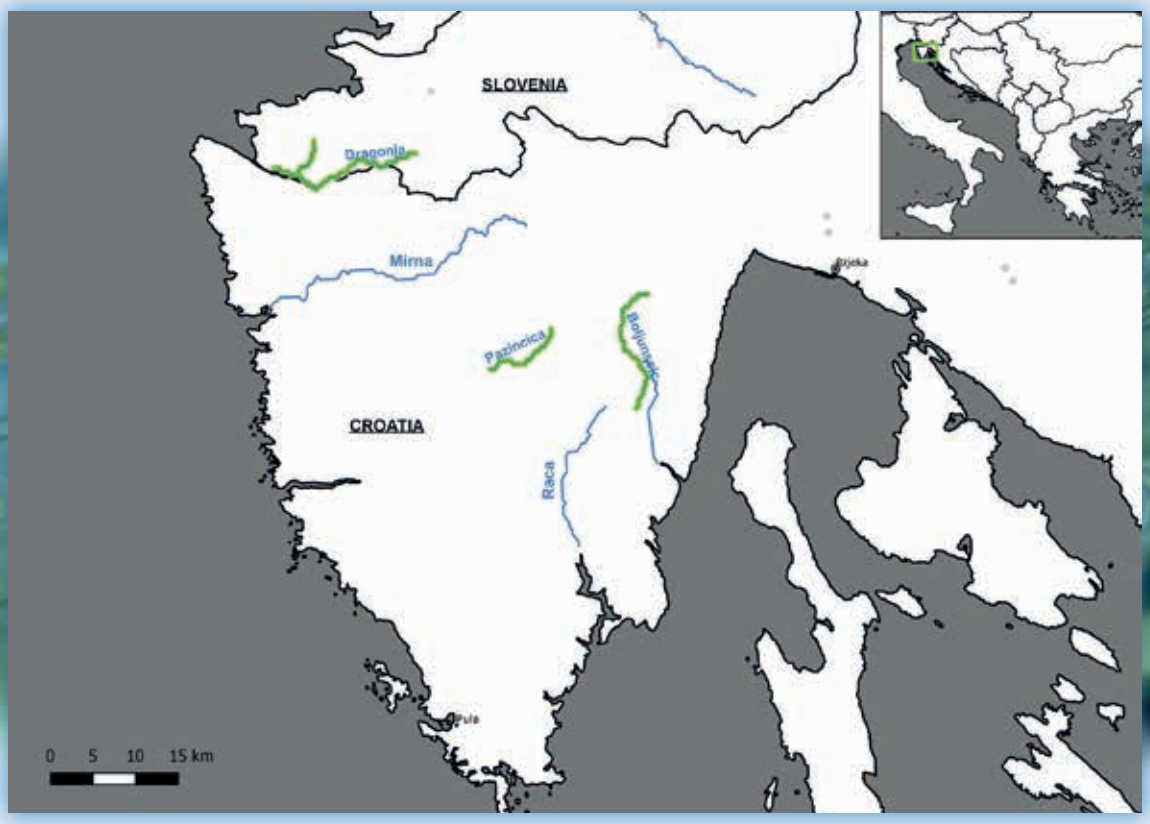
Hydropower Sensitivity:
Low-to-Moderate

Balkan Dam Threat:
Low

Distribution and Habitat - Slovenia, Croatia

The **Istrian chub** was first reported as endemic to the upper Dragonja River system on the Istrian Peninsula between Slovenia and Croatia (Bogutskaya & Zupančič (2010). It has also been recorded in another Istrian river (not shown), Boljunšćica River (Zupančič et al 2010). It is a riverine species spawning on gravel substrates in relatively fast-flowing water. Taxonomic position of the species is questioned in Ćaleta et al. (2015). It is probably, at most, only moderately sensitive to hydropower development, depending on access to adequate spawning habitat. The species reaches about 35 cm SL and thus can also be the target of human consumption. In general, the threats to native chubs are direct habitat destruction, overfishing and invasive species (Ćaleta et al. 2015).

There are currently no hydropower schemes planned in the region where the Istrian chub lives.



Squalius microlepsis

Makal dace (eng.), Imotski Döbel (ger.), Makal (hr.)

IUCN:
Endangered

EUR-HAB-DIR:

Bern Convention:
Annex III

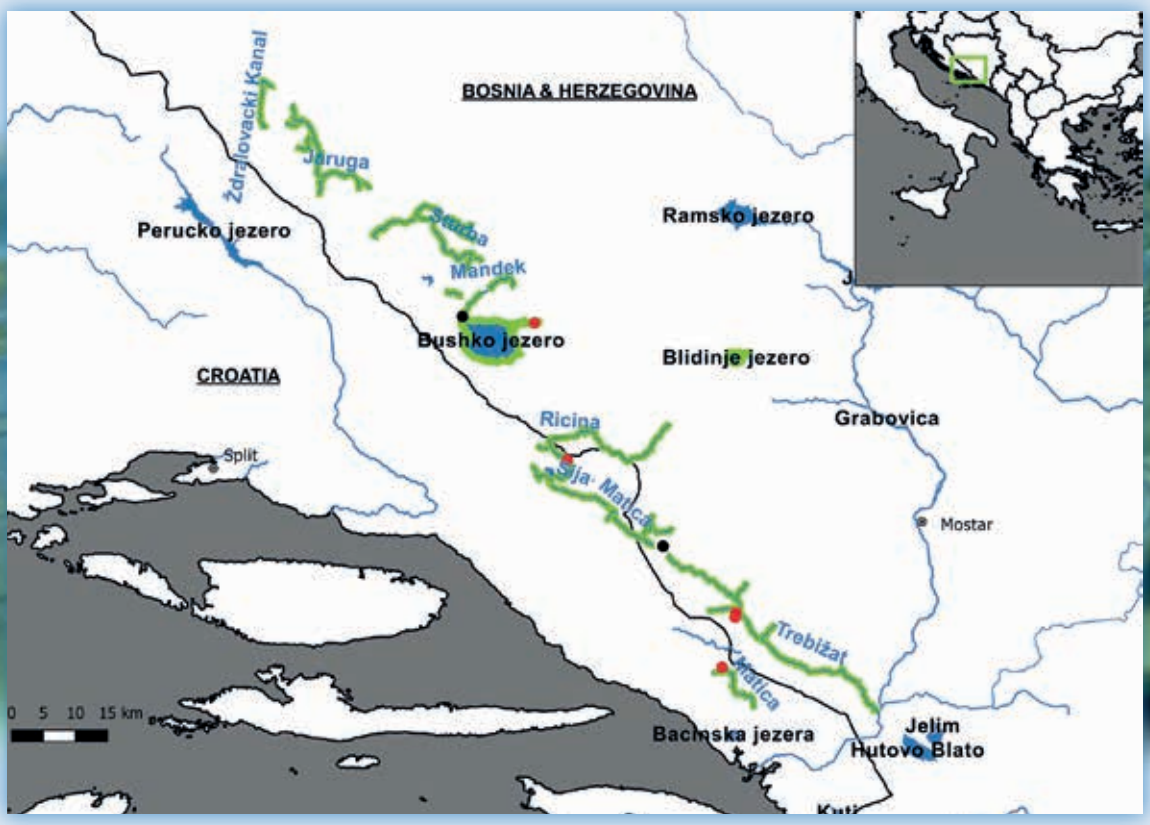
Hydropower Sensitivity:
Low-to-Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat - Croatia, Bosnia-Herzegovina

Makal dace are limited to the Neretva basin including the Matica River, Baćina and Prološko Blato lakes in Croatia and the Buško and Mandecko reservoirs near Livno. These and other reservoir occurrences in northern part of the depicted Bosnian range may be due to introductions, but must also be checked for potential misidentification with *S. tenellus*. The Makal dace is a riverine species that spawns on gravel substrates in relatively fast flowing water (Ćaleta et al. 2015). The species is listed as critically endangered in Croatia. Probably moderately sensitive to hydropower development, dependent on access to adequate spawning habitat (Crivelli 2016c; Ćaleta et al. 2015). Makal dace are reported to be declining and is very sensitive to introduced species and hydrological disturbance.

There are currently five hydropower schemes planned directly in Makal dace's habitat. Other projects in the vicinity could further affect water supply for these habitats due to complex and unpredictable effects to both surface and groundwater distribution in this karst region. Populations in Croatia are at a much higher risk of extinction than those in Bosnia-Herzegovina.



Squalius svallize

Neretva chub (eng.), Neretva Döbel (ger.), Svalić (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:

Bern Convention:
Annex III

Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat - Croatia, Bosnia-Herzegovina

The **Neretva chub** is thus far confirmed from the Neretva basin including the Matica River and the Trebišnjica and Ljhuta drainages (Pira et al. 2012, Ćaleta et al. 2015). The Nerertva chub is the smallest regionally endemic chub, reaching sizes of 20 cm SL (Ćaleta et al. 2015). Diet studies have been carried out on Lake Deran and the Bregava and Krupa rivers from the lower Neretva basin in Bosnia-Herzegovnia (Ivanković et al. 2011). The species enters subterranean habitats to avoid adverse hydrological conditions, but also requires fast-flowing waters for spawning and thus is vulnerable to hydropower if spawning grounds are blocked (Freyhof 2012). More widely distributed in the Neretva basin than other members of the genus.

Extensive hydropower planning in the upper Neretva basin threaten ca. 25% of the Neretva chub's habitat. These areas are also home to softmouth and marbled trout.

Squalius tenellus

Livno masnica (eng.), Livno Döbel (ger.), Sitnoljuskavi klen (hr.)

IUCN:
Endangered

EUR-HAB-DIR:

Bern Convention:
Annex III

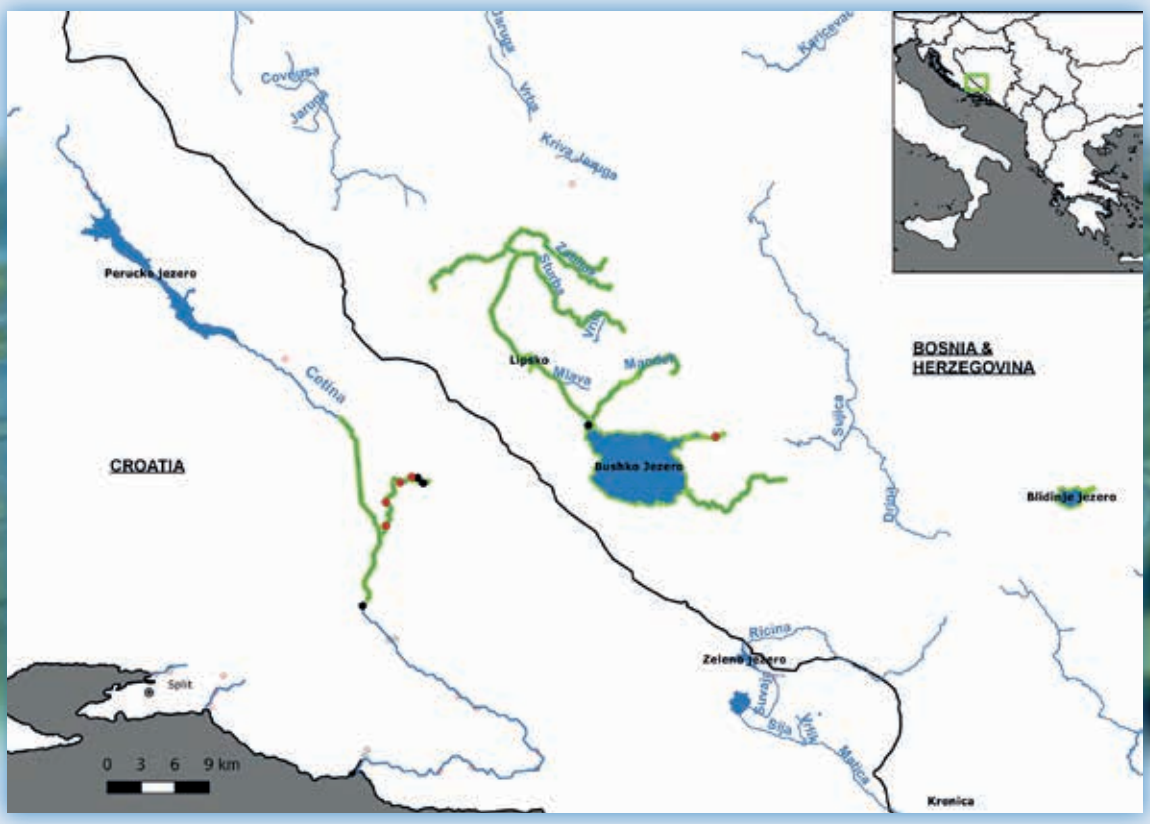
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat - Croatia, Bosnia-Herzegovina

Livno masnica is the largest of the regionally endemic chubs. It occurs in karst streams of the Livno fields and Buško Blato as well as Mandek Lake in Bosnia-Herzegovina, and in the Cetina and Ruda rivers of Croatia. It may have been introduced to the Blidinja reservoir (jezero) in Bosnia-Herzegovina (Šedivá et al. 2010, Freyhof 2012, Ćaleta et al. 2015). The species is able to colonize reservoir habitats and thus may be only moderately sensitive to hydropower development, but like most karst species, they are very sensitive to the spread of invasive species (Freyhof 2012), which is invariably promoted by the creation of impoundments. Livno masnica are listed as endangered in Croatia.

At least five planned hydropower projects in the Cetina basin, a hotspot of endemic fish diversity, threaten most of this species' habitat in Croatia, equaling about a third of its global distribution.



Telestes croaticus

Croatian pijor (eng.), Ricica Strömer (ger.), Hrvatski pijor (hr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

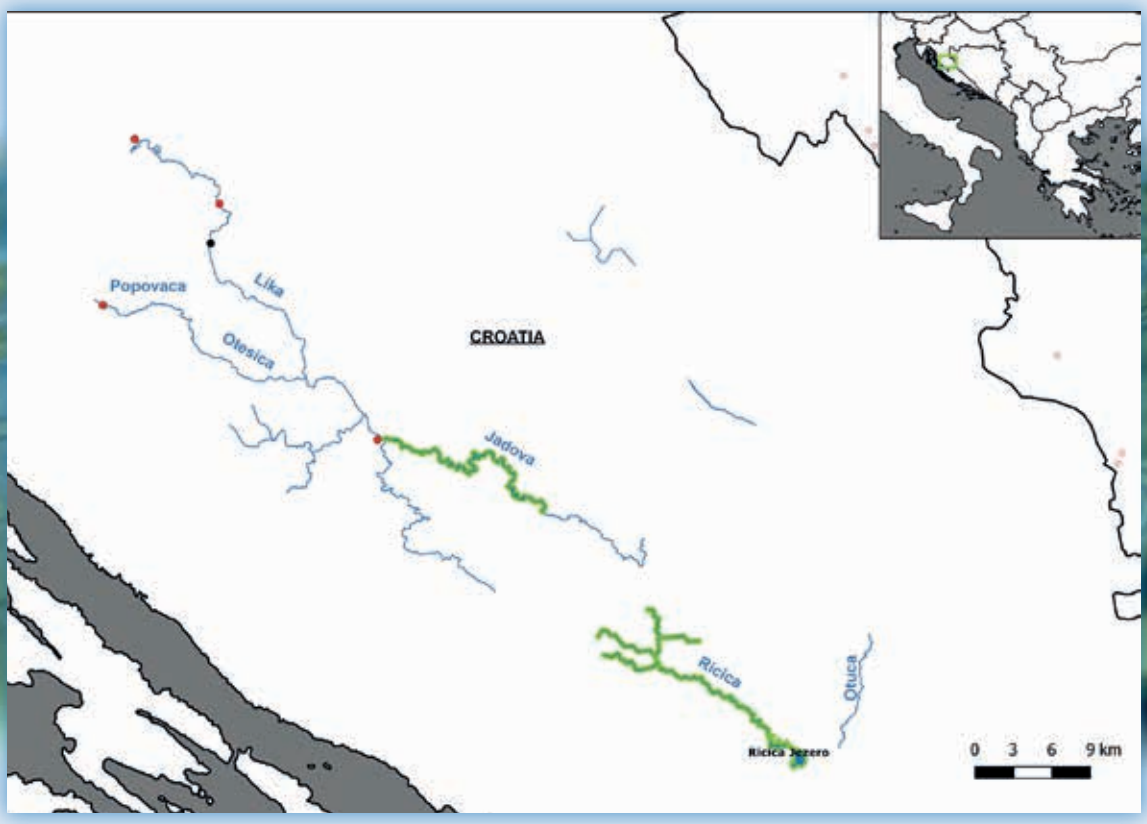
Hydropower Sensitivity:
High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Croatia

The **Croatian pijor** is one of at least 8 steno-endemic karst minnows of the genus Telestes found in the region. It is a Croatian endemic limited to endorheic systems in the Jadova and Ričica river catchments (Jelić et al. 2016, Ćaleta et al. 2015). Once much more widespread, populations have been reduced to two river drainages; the species retreats to subterranean habitats during low flows and winter (Jelić et al. 2016). They are very sensitive to hydropower due to the fact that impoundments invariably promote the spread of invasive species, but also because Croatian pijor require flowing water and rocky shoals for spawning (Freyhof 2012, Ćaleta et al. 2015).

Four planned hydropower schemes in the Lika drainage threaten to continue promoting the spread of invasive species and may affect subterranean hydrological conditions in unpredictable ways.



Telestes dabar

Dabarsko dace (eng.), Dabarsko Strömer (ger.), Dabarski pijor (hr.)

IUCN:
Not Evaluated

EUR-HAB-DIR:
Annex II

Bern Convention:

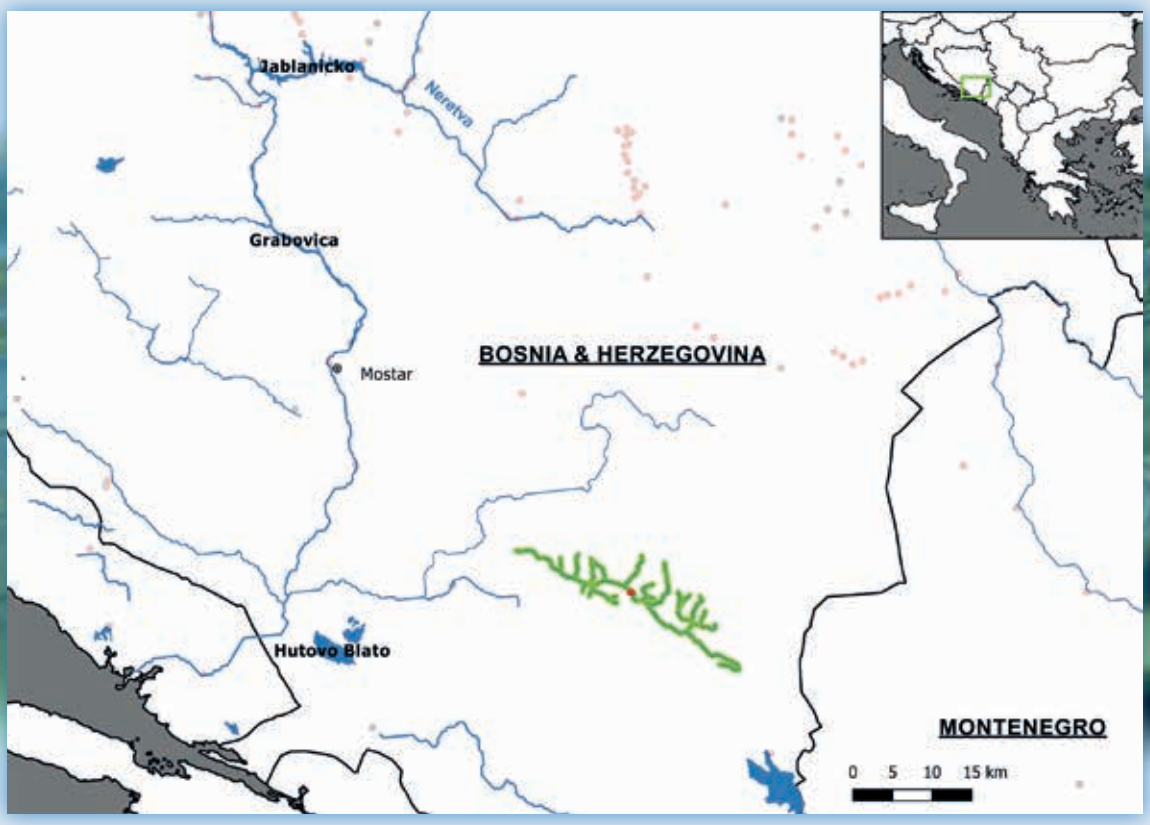
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia

The **Dabarsko dace** is one of two steno-endemic *Telestes* species previously classified as *T. metohiensis* (together with *T. miloradi*) (Bogutskaya et al. 2012). Limited to < 4 km² of habitat on the Konavosko Polje/Lujta River area (Jelić & Jelić 2015); **the authors thus recommend an IUCN assignment of critically endangered.** Presumed to previously occupy a much larger range, direct habitat degradation and the introduction of invasive species (such as rainbow trout *Oncorhynchus mykiss*) are the major threats. Dabarsko dace, together with *Delminichthys ghetaldii*, found in some nearby springs were both thought to be extinct. The phylogenetic relationships and zoogeographical history of this group of karstic daces (*Telestes*) has most recently been reported in Buj et al. (2017).

An underground hydropower scheme at the Ombla spring threatens the hydrological stability of the area (see *Delminichthys ghetaldii*). Any form of hydrological disturbance would most likely result in the extinction of this newly described species.



Telestes fontinalis

Krbava dace (eng.), Krbava Strömer (ger.), Krbavski pijor (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:

Bern Convention:

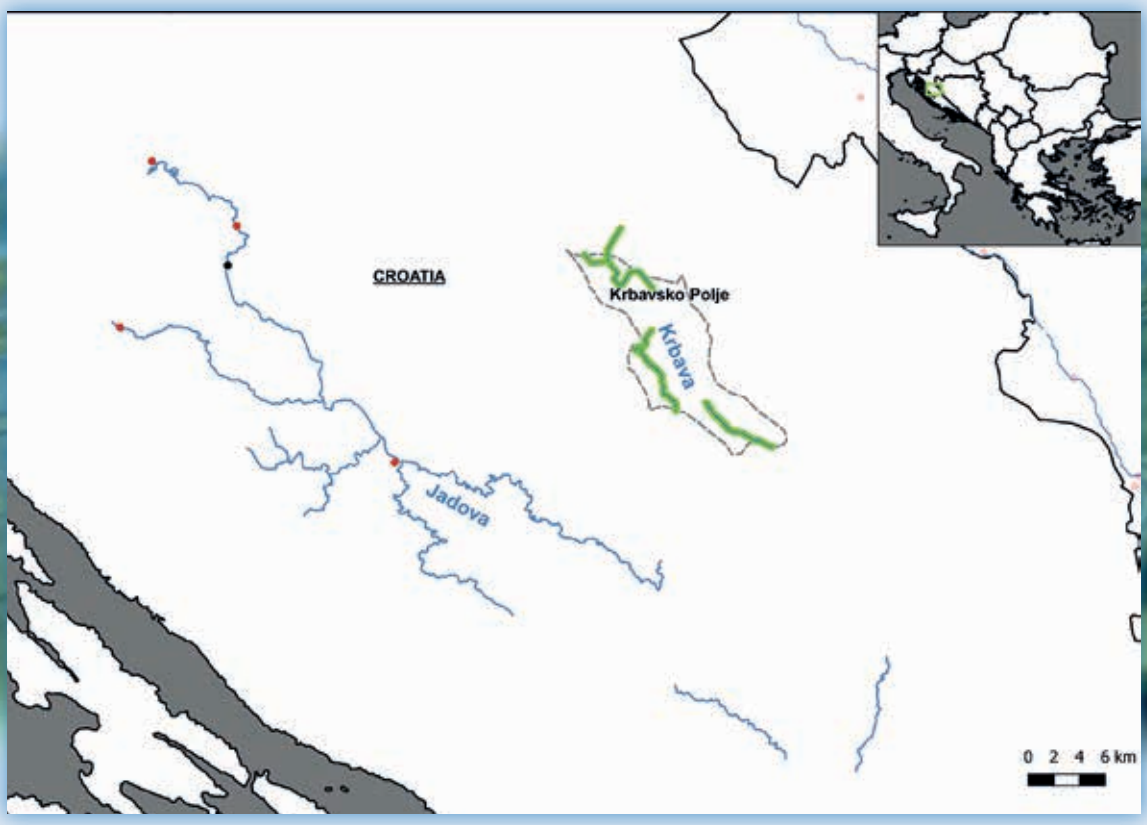
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia

Krbava dace is one of two steno-endemic *Telestes* species (together with *T. karsticus*) found in the Danube catchment. For *T. fontinalis*, the species is limited to the Krbava polje (karst field) (Ćaleta et al. 2015, Jelić et al. 2016). The Krbava dace is typical of all karst daces in being able to colonize subterranean habitats during adverse hydrological conditions and spend up to 8-10 months a year underground (Jelić et al. 2016). Extremely sensitive to hydrological disturbance and invasive species and suspected to be dependent on flowing water for reproduction (Freyhof 2012).

While no hydropower schemes are known to be in planning in the habitat of the Krbava dace, their habitat area is extremely small, and any hydrological disturbance would likely drive this species to extinction.



Telestes karsticus

Karst dace (eng.), Karst Strömer (ger.), Kapelska svijetlica (hr.)

IUCN:
Not Evaluated

EUR-HAB-DIR:
Annex II

Bern Convention:

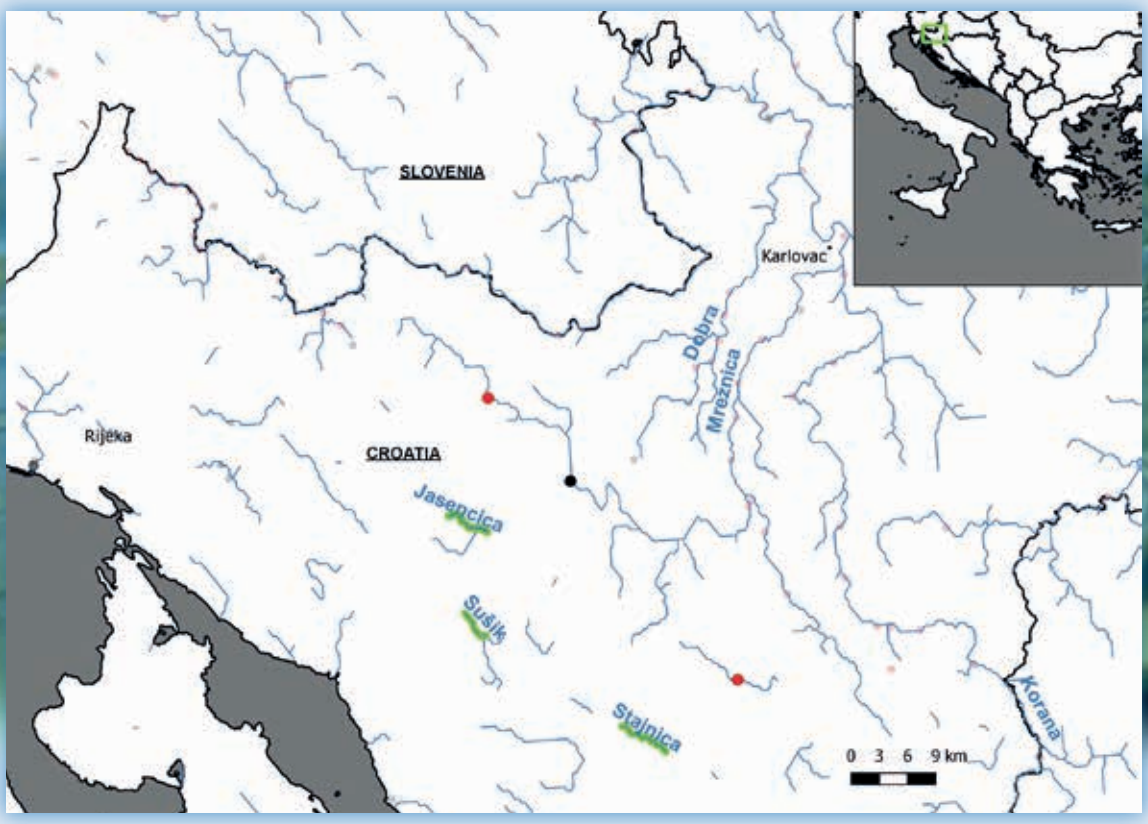
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Croatia

The **Karst dace** is one of two steno-endemic *Telestes* species (together with *T. fontinalis*) found in the Danube catchment. For *T. karsticus*, the species is limited to a single spring in the Stajnica field, Sušik and Janesenčica creeks in the Lug field, and Jezero Lake and Jasenčica Creek in the Jasenak field (Marčić et al. 2011, Ćaleta et al. 2015). Like all karst dace they are assumed to be extremely sensitive to hydrological disturbance and invasive species. The biology of karst dace has been relatively well described in Marčić et al. (2017a,b).

There are no known hydropower schemes planned in the immediate vicinity of Karst dace habitat. However, hydropower facilities in distant locations may have effect on the hydrology of underground springs on which karst dace depend.



Telestes metohiensis

Striped dace (eng.), Bosnischer Strömer (ger.), Bosanski pijor (hr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat - Bosnia-Herzegovina

The **striped dace** occurs in up to 10 karst springs and streams of southern Dalmatia in eastern Bosnia-Herzegovina including the Musica River, Nevesinjsko, Gatacko, Cernicko and Dabarsko poljes (karst fields); no longer recorded in Croatia (Kottelat & Freyhof 2007; Dekič et al. 2012, Milanovič 2015). Recorded in subterranean habitats by Dekič et al. (2012). A typical karst dace species it is assumed to be dependent on flowing water for spawning and very sensitive to both invasive species and hydrological disturbance (Freyhof 2012).

There are no known hydropower schemes planned directly in the habitat of the striped dace. However the springs of this karst region are sensitive to hydrological disturbances even at some distance.

Telestes miloradi

Konavle dace (eng.), Konavlischer Strömer (ger.), konavoski pijor (hr.)

IUCN:
Critically Endangered?

EUR-HAB-DIR:
Annex II

Bern Convention:

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia

Konavle dace is one of two steno-endemic *Telestes* species previously classified as *T. metohensis* (together with *T. dabar*) (Bogutskaya et al. 2012). Limited to < 4 km^2 of habitat on the Konavosko polje/ Ljuta River area (Jelić & Jelić 2015); **the authors thus recommend an IUCN assignment of critically endangered.** Presumed to previously occupy a much larger range, direct habitat degradation and the introduction of invasive species (such as rainbow trout *Oncorhynchus mykiss*) are the major threats. The species, together with *Delminichthys ghetaldii* found in some nearby springs, were both thought to be extinct. The springs of the area are part of the Croatian Natura 2000 network.

A large underground hydropower scheme at the Ombla spring (just north of Dubrovnik) threatens the hydrological stability of the entire area (see *Delminichthys ghetaldii*); this may likely lead to the global extinction of both of these steno-endemic species.

Telestes polylepis

Croatian dace (eng.), Kroatischer Strömer (ger.), Svijetlica (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:

Bern Convention:
Annex III

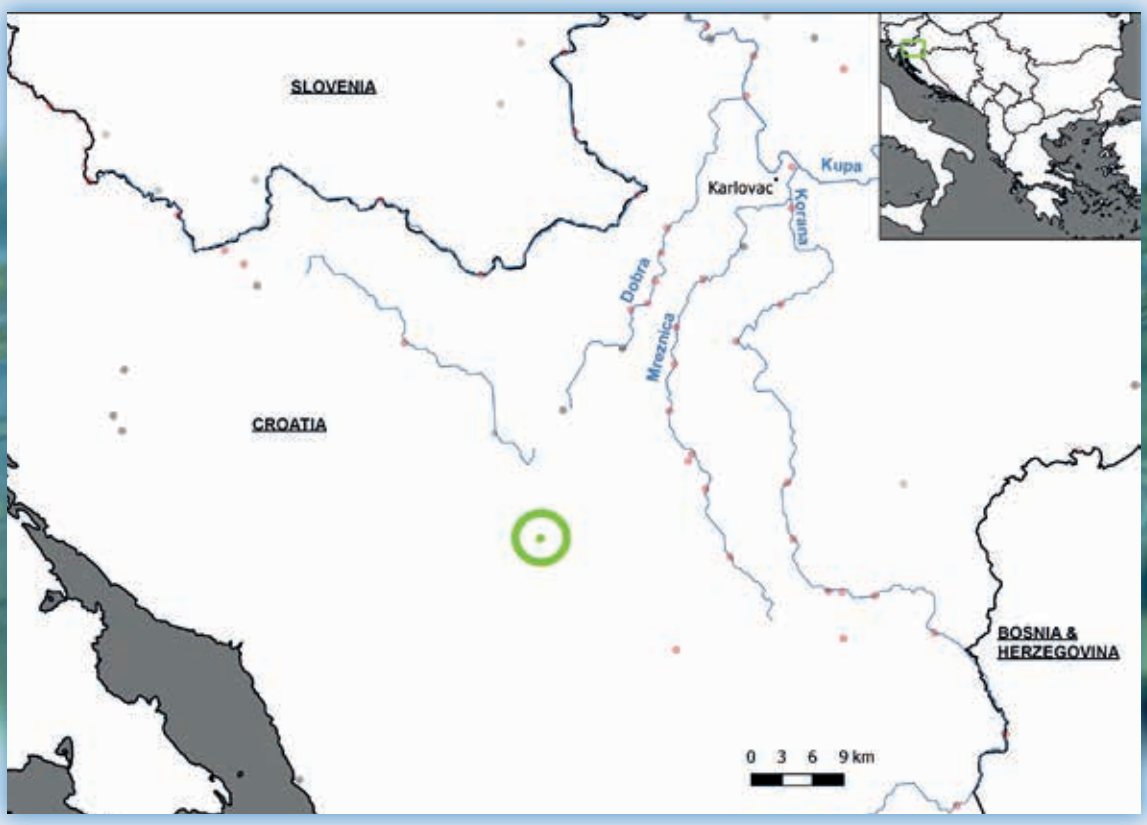
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia

The **Croatian dace** is one of three karst dace (*Telestes*) species endemic to Croatia and found in the Danube catchment area. Croatian dace are found only in Smitovo zezero and Rupećica sinkhole near Ogulin (Ćaleta et al. 2015). Previously more widespread (Mustafić et al. 2008), the species has declined rapidly for unknown reasons – like other members of the genus in the region, it is apparently not able to survive impoundments and is extremely sensitive to introduced species (Freyhof 2012).

There are no planned hydropower schemes in the immediate vicinity of this species' presumably last habitat. However, as noted for many of these karst species, any type of hydrological disturbance in the general area could have unforeseen consequences on groundwater dynamics due to the complex and unpredictable nature of karst hydrology.



Telestes turskyi

Cikola riffle dace (eng.), Cikola Strömer (ger.), Turski klen (hr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:

Bern Convention:
Annex III

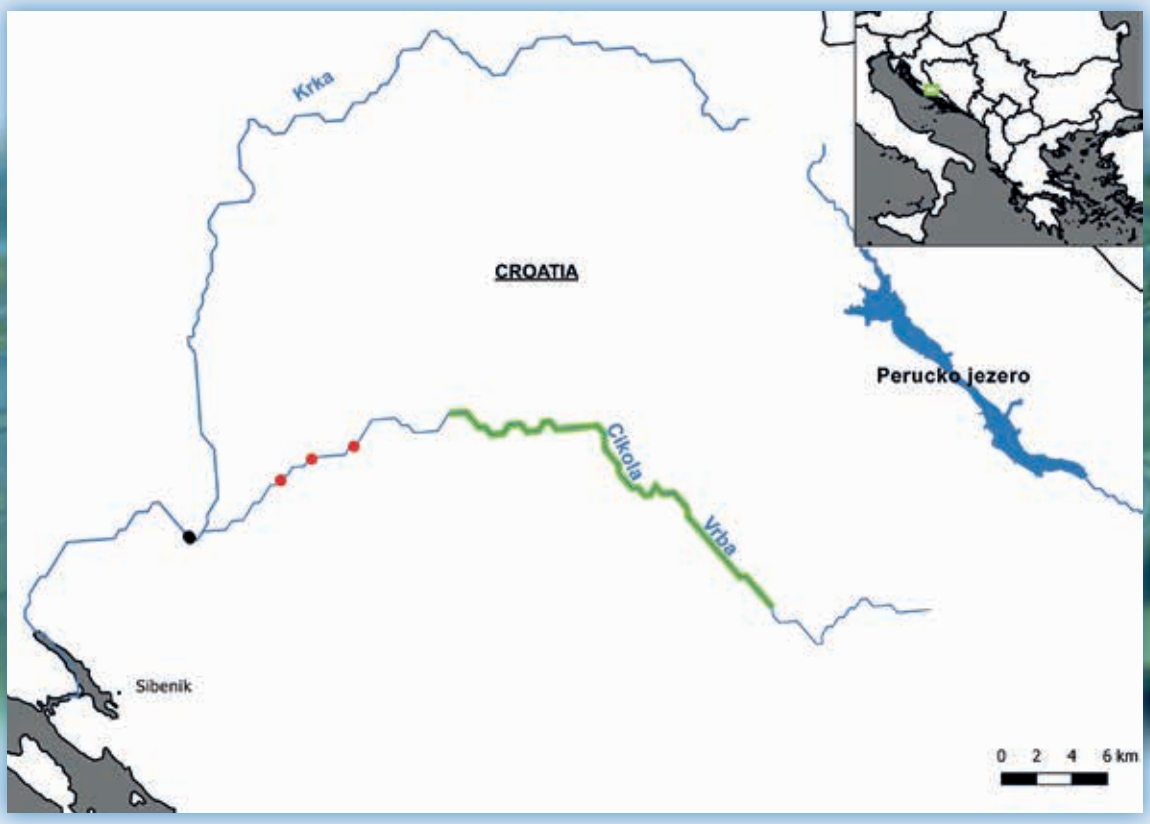
Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat - Croatia

Cikola riffle dace is one of nine species of the karst dace genus *Telestes* found in the region. The Cikola riffle dace is found only in the Čikola and Vrb rivers of the Krka catchment (Ćaleta et al. 2015). Once thought to be extinct – these dace inhabit slow-flowing waters and springs, and are able to colonize still waters but are nonetheless extremely sensitive to introduced species, water pollution and water extraction (Mihinjač et al. 2014, Freyhof 2012).

Three planned hydropower facilities in the Čikola River threaten the populations of this sensitive karst species by promoting the spread of invasive species and disrupting the hydrological regime, potentially of subterranean habitats in unpredictable ways.



Telestes ukliva

Ukliva dace (eng.), Ukliva Strömer (ger.), Cetinska ukliva (hr.)

IUCN:
Extinct*

EUR-HAB-DIR:

Bern Convention:

Hydropower Sensitivity:
High

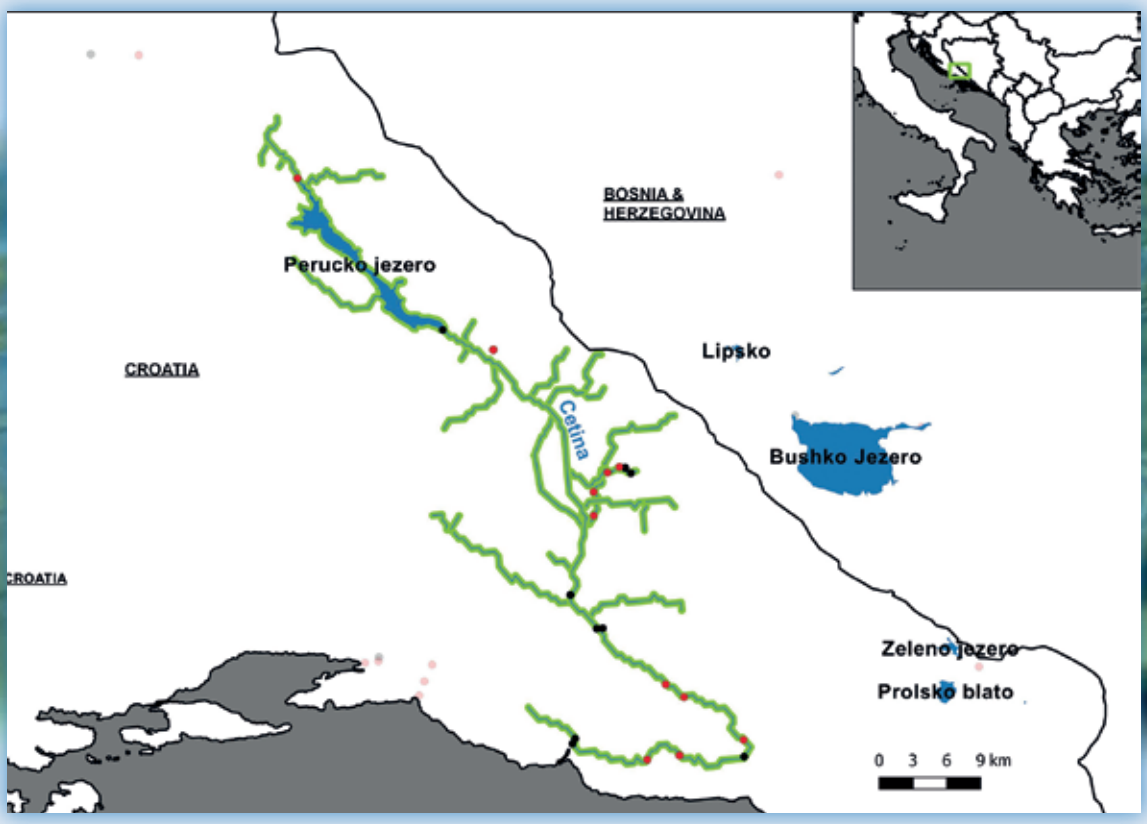
Balkan Dam Threat:
Very High

* not extinct

Distribution and Habitat - Croatia

The **Ukliva dace** is one of nine species of karst dace (*Telestes*) endemic to the region. The Ukliva dace is endemic to Croatia and was previously reported to be extinct; the species was rediscovered in 1997 (Zanella et al. 2008) and is found throughout the Cetina River (Valić et al. 2010), a regional hot spot for endemic fish species in the region. Ukliva dace inhabit slow-flowing waters and springs, and are able to colonize still waters but is extremely sensitive to introduced invasive species, water pollution and water extraction (Mihinjač et al. 2014, Freyhof 2012).

At least eleven planned hydropower schemes in the Cetina River catchment threaten the global existence of the Ukliva dace, along with eight other threatened or endangered species in the river. The dams would promote the spread of invasive species and disrupt both the surface and underground hydrological regimes, to which these sensitive species have adapted.



Pomatoschistus canestrinii

Black-spot goby (eng.), Schwarzflecken Sandgrundel (ger.), Glavocic crnotrus (hr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex II, III

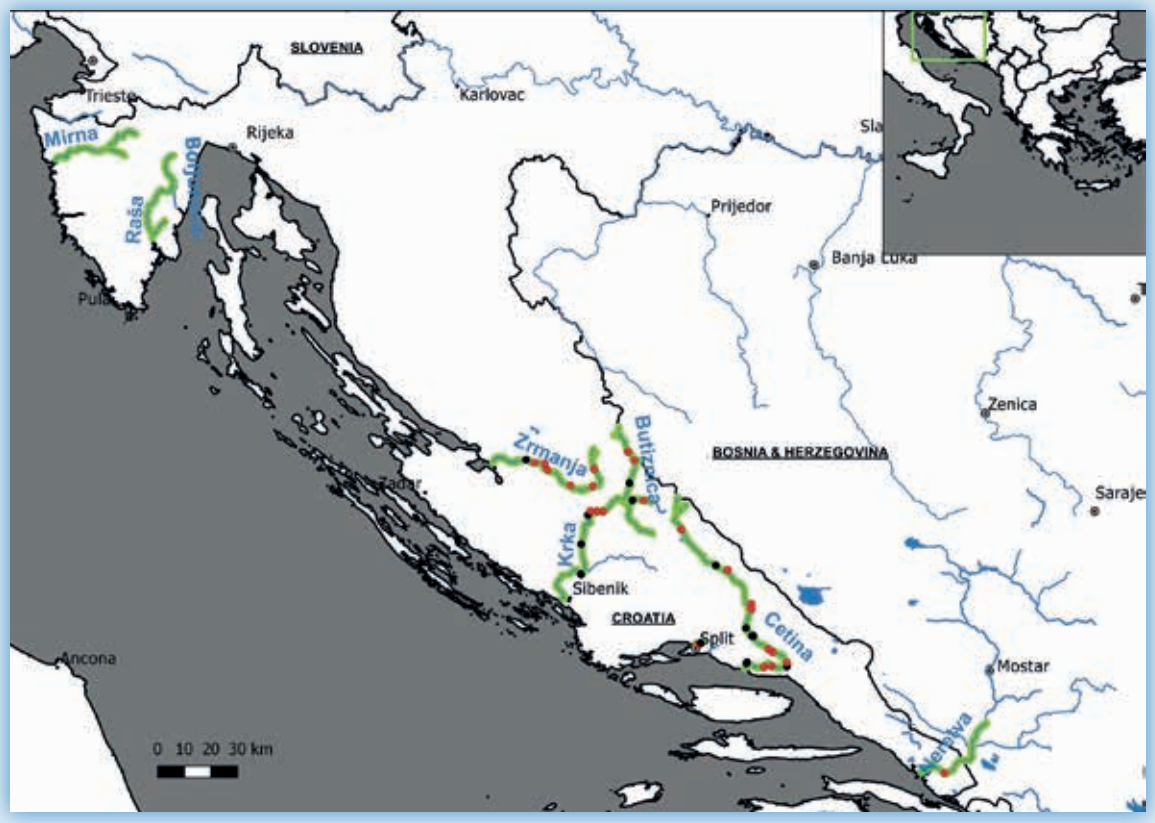
Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat - Slovenia, Croatia. Bosnia-Herzegovina

The **Black-spot goby** is endemic to the Adriatic basin. It lives in brackish and freshwater habitats of the lower courses and deltas of large rivers. In Croatia it is found in the Zrmanua, Krka, Zrnovnica, Cetina, Dobarnica, and Nadvoda rivers, including lagoons and wetland lakes (Franco et al. 2005; Kovačić 2005). It was recently reported from Lake Svitava in the Neretva basin – a first record for Bosnia-Herzegovina (Tutman et al. 2013). While assigned a least concerned status globally, populations in Croatia are considered endangered (Mrakovčić et al. 2006); large-scale degradation of European coastal wetlands via pollution and river regulation has resulted in this species being of community interest (Franco et al. 2012).

Two thirds of the river systems containing this species are threatened with the construction of at least 20 hydropower schemes. Power plant operations leading to hydropeaking and disrupted bed-load transport has a heavy impact on goby habitats. The species could lose most of its habitat in the eastern Adriatic.



Knipowitschia

Dwarf Gobies – Fam. Gobiidae

	K. croatica [1]	*K. mrakovcici* [2]	*K. panizzae* [3]	*K. radovici* [4]
IUCN:	VU	CR	LC	VU
EUR-HAB-DIR:		Annex II	Annex II	Annex II
Bern Convention:		Annex II, III	Annex II, III	Annex II, III
Hydropower Sensitivity:	Moderate-High	Moderate-High	Moderate-High	Moderate-High
Balkan Dam Threat:	Very High	Very High	Very High	Very High

Distribution and Habitat – Slovenia, Croatia, Bosnia-Herzegovina, Montenegro

The dwarf gobies are a primarily European genus of small-sized freshwater gobiid fishes. The four species depicted here live in karst spring habitats, lakes and lowland reaches of rivers along the Adriatic coast. The **Neretva dwarf goby**[1] is found in the lower reach of the Neretva River including lakes and tributaries; the **Visovac goby**[2] is found in Visovac Lake only. The **Norin goby**[4] is found in one right tributary (the Norin River) of the lower Neretva River and the **Adriatic dwarf goby**[3] is more widespread living in a number of river mouths along the coasts of Slovenia and Croatia. The threats to these species include eutrophication, pollution, riverbed regulation and the spread of invasive species (Ćaleta et al. 2015). Gobies are also consumed by the local population as a delicacy.

Dams in general, even when not near these coastal habitats, alter the hydrological and sediment regimes of the rivers they are built in. Thus, the lower courses and delta areas of Adriatic rivers are among the most impacted aquatic habitats in the region. The wetlands along the lower Neretva River, for example, where the Norin goby lives are influenced by all that takes place in the Neretva basin.

At least six planned hydropower facilities in and around Krka National Park threaten to heavily impact the last available habitat for the Visovac goby. Planned hydropower schemes on the lower Neretva River below Mostar as well as a seawater-control dam in the lower Neretva in Croatia threaten at least 50% of the habitat of both the Neretva dwarf goby, and the Norin goby.

Gymnocephalus baloni

Balon's ruffe (eng.), Donaukaulbarsch (ger.), Grbasti okun (slo.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II, IV

Bern Convention:
Annex III

Hydropower Sensitivity:
Moderate

Balkan Dam Threat:
Moderate

Distribution and Habitat – Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Bulgaria

Balon's Ruffe occupy a variety of habitats (sand and muddy substrates), yet prefer moderate currents. They are a member of the rheophilic guild among large-river fishes. In reservoirs, they are found at the head, where current velocity is sufficient (Tarkus et al. 2010). A lowland river specialist, somewhat tolerant of river channel changes, they also occur in connected backwater habitats (Schiemer & Spindler 1989). Although once frequent in the Slovenian Sava, it has now become relatively rare (except for Sora tributary) (Simonovič et al. 2015). The IUCN lists the species as *Least Concern* due to its large range outside the Balkans.

A chain of dams on the Mura and Sava rivers in Slovenia and Croatia threaten to eliminate a large portion of the species habitat in those rivers. The first of these (10-50 MW) on the Sava in Slovenia (Brežice) is already under construction.

Gymnocephalus schraetser

Yellow pope (eng.), Schrätzer (ger.), Prugasti balavac (hr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II, IV

Bern Convention:
Annex III

Hydropower Sensitivity:
Moderate-to-High

Balkan Dam Threat:
High

Distribution and Habitat - Slovenia, Croatia, Serbia, Bosnia-Herzegovina, Bulgaria

The **Yellow pope** is a bottom-dwelling, primarily nocturnal inhabitant of large rivers with moderate currents (Kottelat & Freyhof 2007). The species is difficult to sample and thus information on population status is poor. It was not caught in the Slovenian Mur after extensive surveys (Weiss 2017), and is listed as critically endangered in Croatia (Ćaleta et al. 2015). The species is viewed as tolerant of impoundments, preferring flows of ca. 20 cm/s at 7 cm off the bottom (Zauner 1996). Zauner et al. (2007) report a good status for the species at the head of a Danubian reservoir, where renaturation measures have been implemented. Still, the species is disappearing rapidly from other river reaches as channel engineering and numbers of impoundments increase. Re-assessment of the species is urgently needed.

Continued channel regulation measures and planned hydropower schemes (*N* = 30) dams in virtually all of the Yellow pope's habitat threaten at least 50% of its range in the Balkans.

Zingel balcanicus

Vretenar (eng.), Vardar Streber (ger.), Vretenar (mk.)

IUCN:
Critically Endangered?

EUR-HAB-DIR:
Annex II

Bern Convention:

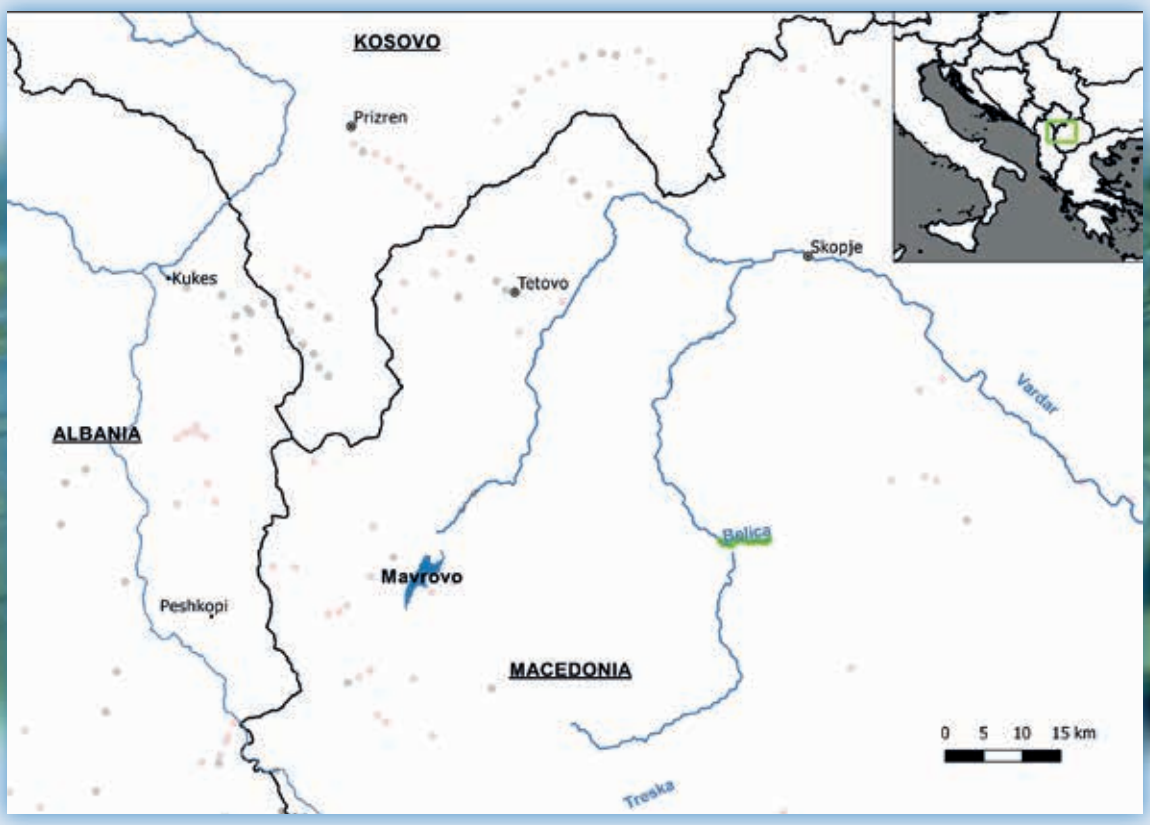
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
Very High

Distribution and Habitat – Macedonia

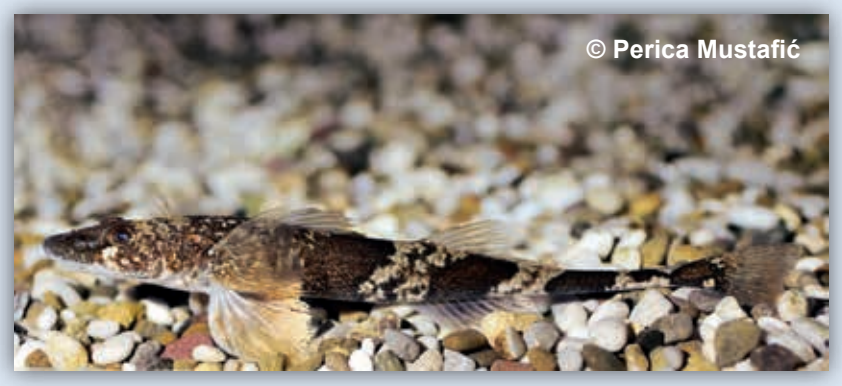
Vretenar is a percid fish endemic to Macedonia, listed in Kottelat & Freyhof (2007) from the middle reaches of the Vardar River and its Treska tributary; however the authors noted that the species may be extinct. Arsovska et al. (2014) recently report the species from the upper Treska drainage, with a single find in a small tributary (Belica River) of the Treska River, above a reservoir. The IUCN listing is data deficient and needs updating; considering this very limited distribution and the assumed sensitivity to habitat changes, **we recommend a status of critically endangered.** The potential range of the species in the upper Treska drainage needs to be investigated, Zingel sp. are normally inhabiting larger rivers, and thus we presume the species is not limited to this single tributary.

Information on potential hydropower development in the upper Treska is unclear and needs updating.



Zingel streber

Danube streber (eng.), Streber (ger.), mali vretenac (hr.)



IUCN:
Least Concern

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Bulgaria

The **Danube streber** is a bottom-dwelling, nocturnal habitat specialist found in large rivers in relatively fast-flowing water flow and stony substrates (Zanuer 1996, Kottelat & Freyhof 2007). The species is very sensitive to river engineering measures and especially impoundments; even in the distribution area shown, the species has a very sporadic presence (Bănăduc & Curtean-Bănăduc 2014). In the Slovenian Mur it was rare (Weiss 2017), but Simonović et al. (2015) reported presence in Mrna, Krka, Kolpa Savnija and Sotla tributaries of the Sava in Slovenia and Croatia, in the Sava by Davor in Croatia and Babina-Greta in Bosnia and Croatia and the Fojnica in Bosnia; further records stem from the Drava, Sutla, Sava, Una, and Kupa rivers in Croatia (Bănăduc & Curtean- Bănăduc 2014) and the middle Drina in Serbia (Simonović et al. 2015).

More than 50 planned hydropower schemes on the Mur, Drava, Sava and Danube rivers threaten at least 75% of these species' occurrence in the Balkan region.

Zingel zingel

Zingel (eng.), Zingel (ger.), Veliki vretenac (hr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II, IV

Bern Convention:
Annex III

Hydropower Sensitivity:
Moderate-to-High

Balkan Dam Threat:
High

Distribution and Habitat – Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Kosovo, Bulgaria

Zingel is a bottom-dwelling, nocturnally active percid fish primarily found in large rivers (Kottelat & Freyhof 2007, Bănăduc et al. 2014). It prefers deep water and relatively fast flows, but is not quite as sensitive to impoundment as *Zingel streber* (Zauner 1996). Able to live in the head portions of impoundments in the Danube, where sufficient shoreline habitat measures have been carried out, and flows are moderately faster just above the river bed (25-35 cm/s) than found for schraetzer *Gymnocephalus schraetzer* (Zauner 1996).

Despite some tolerance to hydropower, chains of power plants can eliminate the species, such as on the upper Mur in Slovenia, the lower Drau in Croatia, the upper and middle Drina in Serbia and the Bosna River in Bosnia-Herzegovina. At least 100 large dams threaten more than 50% of this species habitat in the Balkan region.

Eudontomyzon hellenicus

Greek brook lamprey (eng.), Griechisches Bachneunauge (ger.), Gavochelo (gr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

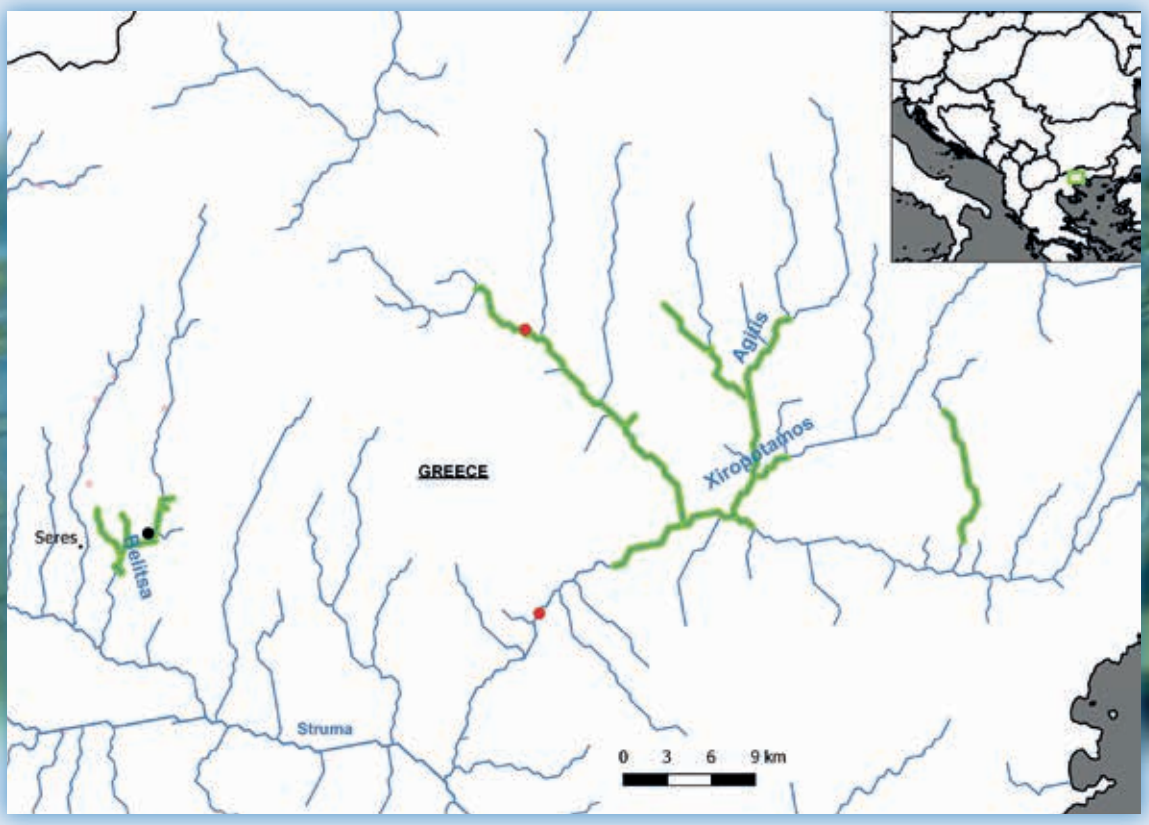
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat - Greece

The **Greek brook lamprey** is endemic to Greece. The occurrence of this small lamprey (up to ca. 150 mm SL) is limited to headwater tributaries of the Sturma basin (Stefanov & Holčik 2007). Populations in the Loúros drainage have been assigned to *E. graecus* (Renaud & Economidis 2010). They are a non-predatory freshwater resident preferring cold, clear and well-oxygenated gravely habitats (Kottelat & Freyhof 2007; Lapierre & Renaud 2015). Stefanov & Holčik (2007) predicted occurrence in the Bulgarian Struma, but no records support this hypothesis, and habitat there is unsuitable (A. Apostolou pers. comm.). Brook lamprey larvae require detritus-rich substrates (Kottelat & Freyhof 2007). Habitat destruction and water extraction are the primary threats to this sensitive species (Maitland et al. 2015).

Two dams in the Agitis drainage threaten to impact nearly half of the known range of this critically endangered species.



Eudontomyzon stankokaramani

Drin brook lamprey (eng.), Drin Bachneunauge (ger.), Kavalli i Drinit (alb.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II

Bern Convention:

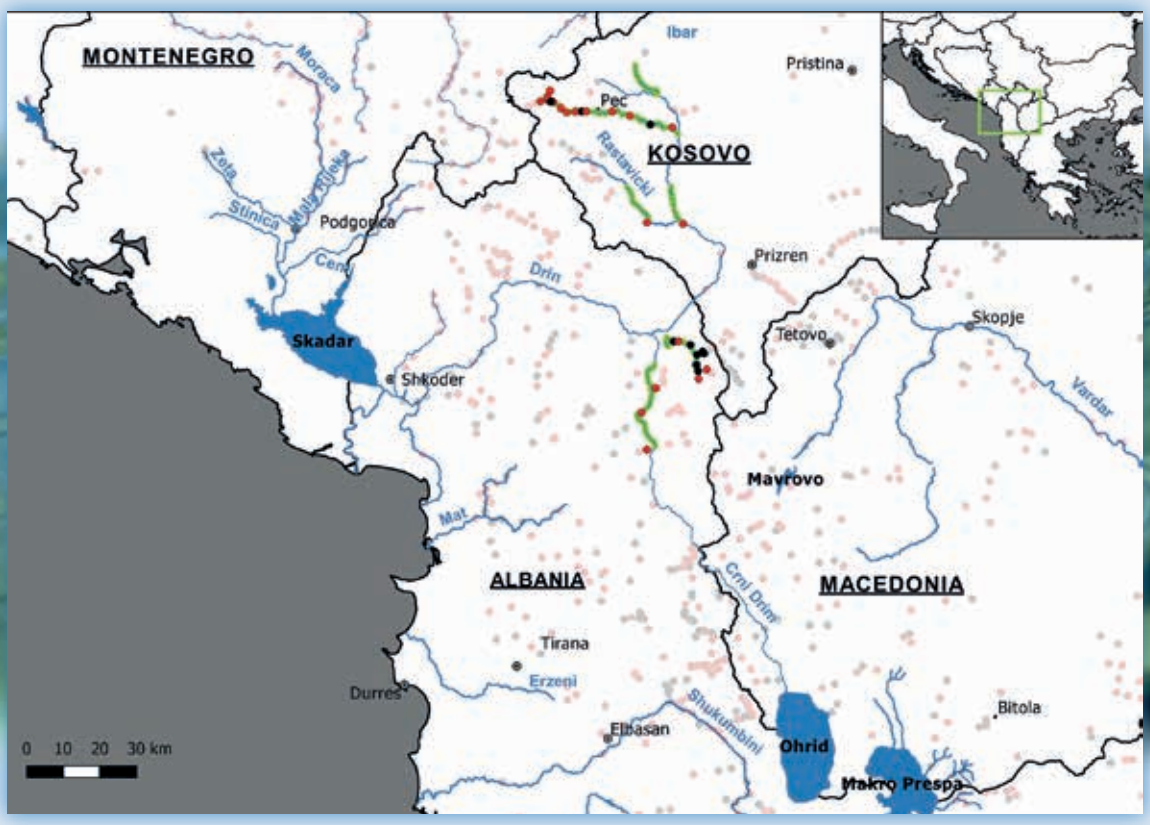
Hydropower Sensitivity:
Moderate-to-High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat – Macedonia, Albania, Kosovo, Montenegro

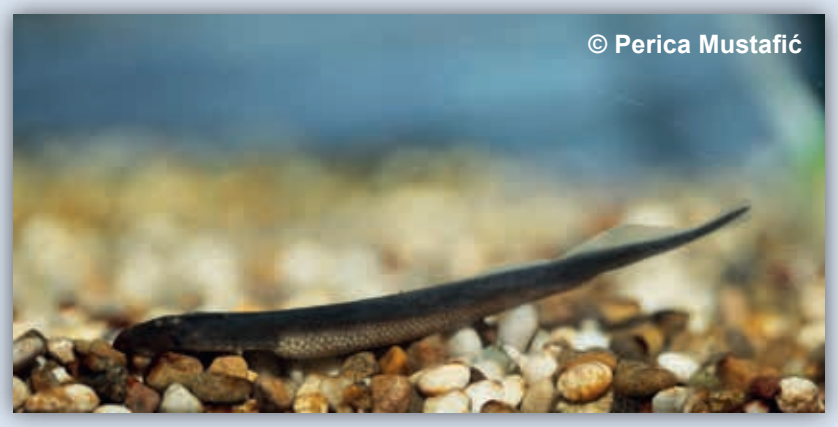
The **Drin brook lamprey** is a mid-sized, non-predatory freshwater resident lamprey; re-described by Holčik & Šorić (2004) from the Istočka River in Kosovo and according to references therein, recorded from the Rastavički brook, Pećka River and Lake Ohrid. However, current records from the lake do not exist. Also recorded from the Pejes River in Kosovo (Grapci-Kotori 2010), and the Zeta River in Montenegro (Lang et al. 2009). Listed in Kottelat & Freyhof (2007) for the entire Drin drainage – this is logical, but catch records are scarce. Lampreys often have a scattered distribution and are not routinely captured in sampling campaigns when not specifically targeted, or they are misidentified. Damming, gravel extraction and pollution are the major threats to most freshwater lampreys (Maitland et al. 2015).

A cascade of thirteen hydropower projects (the first is in construction) on the Pećka River in Kosovo together with at least 10 other hydropower projects in the Drin drainage will likely eliminate at least 75% of the documented habitat for this species.



Eudontomyzon vladykovi

Vladykov's lamprey (eng.), Donaubachneunauge (ger.), Dunavska paklara (hr.)



IUCN:
Least Concern

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex III

Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat – Slovenia, Croatia, Bosnia-Herzegovina

Vladykov's Lamprey is also known as the Danubian brook lamprey; this non-predatory freshwater lamprey has a wide distribution; however, like all brook lampreys they are very sensitive to pollution, migration barriers, hydrological disturbance and gravel extraction (Ćaleta et al. 2015; Maitland et al. 2015). Freshwater lampreys require riffle-like habitats for spawning, similar to salmonids, yet their larval stages require fine sand or clay to burrow into. These requirements, including clean, cold and well-oxygenated water (Kottelat & Freyhof 2007) make them sensitive to anthropogenic pressures. Even small-scale dams may impede migrations or movements from one habitat to another.

At least one-third to one-half of their global distribution area is directly threatened by the construction of at least 50 hydropower facilities. Within the depicted distribution, Vladykov's lamprey occur in a patchwork of fragmented habitats.

Hucho hucho

huchen or Danube salmon (eng.), Huchen (ger.), mladica (hr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II. IV

Bern Convention:
Annex III

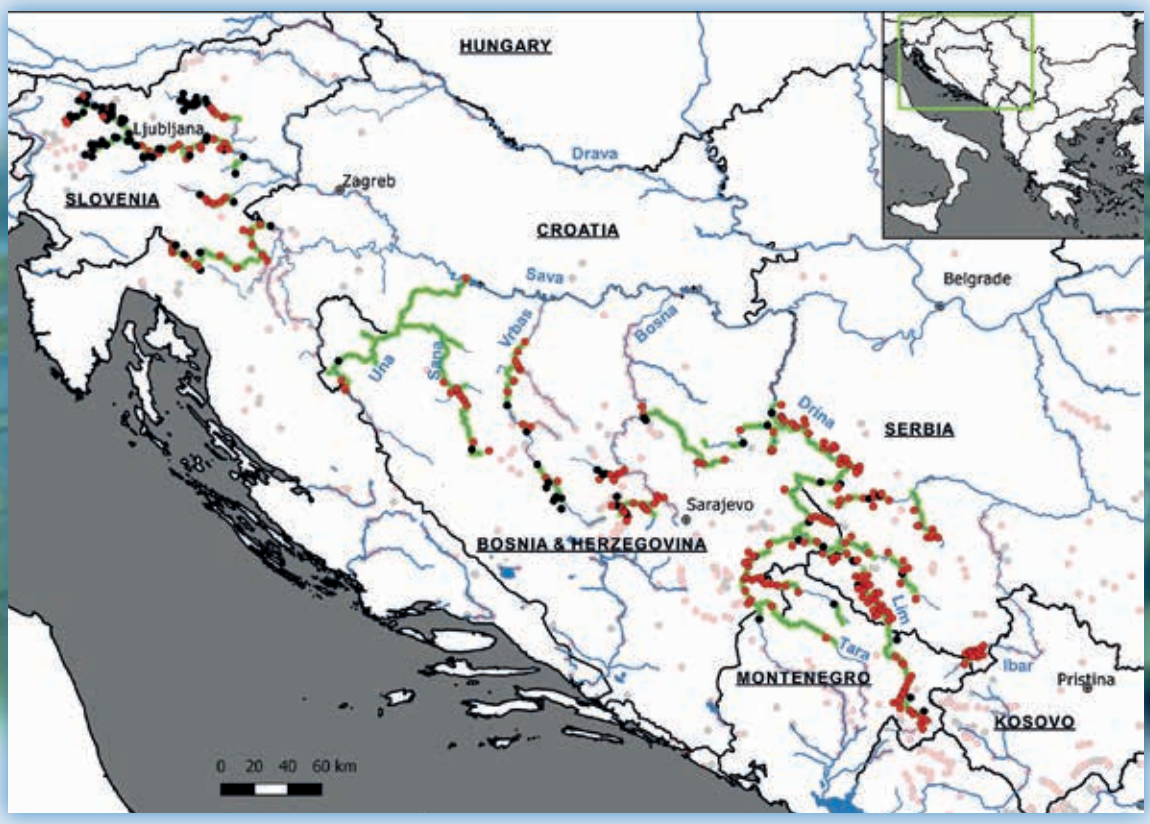
Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat – Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Montenegro

Huchen historically reached sizes up to 60 kg (Holćik et al.1988). They exhibit a freshwater resident life history, are endemic to the Danube basin and are among the largest of all salmonid fishes. Huchen are also an excellent ecosystem indicator as a top predator, and are extremely attractive for sport fisheries. Approximately 65% of their range is on the Balkan Peninsula, where 5 of the 6 longest remaining free-flowing habitats are found (i.e. Kolpa, Una, Sana, Drina, and Lim rivers)(Freyhof et al. 2015). Hydropower development is the most serious threat to the remaining healthy populations. They occur in medium to large-sized rivers, but also migrate into small tributaries to spawn. Loss of spawning and rearing habitat are the biggest impacts of hydropower development on their population sustainability.

A total of 93 hydropower facilities are planned (the first already in construction) directly in river reaches supporting populations of huchen with a potential loss of up to 70% of their populations in the region (Freyhof et al. 2015).



Salmo marmoratus

Marble trout (eng.), Marmorierte Forelle (ger.), Glavatica (hr.)

IUCN:
Least Concern

EUR-HAB-DIR:
Annex II

Bern Convention:

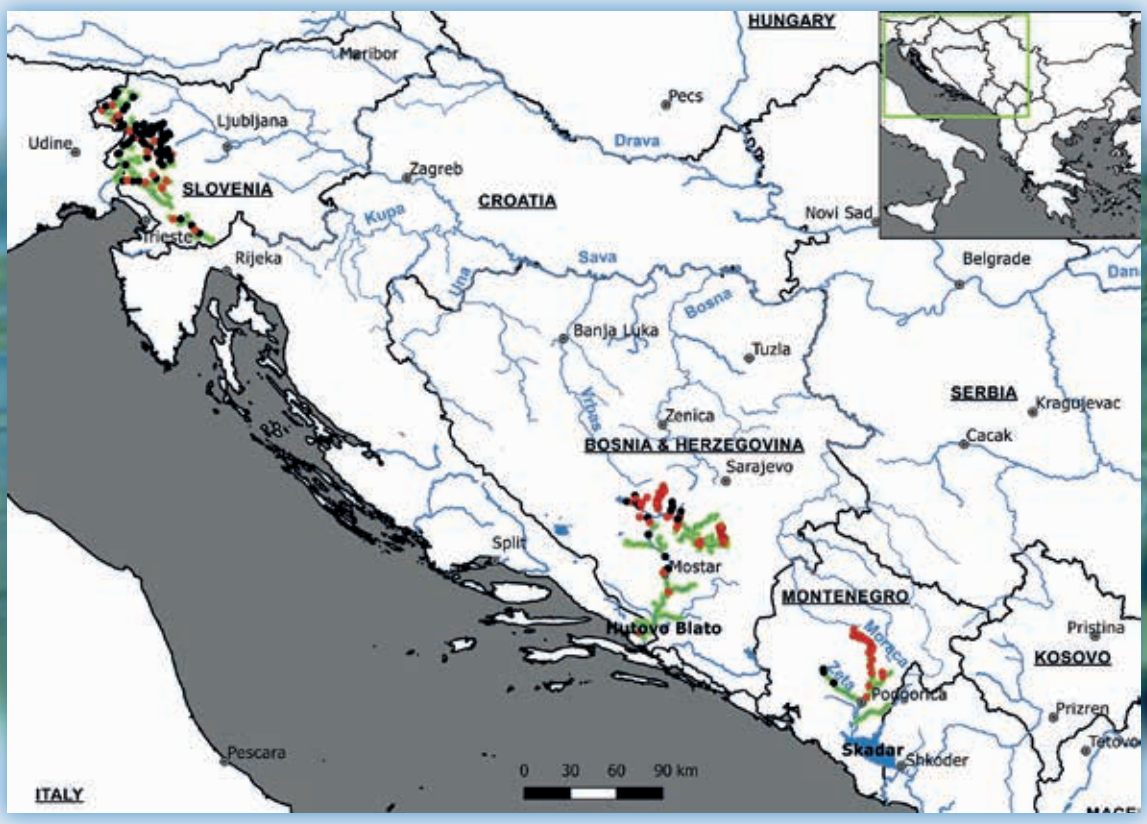
Hydropower Sensitivity:
High

Balkan Dam Threat:
High

Distribution and Habitat – Slovenia, Bosnia-Herzegovina, Montenegro

Marble trout are an Adriatic basin endemic that reach 24 kg in size (Delling 2002) making them extremely popular for sport fisheries. In our study region, they occur in: 1) Soca basin in Slovenia, also the Rižana and Reka rivers, 2) Neretva basin in Bosnia-Herzegovina, and 3) Skadar basin in Montenegro (Zeta, Morača and Cijevna rivers) (Maric 1995, Mrdak et al. 2012), where the species is becoming very rare. Hybridization with introduced *Salmo trutta* is a major problem throughout the range of marbled trout (Meraner et al. 2010; Pustovrh et al. 2011; Sušnik Bajec et al. 2015). The last pure populations in Slovenia are found in a few very small and isolated tributaries of the Idrijca drainage (see http://www.balkan-trout.com/studied_taxa_7_marble_trout.htm).

Hydropower expansion on the upper Cijevna River (Cemi River) in Albania, the Morača River in Montenegro, and the Neretva River in Bosnia-Herzegovina, as well as the Soca basin in Slovenia post a threat for at least 50% if not 75% of the species Balkan range.



Salmo obtusirostris

Softmouth trout (eng.), Weichmaulforelle (ger.), Mekousna (hr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

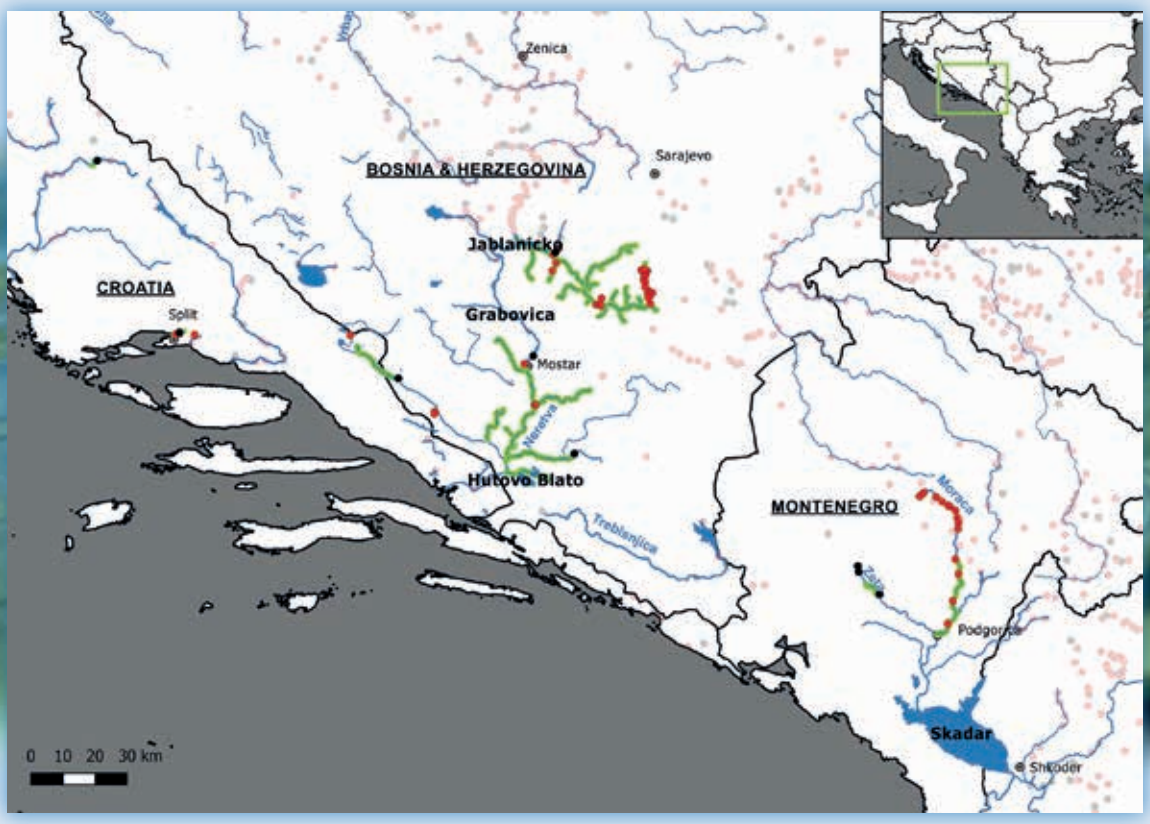
Hydropower Sensitivity:
High

Balkan Dam Threat:
Very High

Distribution and Habitat – Croatia, Bosnia-Herzegovina, Montenegro

Softmouth trout are the most intriguing member of the genus Salmo; previously known as *Salmothymus* (Stearly & Smith 1993). Five distinct populations exist; in the Jadro (Sušnik et al. 2007), Vrljika (Snoj et al. 2008) and Krka rivers of Croatia, the Neretva Basin in Bosnia-Herzegovina (Snoj et al. 2002), and the Zeta and Morača rivers) in Montenegro (Mrdak et al. 2012, Mrdak, pers. Comm). The taxonomic status of these populations remains controversial, so each deserves protection. The population in the Krka River is on the brink of extinction. Several small fragmented sub-populations have been recently found in the Trebižat and Bregava systems of the lower Neretva basin (Glamuzina pers. comm.). Jadro River softmouth have also been transplanted into the Žrnovnica River (not shown).

Planned dams on the upper Neretva River between Konjic and Glavatičevo threatened to exterminate 50% or more of Neretva River populations. Planned dams on the Morača River would most likely eliminate the species in that system.



Salmo peristericus

Prespa trout (eng.), Prespa Forelle (ger.), Pestrofa Prespas (gr.)

IUCN:
Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:

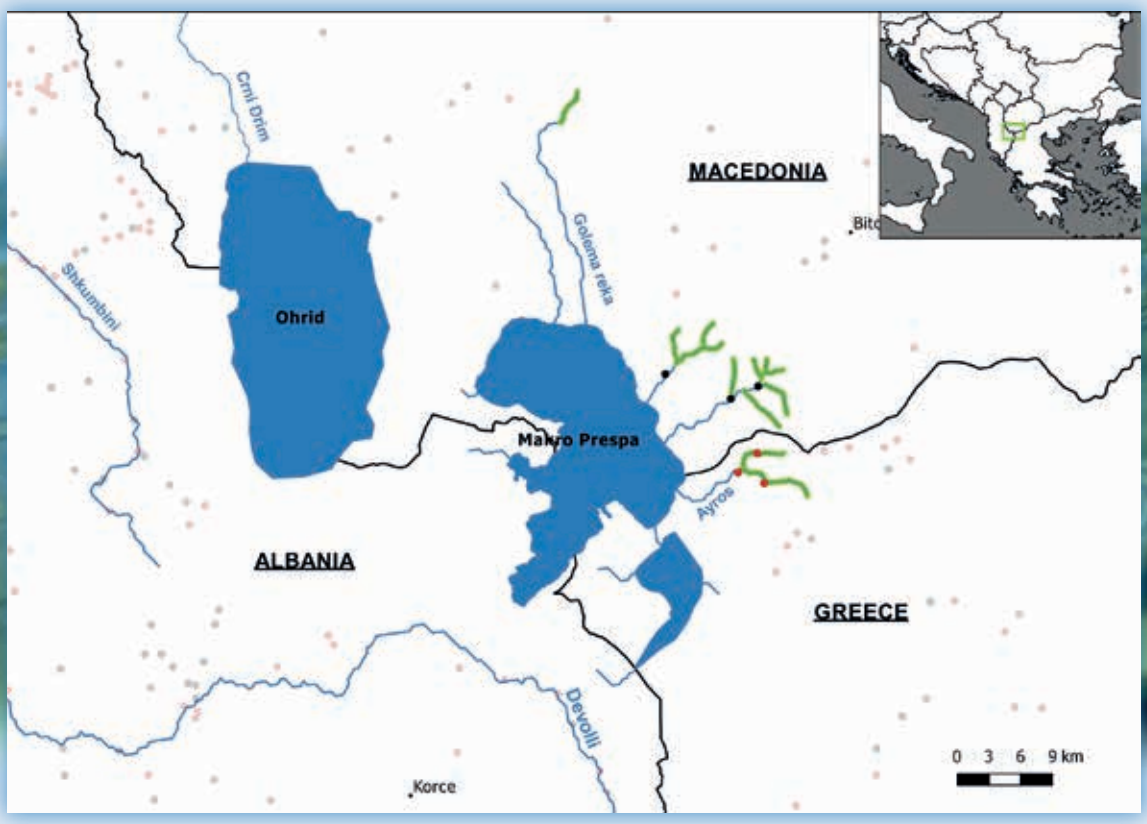
Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat – Greece, Macedonia, Albania

Prespa trout is one of nine endemic fish species to the Prespa Lake basin. These trout persist in small tributary systems of the lake; Leva Reka of the Golema system and Kranska and Brajcinska rivers in Macedonia, and the Agios Germanos system in Greece (Berrebi et al. 2013). The stream habitats where Prespa trout live are between 9 and 16 km long (Koutseri et al. 2010). The occasional lacustrine phenotype may also stem from stocking (Kottelat & Freyhof 2007). However, individuals (*N* = 5) thus far genotyped have been assigned to tributary populations *(N* = 4, Kranska River) or admixture (*N* = 1) (Berrebi et al. 2013). Water abstraction for irrigation and degraded water quality are currently the most important threats.

Three planned dams on the Agios Germanos (Ayros) tributary in Greece would threaten one of the four remaining sub-populations of this species – along with a spawning migration of *Chondrosoma prespense*.



Umbra krameri

European mudminnow (eng.), Europäischer Hundsfisch (ger.), Crnka (sr.)

IUCN:
Vulnerable

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex II

Hydropower Sensitivity:
Very High

Balkan Dam Threat:
High

Distribution and Habitat – Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Bulgaria

The **European mudminnow** occurs in isolated pools, marshes and oxbow habitats of lowland rivers in the Danube and Dniester drainages (Wanzenböck 2004). Such habitats have been extensively degraded via channelization and damming. Mudminnow are extremely sensitive to invasive species and disturbances in the hydrological or sediment regime. Their occurrence is sparse and highly fragmented along the Mur, Sava and Danube rivers (Takács et al. 2015; Marić et al. 2017). Although the entire Slovenian Mur is a Natura 2000 area, and improving habitat for the mudminnow is an explicit goal of this European legislated protection area, a chain of up to eight hydropower plants threaten to eliminate the species both there and potentially in downstream habitats in Croatia as well.

All of the remaining habitat of this species along the Mur, Sava and Danube is threatened by approximately 20 new and relatively large hydropower facilities. Some of these are already in construction or advanced stages of planning, such as along the Sava and Mura rivers in Slovenia.

Valencia letourneuxi

Corfu toothcarp (eng.), Korfu Zahnkarpfen (ger.), Zournás (gr.)

IUCN:
Critically Endangered

EUR-HAB-DIR:
Annex II

Bern Convention:
Annex II

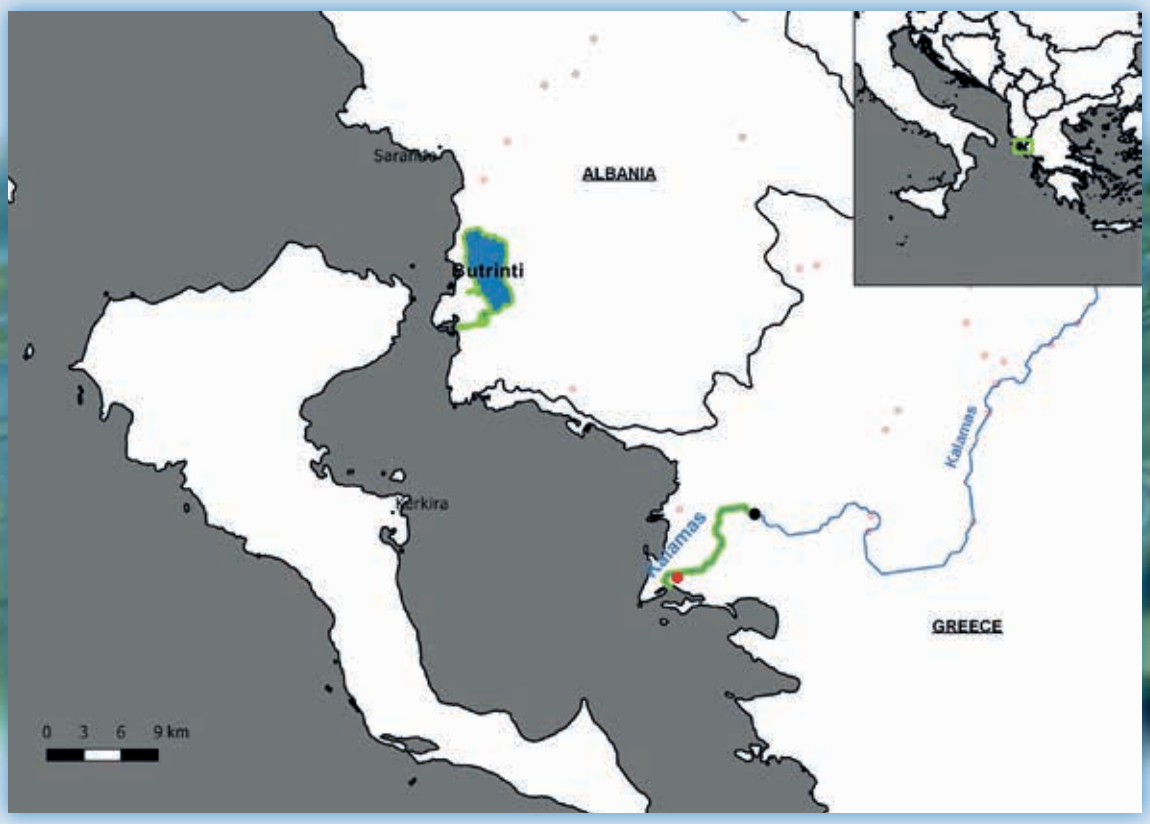
Hydropower Sensitivity:
High

Balkan Dam Threat:
Moderate-to-High

Distribution and Habitat – Albania, Greece

The **Corfu toothcarp** was previously grouped with Cyprinodontidae, and is one of two species represented by the family Valenciidae (Kottelat & Freyhof 2007). The species occurs in freshwater springs and slow-flowing lowland habitats, in relatively deep water with a high percentage of surface vegetation cover (Kalogianni et al. 2010a). In Greece, it was most abundant where introduced Eastern mosquitofish *Gambusia holbrooki* did not occur (Kalogianni et al. 2010). It tolerates low levels of salinity. Water abstraction and agricultural pollution are primary threats; increased flows from hydropeaking eliminated at least one population (Kalogianni et al. 2010b). In our study area it is found in channels flowing into Lake Butrint and in the lower Kalamas River; the current status of the Lake Butrint population in Albania is unknown.

A planned hydropower scheme on the lower Kalamas threatens one of the two remaining sites of this species in our study area.



Non-Endangered Species of Importance.

A number of important species are quite sensitive to hydropower development but were neither mapped nor evaluated. Among them are the **European grayling** (*Thymallus thymallus*) (Fig. 12), which due to their very large range and healthy populations in Scandinavia are not listed in any endangered category. However, they appear on many national red lists and are declining, particularly in the southern portion of their range (Persat 1996, Weiss et al. 2013 and ref. therein). While adults can live in lakes, or even the upper Baltic, they are obligate flowing water spawners, using clean gravel and usually relatively shallow water. They normally are found in cold and clean water and are very sensitive to hydrological disturbance, climate change and, where populations are reduced or fragmented, predation (Uiblein et al. 2002).

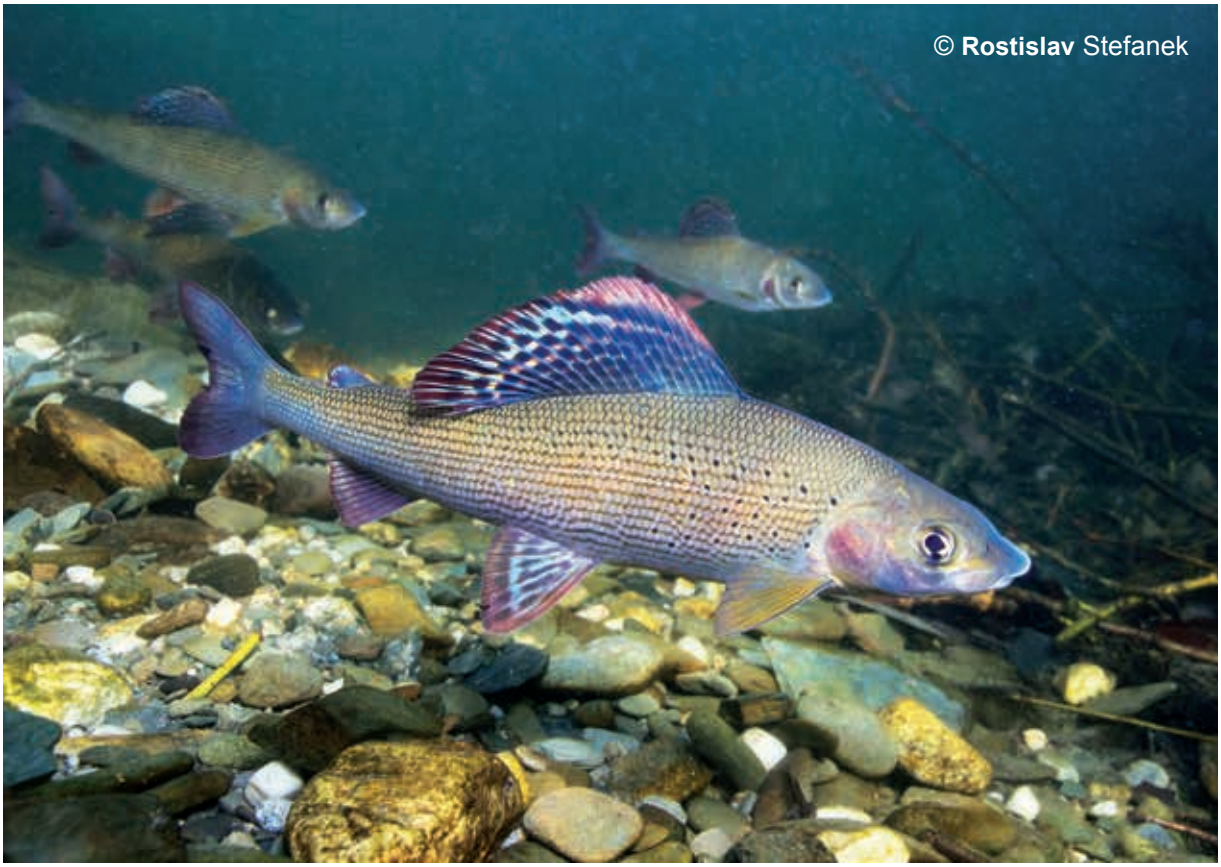


Fig. 12. *European grayling (Thymallus thymallus).*

In the Balkans grayling are native to the Soca Basin (Adriatic lineage), where decades of stocking with the Danubian lineage have all but eliminated the original genetic architecture. Soca fish have also been introduced into the upper Neretva River, Bosnia-Herzegovina. Otherwise, grayling in the Balkans occur in sub-montane rivers of the Danube drainage from the Plav Lake-Lim River catchment in Montenegro north to the upper Sava catchment in Slovenia. **Grayling have become increasingly attractive for lucrative sport fisheries and**

are thus valuable for the local economy and economic valuation of undammed rivers. Such fisheries in several ecologically intact rivers in Montenegro, such as the Lim and Tara rivers have developed very rapidly and professionally over the past decade utilizing international advertising, and **have greatly aided the conservation of these rivers. As local communities value the income,** they are more open to controlling non-point pollution sources and illegal fishing. After years of neglect, the **stocks of both the endangered huchen and grayling have markedly increased** (Mrdak pers. comm.), and the fisheries are primarily managed as catch-and-release.

Sand gudgeons (genus *Romanogobio*) occupy a variety of habitats with a species-specific tolerance for impoundments. The genus is undergoing taxonomic changes due to recent genetic investigations and thus the overview of distribution data needs to be reviewed based on these changes.

Fig. 13. *Romanogobio banarescui (needs validation). Found in the Vardar drainage of Greece and Macedonia, but likely with a broader distribution.*

There are clearly two species present in some rivers of Greece and Republic of Macedonia (*R. elimeius* and *R. banarescui*, the latter is not yet validated) (Fig. 13) and the extent and status of these distributions requires evaluation. In general, populations of *Romanogobio* are in decline due to water extraction, pollution and damming, but they are relatively widespread.

Fig. 14. *Weatherfish Misgurnus fossilis.*

The **weatherfish** is a good indicator of intact floodplain habitats. The species is still widespread but undergoing steady decline in the Danube drainage as floodplain habitats such as oxbow lakes are continuously lost to channelization or pollution. **Along the larger rivers such as the Sava, Drava and Danube, these habitats are heavily impacted by hydropower development,** as floodplains become cut off from the main river.

Trout species of the genus *Salmo* are found throughout the study area and collectively represent fish of high societal value in terms of culinary attraction and sport angling. They are also the subject of considerable scientific research and serve an important ecological role in many headwater systems. The diversity of this genus over its vast range, from the northern coast of Africa to the mountains of Central Asia is captured in a book with over 200 high-quality photos by the hobby biologist and adventurer Johannes Schöffmann (Schöffmann 2013). Our fact sheet on softmouth trout (*Salmo obtusirostris*), describes five distinct populations, which are often treated with sub-specific designations (Figs. 15-19). Due to their level of endangerment as well as uniqueness, we display all five of these populations including were applicable sub-species nomenclature. Eventually, one or more of these populations may be recognized as a distinct species.

Fig. 15. Krka softmouth trout (*Salmo obtusirostris krkensis*).
Known only from a very short (one kilometer at most) reach of the upper Krka River in Croatia. These fish are on the brink of extinction, and a current research project will intensively focus on finding the remaining individuals and attempting to rescue this fish. There is a large power plant (Milacka 2) planned downstream from the habitat of Krka softmouth trout.

Fig 16. Jadro softmouth trout (*Salmo obtusirostris salonitana*).
Limited to a few kilometers of the Jadro River in Croatia, Jadro River softmouth exhibit the mtDNA of Adriatic brown trout, presumed to stem from ancient hybridization (Sušnik Bajec et al. 2007). As noted, these fish were transplanted into the nearby Žrnovnica River as a conservation measure.

Fig. 17. Vrljika softmouth trout (*Salmo obtusirostris ssp*).
Occurs in the Vrljika River, Croatia, an isolated headwater reach of the Trebižat River drainage (Snoj et al. 2008). The Vrljika River in this karst region exhibits subterranean flows, appearing and disappearing several times as it crosses the border between Croatia and Bosnia-Herzegovina; in Bosnia-Herzegovina the river is too warm for salmonids, and thus t**his population is both physically and climatically isolated.** They must have colonized this habitat from the Neretva drainage under different hydrological conditions than occur today.

Fig. 18. Zeta softmouth trout (*Salmo obtusirostris zetensis*).
Known from a very short reach of the Zeta River as well as the Morača River of the Skadar basin in Montenegro. The Zeta softmouth in these systems are extremely rare and cryptic, living in deep pools and often escaping attention from all but the most knowledgeable local biologists or anglers. **The Morača River is currently undammed but a chain of planned large power plants would eliminate the species from this river.**

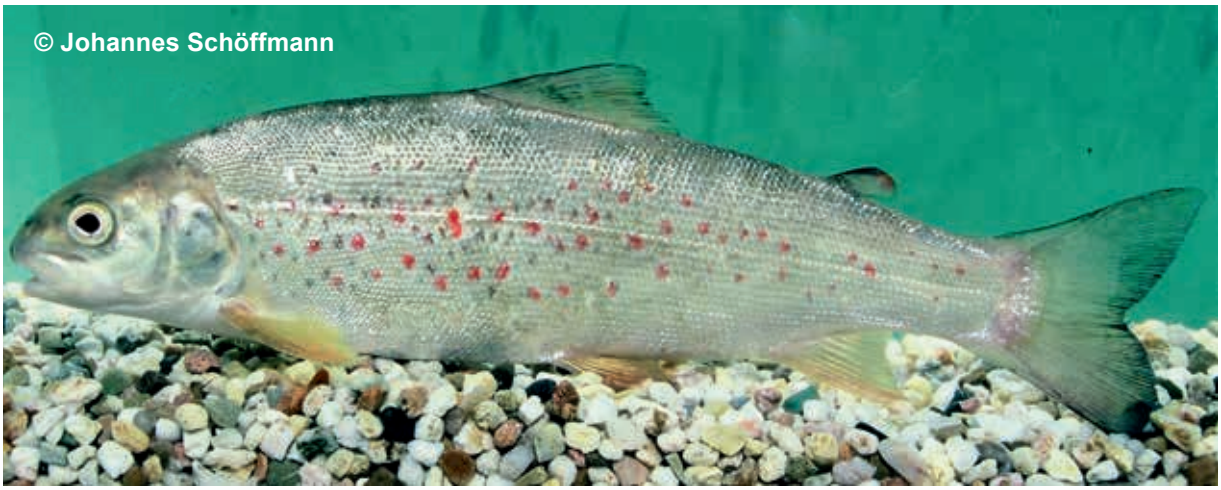


Fig. 19. Neretva softmouth trout (*Salmo obtusirostris oxyrhynchus*). **The Neretva River softmouth is the most abundant of all the softmouth taxa, with the largest population in found** between the towns of Konjic and Glavetičevo. **In this stretch of the Neretva, several large hydropower facilities are planned, which would eliminate 50% of the taxon's range in the basin.** Collectively, the softmouth trout, together with the lacustrine belvitca (*Salmo ohridanus*) from Lake Ohrid, are relatively distant from other trout lineages/species throughout Europe and Asia. The remaining taxa belong to a highly diverse complex of genetic lineages that have all diverged from each other within the last two million years. Many of these taxa are either not yet listed in the IUCN red list, or exist as data deficient. An exception is one of at least three described taxa in Republic of Macedonia.

Fig 20. Crna trout (*Salmo pelagonicus*).

Listed as vulnerable (Freyhof & Kottelat 2008d), **the Crna trout is known only from the lower tributaries of the Vardar River system in Republic of Macedonia and the Aliakomon River system in Greece. Numerous planned hydropower plants in the Crna River system threaten much of the Republic of Macedonian range of the species.** As with all native populations of *Salmo*, stocking of foreign or domesticated strains of trout present a major

problem. At times, the promotion of such introductions is supported by hydropower operators, who often offer "compensation" in the form of paying for stocking measures; this invariably compounds the problem, as the last remaining populations of native fish become introgressed with domesticated lineages, which are not adaptive to local habitats.

Fig. 21. The eastern Adriatic trout (*Salmo farioides*).
The species is relatively widespread from Croatia to Albania, this specimen is from the **Radika River, Republic of Macedonia.** The river flows through **Mavrova National Park** and has been the site of ongoing controversy for a number of hydropower plants. Recently, international funding was withdrawn for the Boško Most power plant, which would have taken habitat within a national park from native populations of *S. farioides*.

Fig. 22. The eastern Adriatic trout (*Salmo farioides*).
This specimen is from the **Drin catchment in Albania.** Albanian mountain streams are currently subjected to the most active hydropower exploitation plans throughout the study area.

Fig. 23. *Salmo sp.* **From the Voidomatis River, Greece.** The river flows through **Vikos-Aoos National Park** and joins the Aoos River, which is the Greek headwaters for the Vjosa River. **The Aoos/Vjosa River flows 260 km undammed through Albania to the Adriatic, making it one of Europe's longest and most unspoiled river systems.**

Fig. 24. *Voidomatis River, Greece in the headwaters of the Aoos/Vjosa drainage.*

Fig. 25. Danube trout *(Salmo labrax).*

The Danubian drainage brown trout, found from Austria to Bulgaria. This specimen stems from the ***Džepska River, Serbia.***

Fig. 26. Marbled trout *(Salmo marmoratus).*

A marbled trout from the Soca River basin in Slovenia *where the last pure genetic strains of this large-growing species are found.*

Endangered Fish Hotspots

The following three river reaches or basin have been chosen to exemplify hotspots of endangered fish biodiversity as well as reaches of relatively pristine free-flowing river with remarkable conservation value. All three areas have various levels of existing protection and yet are threatened by the planning of substantial hydropower exploitation.

Neretva Basin

The Neretva River flows approximately 230 km from the Jabuka Mountains in Bosnia-Herzegovina to the Adriatic Sea, with the last 20 km flowing through Croatia. The river drains over 10,000 km^2 and ends in a delta region of 200 km^2 delta region (Skoulikidis et al. 2009). The wetlands are partially under protection as the Hutovo Blato Nature Park (74 km^2) in Bosnia-Herzegovina (also a Ramsar site) and there are additionally several smaller protected areas in Croatia. Much of the remaining delta area has been reclaimed and is managed for intensive agricultural (mostly vegetables) production. Much of the catchment area upstream is undeveloped, with over 70% being either natural grasslands or forests (Skoulikidis et al. 2009). Reported mean discharges for the Neretva vary widely, from ca. 70 m^3/s (Skoulikidis et al. 2009) to 269 m^3/s Margeta (2000), to 340 m^3/s or more (Wikipedia).

Fig. 27. *Neretva River above the town of Konjic.* ***Prime habitat for the Neretva River softmouth trout, and marbled trout, among other species.***

Fig. 28. *Another view of the Neretva River above the town of Konjic. Deep pools are prime habitat for the elusive Neretva River softmouth trout.*

Fig. 29. *Both rafting and fly-fishing are popular on the Neretva River.*

Fig. 30. *The lower Neretva River at Početilj, Bosnia-Herzegovina,* **habitat for the endemic Dalmatian nase *Chondrostoma kneri* and the Neretva chub *Squalius svallize.***

Fig. 31. *The famous Kravice falls on the Trebižat River,* ***a major tributary of the Neretva River and home to the endangered Makal dace Squalius microlepsis.***

No fewer than 17 of our listed species occur in the Neretva River Basin. In its lower reaches and towards the delta three dwarf gobies (genus *Knipowitschia*) can be found, all listed as vulnerable. The estuary hosts a large number of marine and brackish water species, **and**

Fig. 32. *Downstream of Konjic an aerial view of the Jablanićko Dam, leaving the Neretva River channel below dry.*

offers one of the last estuaries on the eastern Adriatic coast for the critically endangered European eel as well as the increasingly scarce anadromous twaite shad, *Alosa fallax*. The Nereteva River is already heavily exploited for hydropower, with four major dams on its mainstem between Jablanica and Mostar and one on the Rama River (Fig. 35). **Only the uppermost and lower most reaches of the river remain habitat for its rich ichthyofauna.** The entire upper Neretva River, including its headwater tributaries are being targeted for hydropower development. **The largest of the projects, the Bjelimici cascade, is in the heart of the largest habitat for the endangered softmouth trout in the Balkan Peninsula, along with marbled trout, and the largest habitat for the vulnerable Neretva spined loach *Cobitis narentana*.** The lower reaches of the Neretva, while still harboring a number of endangered species and of significant conservation value, have been primarily exploited for intense agricultural management (Figs. 33 and 34). **Thus, the relatively sparsely settled mountainous headwaters represent the last reaches of this biologically rich system that is predominately in its natural state.**

Fig. 33. *Along the lower reaches of the Neretva River much of the wetlands have been reclaimed for agricultural production,* ***but a number of endangered fish species still survive in mainly tributary habitats, such as the Norin Goby Knipowitschia radovici.***

Fig. 34. *Neretva River Delta, Croatia.*

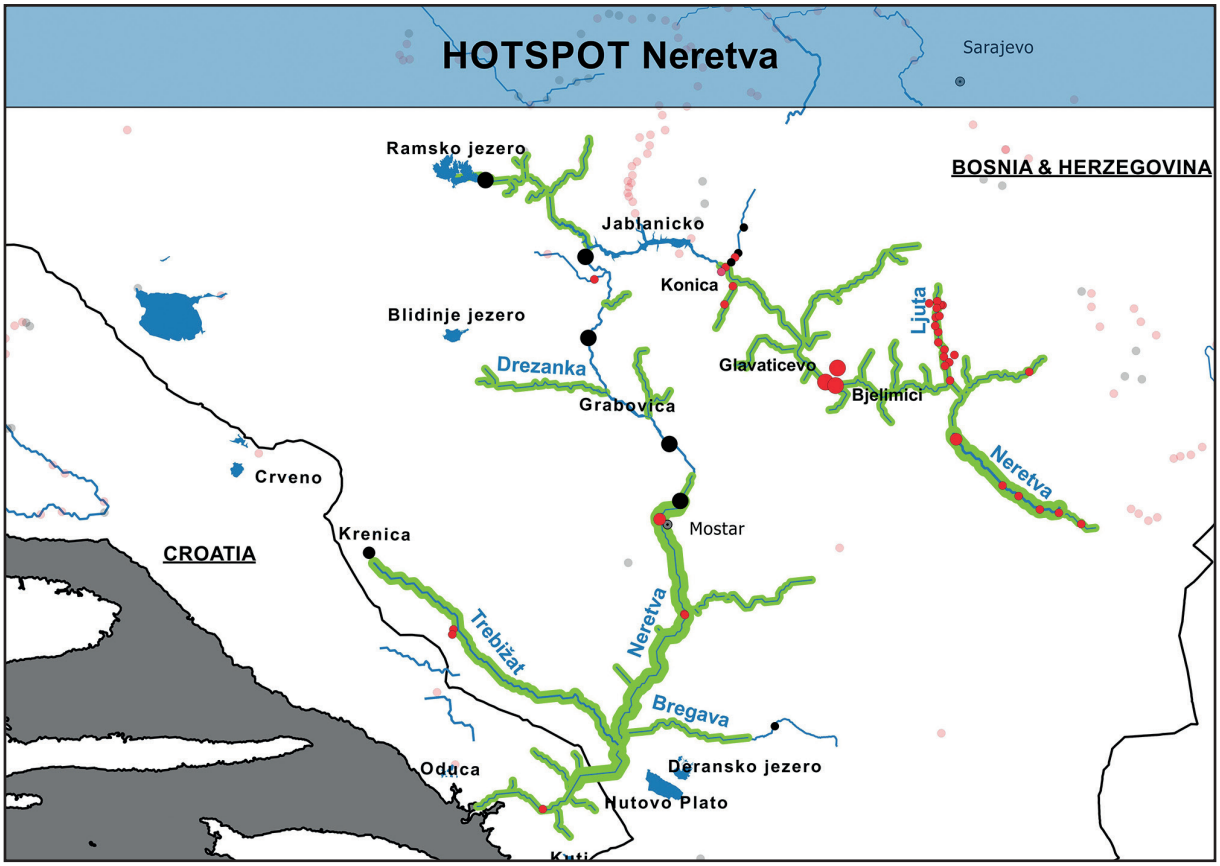


Fig. 35. *Planned (red) and existing (black) hydropower dams on the Neretva River.* ***The river upstream from Konjic is a recreational paradise and home to several endangered and threatened fish species.***

Table 2. *List of native fish species from the Neretva River that are either listed by the IUCN in a threatened category, or protected under the Bern Convention or European Habitats Directive. A list of abbreviations is found on page 145.*

Native fish species	IUCN
Alosa fallax	*LC*
Anguilla anguilla	*CR*
Chondrostoma knerii	*VU*
Cobitis narentana	*VU*
Cottus gobio	*LC*
Delminichthys adspersus	*VU*
Delminichthys ghetaldii	*VU*
Knipowitschia croatica	*VU*
Knipowitschia radovici	*VU*

Native fish species	IUCN
Knipowitschia panizzae	*LC*
Lampetra soljani	*LC*
Pomatoschistus canestrinii	*LC*
Salmo marmoratus	*LC*
Salmo obtusirostris	*EN*
Squalius microlepis	*EN*
Squalius svallize	*VU*
Thymallus	*LC*

Morača Basin (incl. Lake Skadar)

Lake Skadar is the largest natural lake in the Balkan Peninsula, with an average surface area of 370 km^2, two-thirds of which is in Montenegro and the rest in Albania. Its drainage area is 5,490 km^2 and is dominated by the Morača River, the lake's major tributary and source of water (62%), with a mean flow of just over 200 m^3/s. **Approximately 400 km^2 of the lake and riparian area in Montenegro are protected as the country's largest National Park, and the lake's extensive wetlands are on the Ramsar list of wetlands of international importance.**

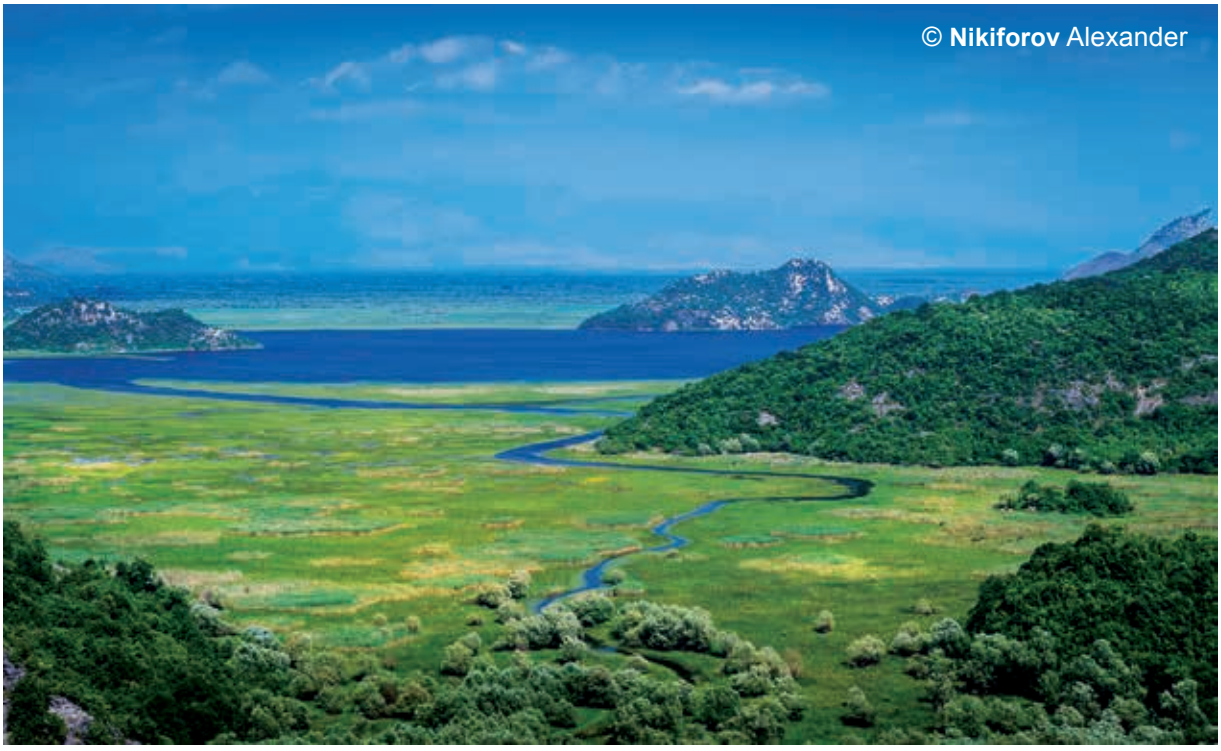


Fig. 36. *View of Lake Skadar and the confluence of short (ca. 12 km) spring-fed Crnojevia River from the north.* ***The lake is 44 km long and up to 14 km wide making it the largest natural lake on the Balkan Peninsula.***

Lake Skadar is a biodiversity hotspot, with for example **34 native species of fish, 282 birds, 39 snails (Pešić & Glöer 2013), and 147 species of aquatic plants.** Together with the two other ancient lakes of the Drin system, Lake Ohrid and Lake Prespa, Lake Skadar is a center of endemism, with e.g. 13 endemic fishes (Talevski et al. 2009) and 12 endemic snails (Pešić & Glöer 2013). Aside from an abundance of sublacustrine springs, **one of the lake's most prominent features is its extensive wetlands and large seasonal fluctuations in surface area, which is tightly connected to the seasonal flow regime of the Morača River.** Mean monthly flows of the Morača River vary by an order of magnitude, with a high mean in November of 284 m^3/s to a low in August of 26 m^3/s (Sekulić et al. 2017). **These variable**

flows result in large-scale wetland dynamics involving up to 12,000 ha whereby the lake's surface area increases on average to 459 km^2 in winter months with an average minimum of 359 km^2 in summer. These seasonably predictable fluctuations and above all the extensive areas of submerged and emergent plants provide both spawning and rearing areas for many of the lake's phytophilous cyprinid fishes as well as **aquatic birds (over 140 species).**

Fig. 37. *Up to 12,000 ha of wetland habitat (emergent, submergent and reed zones) play a vital role in the biological productivity, diversity and ecological balance of the Lake Skadar ecosystem.*

The Morača River is also a major source of nutrients for the lake, and the vegetated areas also serve as a nutrient filter. **Thus the ecology of the entire system it highly dependent on the hydrological regime of the Morača River.** Planned hydropower schemes that would disrupt these flows would in all likelihood aim to store water during high flows and thus reduce the lake's surface area and corresponding wetlands during the critical spring spawning period of many of the lake's species. **As Lake Skadar is also a significant source of income for fishermen, a reduction in spawning area is estimated to result in 30% loss in revenue, or 1.4 million euros per year (Mrdak 2009).**

Fig. 38. *Both commercial and sport fishing are extremely important for the local economy of Lake Skadar.*

Up to 800 families live directly or indirectly from the commercial catches in the lake, with an estimated income of over four million euros annually (Mrdak 2009). Depicted in Fig. 38 is the port at Vranjina with its small commercial fishing boats. To the right left is the pulling of nets among the lilly pads of the lake.

Fig. 39. *An autumn day on Lake Skadar. Autumn and winter rains raise the lake's water levels up to five meters and inundate 100 km² or more of the lake's shore line especially on the north end.*

Fig. 40. *Morača River canyon, Montenegro.* ***This undammed river serves as habitat for both marbled and softmouth trout as well as spawning grounds for several of Lake Skadar's cyprinid fishes; above all, it is the hydrological life-line of the sensitive Lake Skadar ecosystem.***

By far the largest tributary of the Morača River is the Zeta River, a spring-fed right tributary of the Morača River.

Fig. 41. *The upper Zeta River, the largest tributary of the Morača River and* ***the last core habitat of the region's populations of marbled and softmouth trout.***

Both marbled trout (*Salmo marmoratus*) and the increasingly rare and endangered softmouth trout (*Salmo obtusirostris*) can be found in the Zeta and Morača rivers, with softmouth having turned up in the city of Podgorica (D. Mrdak, pers. comm.). Further, the "Zeta" softmouth (originally described as *Salmo obtusirostris* zetensis) is, like all five of the populations of softmouth, highly unique and exists nowhere else on earth. The population overall is extremely small and should be considered as highly threatened with extinction. The Morača River itself also serves as spawning grounds for a number of species primarily residing in Skadar Lake. Most of these species have not been mapped in our study, as they are not currently listed in any endangered category, being relatively abundant; however, a number of these endemics would indeed be threatened by hydropower development on the Morača River. In total, we can list 33 freshwater or anadromous species from the drainage, whereby *Chondrostoma scodrensis* is extinct, and both *Acipenser* species can be considered extirpated from the region if not extinct in the wild. Likewise, *Alosa fallax* is very scarce and may be extirpated, although an open corridor to the Adriatic still exists. **Remaining, we have the critically endangered European eel *Anguilla anguilla*, the endangered *Chondrostoma phoxinus*, the endangered endemic *Gobio skardarensis and Salmo obtusirostris*.**

Table 3. *List of native freshwater or anadromous fish species reported from Lake Skadar/* Morača River (modified from Talevski et al. 2009). A list of abbreviations is found on page 145.

Native fish species	IUCN
Acipenser naccarii	*CR*
Acipenser sturio	*CR*
Alburnoides ohridanus	*VU*
Alburnus scoranza	*LC*
Alosa fallax	*LC*
Alosa sp. nov. 'Skadar'	*VU*
Anguilla anguilla	*CR*
Barbatula zetensis	*LC*
Barbus rebeli	*LC*
Barbus strumicae	*LC*
Carassius gibelio	*LC*
Chondrostoma scodrensis	*EX*
Chondrostoma phoxinus	*EN*
Cobitis ohridana	*LC*
Gobio skadarensis	*EN*
Gasterosteus gymnurus	*LC*
Pelasgus minutus	*DD*
Salaria fluviatilis	*LC*

Native fish species	IUCN
Salaria fluviatilis	*LC*
Salmo farioides	*NE*
Salmo marmoratus	*LC*
Salmo obtusirostris	*EN*
Scardinius knezevici	*LC*
Squalius squalus	*LC*
Telestes montenigrinus	*LC*
Thymallus thymallus	*LC*
Perca fluviatilis	*LC*
Phoxinus limaireul	*LC*
Rhodeus amarus	*LC*
Pomatoschistus	*LC*
montenegrensis	*LC*
Pachychilon pictum	*NE*
Rutilus albus	*LC*
Rutilus ohridanus	

Considering the broad taxonomic richness of the Lake Skadar basin including the Morača River Canyon, its economic value to local fisheries, its touristic value and its multiple levels of national and internationally recognized protection, jeopardizing the stability and uniqueness of the system for one or more hydropower plant facilities should be vehemently opposed. The lake has some problems with respect to pollution and eutrophication and it may even be that distant hydropower plants on the Drin in Albania have already had small influences on the lake's level; such dams hold back bed-load leading to downstream erosion (or river-bed degradation). The Drin joins Lake Skadar's outlet, the Bojana (or Buna) River just a few kilometers from the lake and ca. 40 km from the sea. Thus, sediment deficits into the Bojana River result in a deepening of the channel and thus in turn may be affecting the lake's water levels as well as the valuable delta region. **Thus it is imperative that no further disturbances to the hydrological balance of the lake take place.**

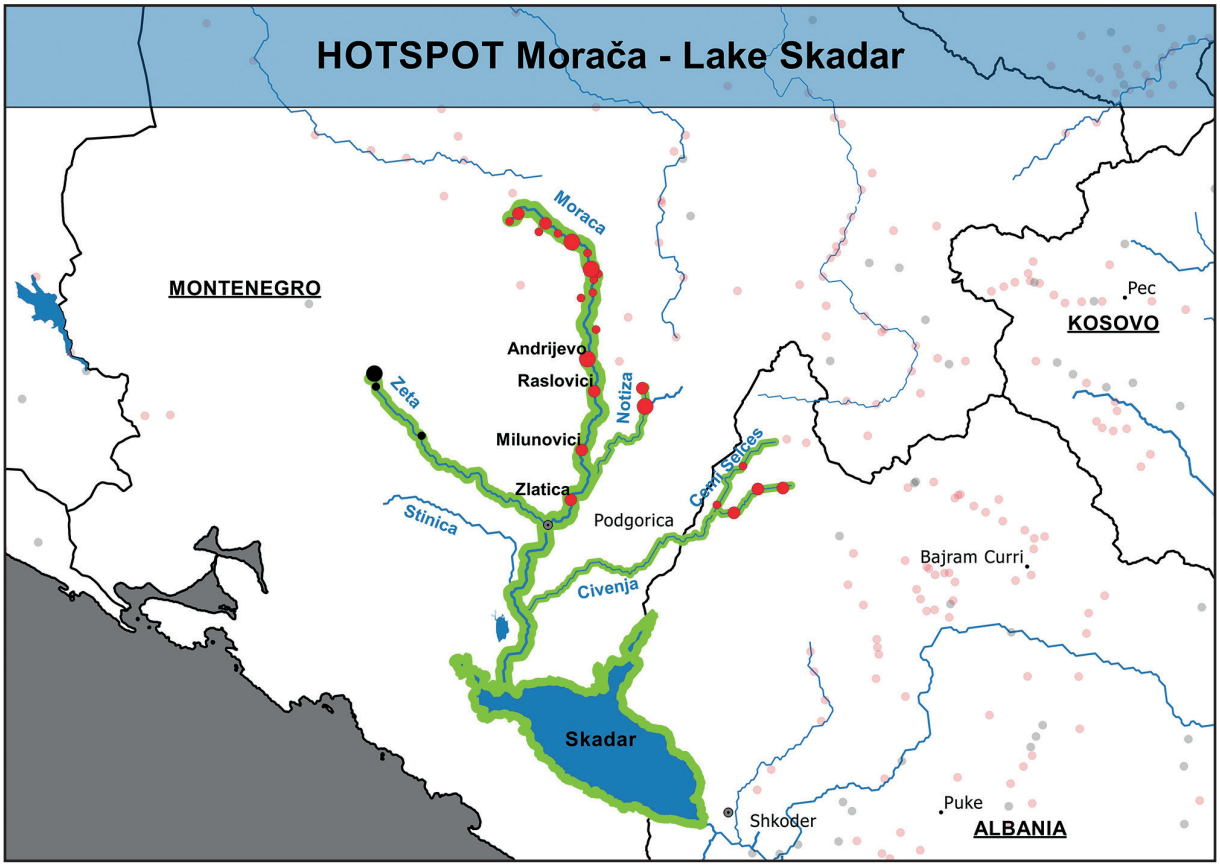


Fig. 42. *Map of the Lake Skadar Basin including the Morača River and its tributaries. The Morača cascade of hydropower dams (planned, red dots, existing black dots) including the large Andrijevo storage facility (127 MW) and three smaller (each 37 MW) facilities has recently appeared on a list from the European Commission for consideration.*

A major shift in its natural nutrient and water supply could have catastrophic consequences for the ecosystem and this risk need not be taken. With great surprise, however, the planned cascade, put on the shelf for many years precisely because of environmental concerns has now emerged again on a list of "potentially" interesting projects to be financed by the European Commission (Directorate-General for Neighborhood and Enlargement Negotiations or DG NEAR)). **A much more prudent vision would be to declare the Morača River a wild and scenic river sanctuary and place it forever out of reach for hydropower development. This would not only protect a beautiful river landscape with its own rare ichthyofauna and recreational interests just outside of Montenegro's capital, but also the hydrological life-line for the entire Lake Skadar ecosystem.**

Drina-Tara Rivers

The Tara River in Montenegro, the country's longest river, begins in the Komovi Mountains with the confluence of the Opasinica and Veruša rivers and flows ca. 144 km before joining the Piva River at the border with Bosnia-Herzegovina to form the Drina River. **The Tara River is famous for flowing through a 78 km-long canyon that reaches 1,300 meters in nearly vertical depth, making it Europe's longest and deepest canyon.** The river drains an area of just over 2,000 km^2 and was first named in the **UNESCO "Man and Biosphere" program in 1977** (Dragićević et al. 2003) and finally officially listed as a **World Natural and Cultural Heritage site in 1980,** due to its geological, hydrological and biological phenomena (Srdanović & Pavić 2013). Sixty kilometers of the canyon are also part of **Montenegro's Durmitor National Park** (Papp & Erzberger 2011), **established in 1952.** The Tara River is habitat for the endangered Danube salmon *Hucho hucho*, as well as European grayling *Thymallus thymallus*, Danubian basin brown trout *Salmo labrax*, sculpin *Cottus gobio*, Barbel *Barbus barbus*, large spot barbel *Barbus balcanicu*s, minnow *Phoxinus phoxinus,* and Nase *Chondrostoma nasus*.

Fig. 42. *The Tara River canyon one of Europe's most scenic and ecologically intact river systems.*

The Tara River is also known for its extraordinarily clean water, abundant springs and rich floral diversity; the surrounding National Park has more than 1,600 vascular plants and provides habitat for brown bear, grey wolf, and European wild cats (whc.unesco.org/en/list/100). Rafting and kayaking is an extremely popular activity on the Tara River, and there are numerous camps along the river that serve this touristic function.

Fig. 44. *The Tara Canyon is very popular for rafting and kayaking; the international rafting championships were held on the Tara and Vrbas rivers in 2009.*

As the Tara River emerges from its canyon, it is joined by the Piva River, which had also carved a spectacular 1,200 m deep canyon; but is now behind a 220 meter high dam. As the Piva meets the Tara to form the Drina, the mean flow reaches 154 m^3/s as it flows about 45 km through the Suhi-Do-Biserovina gorge. The fish fauna is not unlike that in the Tara, but as one moves downstream more species are found and in total at least 22 native species have been recorded (Tab. 4) (Sofradžija 2009).

Fig. 45. *The upper Drina River flattens out a bit after the confluence of the Tara and Piva rivers forming one of the larger unspoiled river stretches of its kind in the Danube basin.*

Table 4. *At least 22 native species can be recorded for the Tara and upper Drina rivers in Montenegro and Bosnia-Herzegovina.*

Native fish species	IUCN
Alburnus alburnus	*LC*
Alburnoides bipunctatus	*LC*
Barbus barbus	*LC*
Barbus balcanicus	*LC*
Chondrostoma nasus	*LC*
Cobitis elongatoides	*LC*
Cottus gobio	*LC*
Eudontomyzon vladykovi	*LC*
Gobio gobio	*LC*
Hucho hucho	*EN*
Lota lota	*LC*

Native fish species	IUCN
Phoxinus phoxinus	*LC*
Rutilus pigus	*LC*
Rutilus rutilus	*LC*
Salmo labrax	*LC*
Sabanejewia aurata	*LC*
Squalius cephalus	*LC*
Silurus glanis	*LC*
Telestes souffia	*LC*
Thymallus thymallus	*LC*
Vimba vimba	*LC*
Zingel streber	*LC*

Not all of these species listed in Table 4 will occur in Tara canyon, but downstream the fauna eventually becomes more diverse and species such as burbot, Wels, and roach occur. **While only the huchen is listed as endangered, a number of other species are very sensitive to hydropower development such as the grayling, nase, and vairone** (*Telestes souffia*). Eventually, the Drina River meets its first dam near the town of Goražde and the fish fauna begins to become dominated by both native and non-native cyprinids (Sofradžija 2009). **The combination of the Tara River and its headwater tributaries, together with the first 50 km or so of the Drina river result in an over 200 km-long nearly pristine Danube basin river system, perhaps the most intact and least polluted stretch of river in the whole basin.** Despite its international reputation and touristic attraction, little to no system-level science has been carried out on the system, to determine, for example, where the key spawning areas of huchen or grayling or nase are. All three species can undergo considerable migrations to fulfill their life-history needs. Canyons, in general, with their high hydraulic stress and steep channel-form offer few opportunities for spawning and rearing, and much of the Tara Canyon lacks accessible tributaries. **This means that the long-term population stability of many of the species may depend on movements in and out of the canyon to access spawning grounds.** Historically, fish like huchen were reported to follow spawning runs of fish like the nase (*Chondrostoma nasus)* to prey on them, and both nase and grayling are primary prey for huchen (Schmutz et al. 2002).

Fig. 46. *Chondrostoma nasus, one of the main prey species of the endangered huchen, known to undergo relatively long spawning migrations and very sensitive to hydropower development.*

In much of Central Europe, these migratory populations of nase have all but disappeared. Citing a tagging study from 1937, Waidbacher & Haidvogl (1998) reported that 25% of the tagged barbel and nase in a Danube study, migrated more than 50 km, some several hundred kilometers both up and downstream. **Such migrations on European rivers today are rarely possible, but it is highly likely that movements nearing these distances take place in the Tara/Drina system. Thus, population-level processes in the Tara Canyon may be very much be dependent on preserving the open-corridor and flowing-water habitats of the uppermost Drina River.**

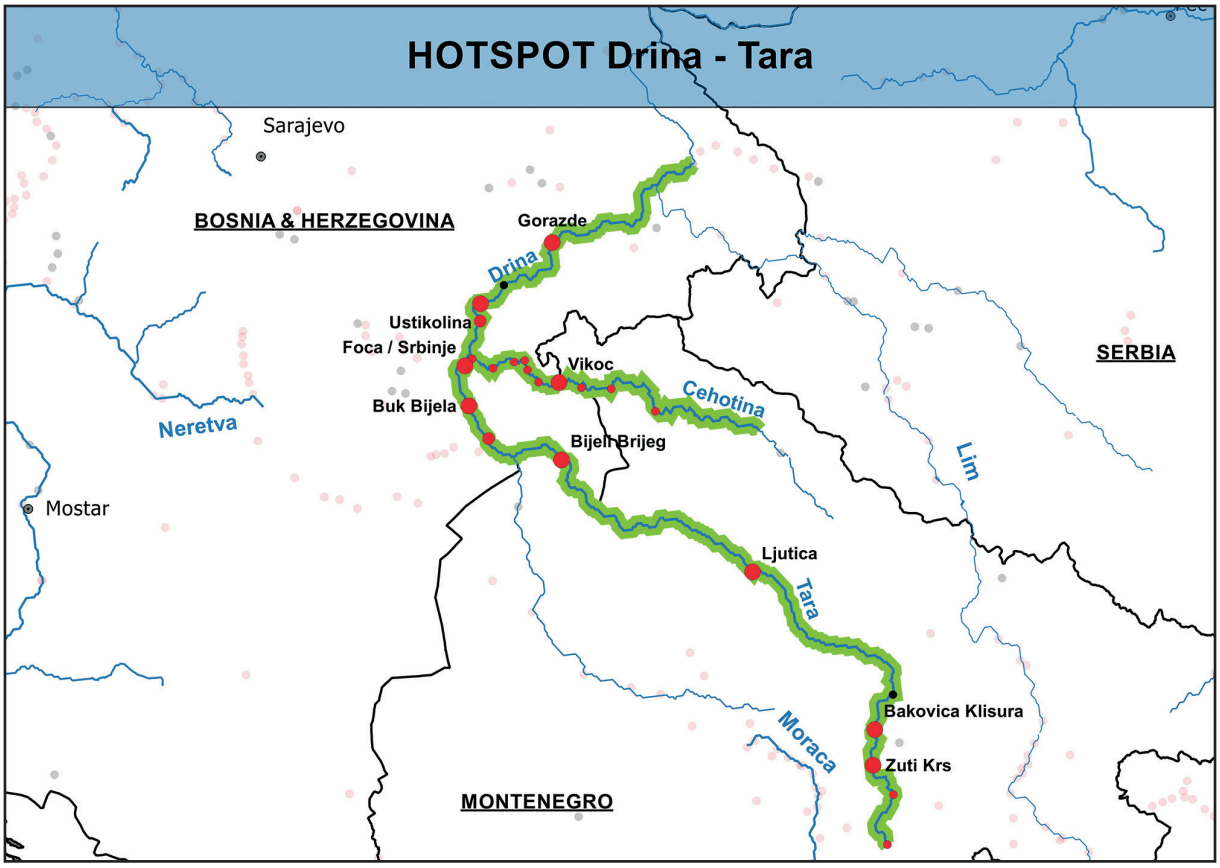


Fig. 47. *The Tara/upper Drina River corridor, showing nearly 200 km of undammed and relatively pristine river habitat. Shown in red are planned hydropower facilities, whereby the Buk-Bijela is apparently the most relevant at this time. Black dots indicate existing hydropower plants.*

After decades of controversy concerning the damming of the upper Drina River, the government of Bosnia-Herzegovina has signed a memorandum of cooperation with AVIC-ENG, a Chinese Aero-Technology Corporation for a 50 year concession to construct the power plant, approximately eleven kilometers upstream from Foca and just a few kilometers downstream from the Tara/Piva River confluence (https://balkangreenenergynews.com/memorandum-of-cooperation-on-construction-of-hpp-buk-bijela-signed/). While insufficient details are available, such a construction will clearly create a reservoir that backs up into the Tara Canyon.

In a World Bank Report published in June 2017, the values of the canyon, the ecosystem and its fauna including the endangered huchen were noted, together with many technical details of a full hydropower development plan for the upper Drina River (World Bank Group_ Water 2017). **The report further notes that insufficient studies of the biodiversity have been conducted and must take place, that discussions must consider all transboundary agreements, and that details of the project at this point are insufficient to make a decision.**

The Tara River in particular, but also the ecologically-bound upper reaches of the Drina River is one of the most treasured and legislatively protected river reaches on the European continent. The local population and government of Montenegro have resisted, protested and successfully prohibited planned hydropower development in the canyon for at least 40 years, including plans to construct a dam in the upper Drina, which would affect the Tara River. The system supports sustainable local economic activity and attracts international attention on many levels. **From the perspective of endangered fishes, it is the longest free-flowing river reach in the Danube basin that supports a naturally reproducing population of huchen.** If the Tara River and its fauna and flora are to remain intact, there is clearly still work to do in negotiating an agreement with the government of Bosnia-Herzegovina to somehow put yet one more piece of legislation in place to protect this unique and valued ecosystem.

Fig. 48. *Among the world's largest salmonid fishes, the huchen, or Danube salmon. Pictured here is a pair of adults preparing a "redd" where their roe will be laid.*

Results & Discussion

A total of 69 of the reviewed 113 species are endemic to the study area. **Carrying out most or all of the planned hydropower projects in the range of these 69 species will potentially lead to 11 global extinctions (Fig 49).** These are primarily species with limited ranges that are already critically endangered and almost any kind of disturbance to their habitat could be fatal. These species include the Jadova spined loach, the Vistonis schemaya, the Jadova minnow, the Krbava minnow, the Dalmatian minnow, the Croatian dace, the Cikola riffle dace, the Ukliva dace, the Visovac goby, the Vretenar and the Greek brook lamprey. Additionally, **there will be a clear negative development in the overall status of nearly all Balkan endemics evaluated in this study.** While the total number of critically endangered species (CR) will drop

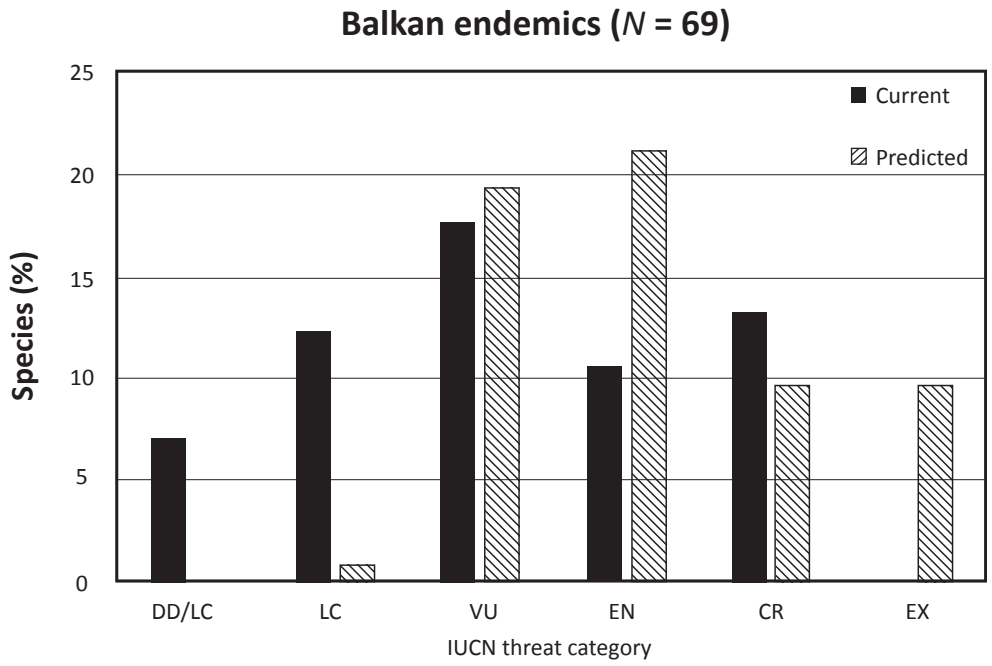


Fig. 49. *Current and predicted shift in threat status for 69 Balkan endemic fish species. All data deficient or not evaluated species will enter a threat category, and overall 68 of 69 evaluated species will be in an IUCN threat category.*

at first due to extinctions, **the number of endangered species (EN) will double together with an increase in the number of species with a vulnerable status (VU). Nearly all (68**

of 69) evaluated endemics will be in an IUCN threatened category. Considering all 113 evaluated species, the same prediction can be made but limited to the Balkan range. That is, the term extinction includes extirpation from the Balkan region, for those species have ranges that extend beyond the study area.

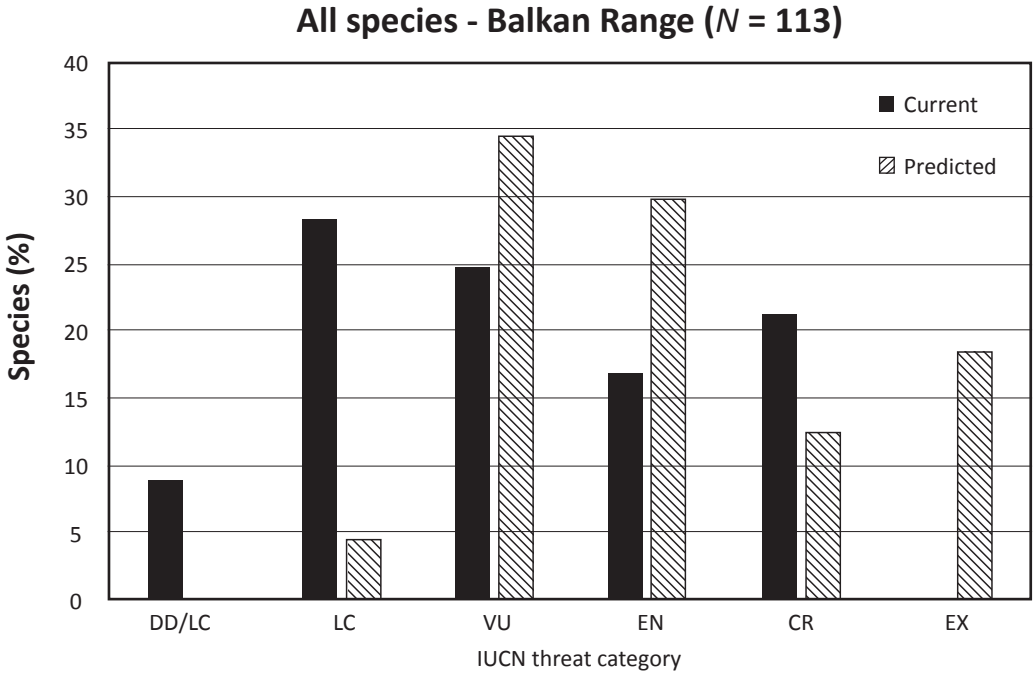


Fig. 50. *Current and predicted shift in threat status for all 113 evaluated freshwater species in the Balkans. Note that for this graph "ex" includes not only global extinction but also extirpation from the Balkans for species with broader geographic ranges.*

With this analysis, the number of species that could permanently disappear from the Balkan region (including global extinction) rises to 21 (Fig 50). This number includes five species of sturgeon (*Acipenser* sp.), which are already more or less extirpated, but would have no chance of recovery. Again, due to elimination, there is a drop in the absolute number of critically endangered species **but relatively large increases in both the number of species assigned to an endangered (+15) or vulnerable (+11) status. Thus, all but five of the 113 analyzed species would be assigned to a threat category or extirpated from the Balkan Peninsula, or 95% of the species analyzed.** This analysis does not take into account the reduced abundances of a number of other species not evaluated that are presently considered "Least Concern" or "Near Threatened" by the IUCN but would likely enter the "Near Threatened" or potentially the "Vulnerable" status (i.e. with a loss of 30% of their habitat), if not globally, then at least regionally. **For example, most species of the genus *Barbus* (barbels), as well as *Salmo* (trout), *Thymallus* (European grayling) and *Cottus***

(sculpin), while all widespread, will undergo major declines in range and abundance. The predictions should come as no surprise. **Dias et al. (2017) carried out a meta-analysis on extinction rates of freshwater fishes in North American and Europe.** When accounting for natural extinction rates, **the only factors that significantly correlated with increased anthropogenic extinction rates were fragmentation from dams and percentage of non-native species.** Both Dias et al. (2017) and Burkhead (2012) report extinction rates for freshwater fishes as 2 to 3 orders of magnitude higher than natural rates of extinction; in Burkhead (2012), limited to North America, this rate was higher than for any other group of vertebrates. **Xenopoulos et al. (2005) noted** that the interaction of climate change and water abstraction could result in an **up to 75% reduction in freshwater fish diversity in rivers experiencing abstraction,** and that many of these losses could be avoided if sufficient discharge could be allocated to the rivers. Concerning climate change and freshwater fish distributions; **some compensation for climate change can take place with the upstream shift in occupied habitat, provided the river corridor is not fragmented,** and fish have the ability to shift their range. Thus, **the combined scenario of climate change, further fragmentation of river habitats and multiple sources of competition for decreasing water resources, including those that would need to be allocated to residual flows and fish passage paints a very pessimistic future for freshwater biodiversity in the Balkans if such hydropower expansion scenarios as presented here are carried through.**

Most riverine systems in Europe are experiencing multiple stressors, such as pollution, gravel extraction, water extraction independent of hydropower, invasive species and climate change, and thus the effects of hydropower are not the sole source of threat to the Balkan ichthyofauna. **At the landscape-level,** however, and considering the negative synergistic interactions of further water extraction (through diversions) and impoundment, **there is presently no immediate threat as great to the health and biodiversity of Balkan rivers and their productivity than the present outlook with hydropower expansion. There are also multiple sources of legal conflict regarding Balkan countries' obligations under the European Habitats Directive, the European Water Framework Directive, the Bern Convention as well as potential loss of IUCN National Park status for various protected areas, if these areas are managed with a priority of energy exploitation instead of the legislated conservation goals.** How can these predicted losses be avoided? Considering this challenge and the results of this study, we offer several options for trying to conserve Balkan species diversity and a reasonable percentage of ecologically intact and/or productive systems.

Recommendations

Two strategic initiatives are essential for buffering or combating the impending degradation of aquatic diversity and productivity in the Balkan Peninsula: 1) **complete avoidance of degradation in systems that have existing obligations to habitat or species conservation;** and 2) **reduced density in exploitation in other systems, to ensure that faunal elements and ecological function are not completely lost.** It is not our purpose to suggest a conservation plan for the Balkans, or to discuss optimizing trade-offs (see e.g. Ziv et al. 2012), or to suggest which rivers should or could be sacrificed for the sole purpose of energy exploitation. Rather, we focus on imperatives from a scientific perspective including acknowledgment of existing legislation, the species concerned and river conservation. First, a number of rivers harbor a disproportionate amount of the biodiversity, including threatened or endangered species. Some of these systems have been outlined, and include **for the Adriatic region, the remaining reaches of the Neretva River and its tributaries and the Morača River and Lake Skadar system.** Not discussed at length here but currently receiving a great deal of media attention is **the Vjosa River in Albania. The Vjosa is by far the longest unspoiled river in the Adriatic basin and habitat for the critically endangered European eel (*Anguilla Anguilla*) and the regionally endangered twaite shad (*Alosa fallax)*.** These three systems stand out due to their high and unique diversity with respect to endemic taxa, or large areas of relatively undeveloped landscape. **The Cetina River, though heavily exploited, as well as the karst fields of eastern Bosnia-Herzegovina and southern Croatia are a special case,** as many of the habitats, whether by nature or anthropogenic activity, are already small and fragmented. Nevertheless, there is an exceptional amount of unique diversity there which is threatened at times in subtle and indirect ways – **these areas need careful and detailed attention, rather than an explicit landscape-level prohibition to further exploitation.**

In the Danube system, t**he Tara/upper Drina system stands out as a long river system with relatively unspoiled landscape character, habitat for the endangered huchen, a recreational paradise sustainably utilized to the benefit of the local community, and a system with multiple levels of legislative protection. The Sava River and some of its tributaries, while already heavily exploited in some reaches, remain a species-rich system and key habitat for at least fifteen species listed in our study. The Slovenian Mur, a Natura 2000** area connected to three additional Natura 2000 areas **is not pristine, but of key importance for maintaining the longest free-flowing lowland river system in Europe, the planned Transboundary UNESCO Biosphere Reserve "Mura - Drava - Danube" between Austria, Slovenia, Croatia, Hungary and Serbia (http://www.amazon-of-europe.com)**

(see also Weiss 2017). Elsewhere in the Danube basin of the Balkans, a number of river reaches have already been identified (Freyhof et al. 2015) that offer **an easily applied indicator for large-scale conservation;** residence of self-reproducing populations of the endangered huchen, a top aquatic predator. Among these are the above-mentioned **Tara/upper Drina River in Montenegro and Bosnia-Herzegovina and the Sava River in Slovenia. Among the remaining longest undammed rivers sustaining huchen there is the Lim River in Montenegro (Fig. 51), the Sana River in Bosnia-Herzegovina (Fig. 52), the Una River along the Croatian-Bosnian-Herzegovinian border (Fig. 53) and the Kolpa (or Kupa) River along the Slovenian-Croatian border (Fig. 54).**

Fig. 51. *The Lim River, Montenegro, near the town of Andrijevica. It harbors self-sustaining populations of huchen at the most southern edge of its natural range. Rafting and fly-fishing have become particularly popular and lucrative in recent years for the local community.*

Some small rivers threaten the global existence of particular species. **The discovery of *Zingel balcanicus* in a tributary of the upper Treska River in Republic of Macedonia is an example. This could be the very last habitat for this species.** While in our maps, there is no new hydropower facility depicted, local information was contradictory. **For the Kalamas River, Greece, the endangered Louros spined loach finds its habitat threatened by a chain of up to eighteen hydropower plants. The river, near the sea, also provides habitat for the critically endangered Corfu toothcarp.**

Fig. 52. *The Sana River, Bosnia-Herzegovina.* ***One of the six longest undammed rivers in the Balkans supporting self-sustaining populations of the endangered huchen.***

Fig. 53. *The Una River, Bosnia.* ***Known for picturesque waterfalls, spring-fed water, flora and faunal diversity and productive fisheries.*** *Partly in Una River National Park - one of the six longest rivers in the Balkans supporting the endangered huchen.*

Fig. 54. *The headwaters of the Kupa River, Croatia. A chain of hydropower plants are planned along its entire length.* **The river provides habitat for the endangered huchen and recently described but not yet evaluated Kolpa schemaya** *(Alburnus sava).*

Fig. 55.*God's bridge on the Kalama River, near Lithino, Greece.* *A chain of hydropower plants is planned across the entire drainage, some of which are already in construction.* ***The river is habitat to the endangered Lourus spined loach, and near the sea, to the critically endangered Corfu toothcarp.***

These are simply examples of individual rivers that provide habitat for the global distribution, or large portions of the global distribution of individual species, or provide some of the largest contiguous habitats for a relatively large number of threatened species. **Avoidance of hydropower expansion in these rivers would conserve a considerable number of species. Additionally, regions of Greece, Albania and Republic of Macedonia where all climate models support significant reductions in precipitation should consider whether additional hydropower exploitation is at all wise.** The second issue, aside from simple avoidance of development where species are threatened with extinction, is a landscape-level understanding of exploitation density and its consequences. **Single small-scale hydropower facilities in a river may not necessarily have significant environmental costs, if constructed and maintained properly. However, chains of such facilities invariably do.** Historically, hydropower plants were not build in chains, at least not all at one time. This issue goes well beyond the goals of this report, but nonetheless we need to communicate that even when **applying the standard technology and minimum legal requirements that currently exist, there is still no way to avoid decimating native fish populations once a give density of hydropower exploitation is reached.** Compromise can only be reached when there is access to sufficient habitats between hydropower facilities as well as sufficient river kilometers to buffer against the stressors (e.g. flushing) that power plant operation cause. In summary, **the primary purpose of this report is to show where endangered or threatened fish species, as well as productive or pristine systems in the Balkans exist, in order that reasonable plans can be made to protect them.** In many but not all cases, existing protection areas, national parks and competing sustainable and economically viable activities should provide a sufficient barrier to prevent needless exploitation and degradation, provided that existing nature protection legislation and agreements are respected and not diluted or overrun by competing legislation promoting uncontrolled development.

List of abbreviations

IUCN abbreviations

CR	Critically Endangered
DD	Data Deficient
EN	Endangered
LC	Least Concern
NE	Not Evaluated
VU	Vulnerable

Country abbreviations

alb.	albanian
bg.	bulgarian
bh.	bosnian
eng.	english
ger.	german
gr.	greek
hr.	hrvatska (croatian)
mk.	Republic of Macedonian
slo.	slovenian
sr.	serbian
tr.	turkish

Other abbreviations

IUCN	International Union for Conservation of Nature
EUR-HAB-DIR	European Habitat Directive
Mod.	Moderate

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